SESSIONAL PAPERS

VOLUME 18

THIRD SESSION OF THE ELEVENTH PARLIAMENT

OF THE

DOMINION OF CANADA

SESSION 1911

VOLUME XLV.

See also Numerical List, Page 7.

ALPHABETICAL INDEX

TO THE

SESSIONAL PAPERS

OF THE

PARLIAMENT OF CANADA

THIRD SESSION, ELEVENTH PARLIAMENT, 1911.

A

B

L

M

Mc

N

O

P

Q

R

S

T

See also Alphabetical List, Page 1.

LIST OF SESSIONAL PAPERS

Arranged in Numerical Order, with their titles at full length; the dates when Ordered and when Presented to the Houses of Parliament; the Names of the Senator or Member who moved for each Sessional Paper, and whether it is ordered to be Printed or Not Printed.

CONTENTS OF VOLUME 1.

(This volume is bound in two parts.)

1. Report of the Auditor General for the year ended 31st March, 1910. Volume I, Parts A to P, and Volume II, Parts Q to Y. Presented 21st November, 1910, by Hon. William Paterson.. .. ..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 2.

2. Public Accounts of Canada, for the fiscal year ended 31st March, 1910. Presented 21st November, 1910, by Hon. William Paterson.
Printed for both distribution and sessional papers.

3. Estimates for the fiscal year ending 31st March, 1912. Presented 2nd December, 1910, by Rt. Hon. Sir Wilfrid Laurier... ..*Printed for both distribution and sessional papers.*

4. Supplementary Estimates for the fiscal year ending 31st March, 1911. Presented 6th February, 1911, by Hon. W. S. Fielding.
Printed for both distribution and sessional papers.

5. Further Supplementary Estimates of sums required for the service of the Dominion for the year ending on 31st March, 1911. Presented 16th March, 1911, by Hon. W. S. Fielding.. .. ..*Printed for both distribution and sessional papers.*

5*a*. Further Supplementary Estimates for the year esding 31st March, 1911. Presented 8th May, 1911, by Hon. W. S. Fielding.
Printed for both distribution and sessional papers.

5*b*. Further Supplementary Estimates for the fiscal year ended 31st March, 1911 Presented 3rd May, 1911, by Hon. W. S. Fielding.
Printed for both distribution and sessional papers.

5*c*. Further Supplementary Estimates for the fiscl year ending 31st March, 1912. Presented 9th May, 1911. by Hon. W. S. Fielding.
Printed for both distribution and sessional papers.

5*d*. Further Supplementary Estimates of sums required for the service of the Dominion for the year ending on 31st March, 1912. Presented 17th May, 1911, by W. S. Fielding.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 2—*Concluded.*

6. List of shareholders in the Chartered Banks of the Dominion of Canada as on December 31, 1910. Presented 10th April, 1911, by Hon. W. S. Fielding.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 3.

7. Report on dividends remaining unpaid, unclaimed balances and unpaid drafts and bills of exchange in Chartered Banks of the Dominion of Canada, for five years and upwards prior to December 31, 1910. Presented 19th July, 1911, by Hon. William Templeman.. .. ..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 4.

8. Report of the Superintendent of Insurance, for the year ended 31st December, 1910.
Printed for both distribution and sessional papers.

9. Abstract of Statements of Insurance Companies in Canada for the year ended 31st December, 1910. Presented 27th April. 1911, by Hon. W. S. Fielding.
Printed for distribution.

CONTENTS OF VOLUME 5.

10. Report of the Department of Trade and Commerce, for the fiscal year ended 31st March, 1910. Part 1, Canadian Trade. Presented 22nd November, 1910, by Rt. Hon. Sir Wilfrid Laurier.. .. ..*Printed for both distribution and sessional papers.*

10*a*. Report of the Department of Trade and Commerce, Part II. Canadian Trade with France, Germany, United Kingdom and United States. Presented 32nd November, 1910, by Rt. Hon. Sir Wilfrid Laurier.
Printed for both distribution and sessional papers.

10*b*. Report of the Department of Trade and Commerce, Part III. Canadian Trade with foreign countries, except France, Germany, the United Kingdom and United States Presented 22nd November, 1910, by Rt. Hon. Sir Wilfrid Laurier.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 6.

10*c*, Report of the Department of Trade and Commerce for the fiscal year ended 31st March, 1910. Part IV, Canadian Trade, Miscellaneous. Presented 31st March, 1911, by Hon. W. S. Fielding.. .. ..*Printed for both distribution and sessional papers.*

10*d*. Report of the Department of Trade and Commerce for the fiscal year ended March 31st 1910. Part V, Grain Statistics, including the crop year ended August 31st 1910, and the season of navigation ended December 6th, 1910. Presented 12th May, 1911, by Hon. William Paterson....*Printed for both distribution and sessional papers.*

10*e*. Report of the Department of Trade and Commerce for the fiscal year ended 31st March, 1910, Part VI., Subsidized steamship services. Presented 20th April, 1911, by Hon. William Paterson.. .. ..*Printed for both distribution and sessional papers.*

10*f* Report of Trade and Commerce for the fiscal year ended 31st March, 1910, part VII.—Trade of foreign countries and Treaties and Conventions. Presented 31st March, 1911, by Hon. W. S. Fielding.. ..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 7.

11. Report of the Department of Customs, for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. William Paterson.
Printed for both distribution and sessional papers.

12. Reports, Returns and Statistics of the Inland Revenue for the Dominion of Canada, for the year ended 31st March, 1910. Presented 21st November, by Hon. William Templeman.. .. ..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 8.

13. Inspection of Weights and Measures, Gas and Electric Light, for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. William Templeman.
Printed for both distribution and sessional papers.

14. Report on Adulteration of Food, for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. William Templeman.
Printed for both distribution and sessional papers.

15. Report of the Minister of Agriculture for the Dominion of Canada, for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. S. A. Fisher.
Printed for both distribution and sessional papers.

15a. Report of the Dairy and Cold Storage Commissioner for the fiscal year ending the 31st March, 1910. Presented 12th January, 1911, by Hon. S. A. Fisher.
Printed for both distribution and sessional papers.

15*b*. Report of the Veterinary Director General and Live Stock Commissioner, J. G. Rutherford, V.S., for the year ending 31st March, 1909.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 9.

16. Report of the Director and Officers of the Experimental Farms, for the year ending 31st March, 1910. Presented 21st November, 1910, by Hon. S. A. Fisher.
Printed for both distribution and sessional papers.

17. Criminal Statistics for the year ended 30th September, 1909. Presented 21st November, 1910, by Hon. S. A. Fisher.. .. ..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 10.

18. (1908). Return of the eleventh general election for the House of Commons of Canada, held on the 19th and 26th of October, 1908.. .. ..*Reprinted.*

18. Return of By-Elections (Eleventh Parliament) House of Commons. 1910.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 11.

19. Report of the Minister of Public Works on the works under his control for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. William Pugsley.
Printed for both distribution and sessional papers.

19a. Progress Report Ottawa River Storage, for the fiscal year 1909-1910 (supplementing investigations in regard to Georgian Bay Ship Canal project). Presented 6th March, 1911, by Hon. William Pugsley..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 12.

CONTENTS OF VOLUME 13.

CONTENTS OF VOLUME 14.

CONTENTS OF VOLUME 15.

CONTENTS OF VOLUME 15—*Concluded.*

24. Report of the Postmaster General for the year ended 31st March, 1910. Presented 22nd November, 1910, by Rt. Hon. Sir Wilfrid Laurier.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 16.

ERRATUM.

Volume 18.

No. 26*a*. Mines Branch, should read 1910, instead of 1909, and Memo. below relating to same expunged.

CONTENTS OF VOLUME 18.

25*d*. Report of the Hydrographic Survey (Streams measurement). Department of the Interior.. .. ..*Printed for both distribution and sessional papers.*

26. Summary Report of the Geological Survey Branch, Department of Mines, for Calendar year 1910. Presented 19th. July, 1911, by Hon. William TeTmpleman.
Printed for both distribution and sessional papers.

26*a*. (1909) Summary Report of the Mines Branch of Department of Mines, for the calendar year, 1909. Presented 26th. January, 1911, by Hon. William Templeman.
Printed for both distribution and sessional papers.
This is bound in Vol. XVI, 1910.

CONTENTS OF VOLUME 19.

27. Report of the Department of Indian Affairs, for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. Frank Oliver.
Printed for both distribution and sessional papers.

28. Report of the Royal Northwest Mounted Police, 1910. Presented 2nd December, 1910, by Rt. Hon. Sir Wilfrid Laurier..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 20.

29. Report of the Secretary of State of Canada for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. Charles Murphy.
Printed for both distribution and sessional papers.

29*a*. (No issue).

CONTENTS OF VOLUME 12.

CONTENTS OF VOLUME 14.

CONTENTS OF VOLUME 15.

CONTENTS OF VOLUME 15—*Concluded.*

24. Report of the Postmaster General for the year ended 31st March, 1910. Presented 22nd November, 1910, by Rt. Hon. Sir Wilfrid Laurier.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 16.

25. Report of the Department of the Interior, for the fiscal year ending 31st March, 1910. Presented 21st November, 1910, by Hon. Frank Oliver.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 17.

25*a*. Report of the Chief Astronomer, Department of the Interior, for year ending 31st. March, 1910.. .. ..*Printed for both distribution and sessional papers.*

25*b*. Annual Report of the Topographical Surveys Branch, Department of the Interior, 1909-10. Presented 31st March, 1911, by Hon. Frank Oliver.
Printed for both distribution and sessional papers.

25*c*. Report of Dr. P. H. Bryce, Chief Medical Officer, Appendix to Report of Superintendent of Immigration. Presented 9th. December, 1910, by Hon. Frank Oliver.
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 18.

25*d*. Report of the Hydrographic Survey (Streams measurement). Department of the Interior.. .. ..*Printed for both distribution and sessional papers.*

26. Summary Report of the Geological Survey Branch, Department of Mines, for Calendar year 1910. Presented 19th. July, 1911, by Hon. William TeTmpleman.
Printed for both distribution and sessional papers.

26*a*. (1909) Summary Report of the Mines Branch of Department of Mines, for the calendar year, 1909. Presented 26th. January, 1911, by Hon. William Templeman.
Printed for both distribution and sessional papers.
This is bound in Vol. XVI, 1910.

CONTENTS OF VOLUME 19.

27. Report of the Department of Indian Affairs, for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. Frank Oliver.
Printed for both distribution and sessional papers.

28. Report of the Royal Northwest Mounted Police, 1910. Presented 2nd December, 1910, by Rt. Hon. Sir Wilfrid Laurier..*Printed for both distribution and sessional papers.*

CONTENTS OF VOLUME 20.

29. Report of the Secretary of State of Canada for the year ended 31st March, 1910. Presented 21st November, 1910, by Hon. Charles Murphy.
Printed for both distribution and sessional papers.

29a. (No issue).

CONTENTS OF VOLUME 20—*Concluded.*

CONTENTS OF VOLUME 21.

CONTENTS OF VOLUME 22.

CONTENTS OF VOLUME 22—*Concluded.*

CONTENTS OF VOLUME 23.

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

56*j*. Return to an order of the Senate dated February 1, 1911, calling for in as many columns:—1. The names of all the ships of which the Canadian fleet service is actually composed. 2. The tonnage of each of these ships. 3. How old, is each ship at present. 4. The purchase price, or cost of construction, or, in default thereof, the actual value of each ship. 5. The horse-power of each of them. 6. The motive power, side wheels, propeller or sails. 7. The number of persons of which the crew of each of these ships is composed. 8. The cost of annual maintenance of each ship with its crew. 9. The purpose for which each ship is used, specifying whether it is for the guarding of the coasts, the protection of fisneries, or for the what other purpose. 10. The waters on which each of these ships sails—the waters of the Atlantic or Pacific Oceans, the Greot Lakes, of the St. Lawrence river, or elsewhere, with a short statement showing the number and the net tonnage of the ships of the Great Lakes service,—of the ships stationed on the shores of British Columbia, and of the ships sailing on the waters of the eastern portion of the American continent owned by us. Presented 14th February, 1911.—*Hon. Mr. Landry.* *Not printed.*

56*k*. Orders in Council published in *Canada Gazette* 11th February, 1911, No. 83/146. Regulations for entry of naval instructors. No. 91/146. Revised rates of pay for electricians. No. 86/146. Revised travelling allowances. Presented 23rd February, 1911, by Rt. Hon. Sir Richard Cartwright.. .. ..*Not printed.*

56*l*. Return to an address of the House of Commons, dated 6th February, 1911, for a copy of the final protocol or agreement entered into at the International Naval Conference held in London, December, 1908, February, 1909, and of the general report presented to the said Naval Conference on behalf of its drafting committee, and of all correspondence exchanged between the Imperial Government and the Government of Canada in regard to the same. Presented 10th March, 1911.—*Mr. Monk..* .. ..*Not printed.*

56*m*. 1. Correspondence and documents respecting the International Naval Conference held in London, December, 1908, February, 1909. 2. Correspondence respecting the Declaration of London. 3. Final Act of the Second Peace Conference held at The Hague in 1907, and Conventions and Declarations annexed thereto. Presented 23rd March, 1911, by Rt. Hon. Sir Wilfrid Laurier.. .. ..*Not printed*

56*n*. Return to an order of the House of Commons, dated 27th February, 1911, for a Return showing:—1. How many Canadians have been accepted as members of the Canadian Navy. 2. What are the names and former residence of those who have been accepted. Presented 24th March, 1911.—*Mr. Taylor (Leeds)*,.. .. .. ..*Not printed.*

56*o*. Order in Council, approved by His Excellency the Governor General on the 31st March, 1911, and published in the *Canada Gazette* April 15th, 1911:—No. 358 revised regulations for entry of surgeons into the Naval Service. Presented 24th April, 1911, by Hon. L. P. Brodeur.. .. ..*Not printed.*

57. Return to an Order of the House of Commons, dated the 7th December, 1910, for a copy of all correspondence between the Government of Canada or the Right Honourable, the First Minister, and the government of Manitoba, or the Premier of Manitoba, referring to the demand of Manitoba for an extension of boundaries and an increase in subsidy. Presented 14th December, 1910.—*Mr. Staples.*
Printed for sessional papers.

58. Memorandum respecting the finances of the National Battlefields Commission, as on the 31st March, 1910. Presented 15th December, 1910, by Hon. William Paterson.
Printed for sessional papers.

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

testing against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 28th March, 1911.—*Hon. Mr. Foster.*
Not printed.

59*j*. Further supplementary return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all petitions, memorials and resolutions from individuals, Boards of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 28th March, 1911.—*Hon. Mr. Foster.*
Not printed.

59*k*. Further supplementary return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all petitions, memorials and resolutions from individuals, Boards of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Prsented 31st March, 1911.—*Hon. Mr. Foster.*
Not printed.

59*l*. Further supplementary return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all petitions, memorials and resolutions from individuals, Boards of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 7th April, 1911.—*Hon. Mr. Foster.*
Not printed.

59*m*. Further supplementary return to an Address of the House of Commous, dated 7th December, 1910, for a copy of all petitions, memorials and resolutions from individuals, Boards of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 19th April, 1911.—*Hon. Mr. Foster.*
Not printed.

59*n*. Further supplementary return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all petitions, memorials and resolutions from individuals, Boards of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 19th April, 1911.—*Hon. Mr. Foster.*
Not printed.

59*o*. Further supplementary return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all petitions, memorials and resolutions from individuals, boards of trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States. and also of all similar documents pro-

CONTENTS OF VOLUME 23—*Continued.*

testing against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 2nd May, 1911.—*Hon. Mr. Foster.* *Not printed.*

59*p*. Further supplementary return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all memorials and resolutions from individuals, Boords of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 5th May, 1911.—*Hon. Mr. Foster.* *Not printed.*

59*q*. Return to an Order of the House of Commons, dated 19th April, 1911, for a Return showing what duties are imposed by Australia, New Zealand, Norway, France, Spain, Sweden, Switzerland, Austria-Hungary, Japan, Argentine, Venezuela and Russia, respectively, upon each of the articles included in the reciprocity agreement between the United States and Canada.

And also, a statement showing the import prices in 1910 on which duty was collected on the butter, eggs cheese, salt, beef, bacon, hams, mutton, lamb, pork in brine and other meat products detailed, barley, beans, oats, peas, wheat, hay, flaxseed, green apples, and animals, imported from the above named countries. Presented 8th May, 1911.—*Hon. Mr. Foster*.. .. ..*Not printed.*

59*r*. Return to an order of the House of Commons, dated 8th May, 1911, for a Return showing, taking the latest Return of Commerce and Navigation of the United States as a basis, the advantage Canada will have in the United States market over her principal competitors, under the construction given at Washington by the United States Court of Customs Appeals on April 10th, 1911, regarding the favoured nation clause, by which the competitors of Canada in the United States market are denied the privileges granted to Canada by the reciprocal agreement in regard to the importation into the United States of the following goods and articles, namely: (*a*) Mackerel pickled or salted; (*b*) Herring, pickled; (*c*) Cod, Haddock, Hake and Pollock, dried, smoked, salted or pickled; (*d*) all other kinds of fish, salted or pickled; (*e*) Fish oils: (*f*) Butter; (*g*) Cheese; (*h*) Cattle; (*i*) Horses; (*j*) Oats; (*k*) Coke; (*l*) Mineral Waters; (*m*) Rolled Iron or Steel Sheets, coated with zinc, tin or other metal; (*n*) Mica; (*o*) Flax seed; (*p*) Beans and dried peas; (*q*) Onions; (*r*) Potatoes; (*s*) other vegetables in natural state.

Also showing the present rate of duty in the United States on the above goods and articles; the rate under the proposed reciprocal agreement of the said goods and articles; the value of goods; and the amount of duty collected on goods imported from said competitors on the trade of said year, which will be free under the agreement on goods from Canada. Presented 16th May, 1911.—*Mr. Sinclair..Not printed.*

59*s*. Further supplementary Return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all memorials and resolutions from individuals, Boards of Trade or other bodies and corporations, favouring or asking for a treaty of reciprocity with the United States; and also of all similar documents protesting against or unfavourable to the same, and a copy of all correspondence had with the Government, or any member thereof, concerning reciprocity with the United States, since the 1st January, 1910. Presented 19th May, 1911.—*Hon. Mr. Foster...Not printed.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

64. Return to an order of the House of Commons, dated 6th December, 1910, for a return showing:—1. What newspapers or companies publishing newspapers in the cities of Montreal and Quebec have directly or indirectly received sums from the Government of Canada for printing, lithographing, binding or other work, between the 31st March, 1910, and the 15th November, following.

2. What is the total amount paid to each of said newspapers or companies between the dates above stated. Presented 11th January, 1911.—*Mr. Monk.. .. ..Not printed.*

65. Return to an Address of the House of Commons, dated 7th December, 1910, for a copy of all Orders in Council, correspondence, papers, maps or other documents, which passed between the Government of Canada or any member thereof, and the Government of Quebec, or any member thereof, or any other parties on their behalf, or between the Government of Canada and the Government of Ontario, or any members thereof, regarding the extension of the boundaries of the province of Quebec, as set forth in an Order in Council dated 8th July, 1896, establishing a conventional boundary, therein specified. And also any correspondence, papers, documents, &c., that may have passed between the aforesaid governments or members thereof, relative to the passing of an Act to confirm and ratify the aforesaid conventional boundary, which was passed in 1898. Presented 11th January, 1911.—*Mr. Sproule.*

Printed for sessional papers.

66. Return to an Order of the House of Commons, dated 14th December, 1910, for a Return showing the names of manufacturers in Canada of turned kiln dried maple boot, last and shoe last blocks, in the rough, for making manufacturers' boot and shoe lasts. Presented 11th January, 1911.—*Mr. Hughes.. .. ..Not printed.*

67. Return to an Order of the House of Commons, dated 5th December, 1910, for a copy of all correspondence, reports, memorials, surveys and other papers in the possession of the Government, and not already brought down, regarding the oyster industry of Canada; also a copy of all correspondence, reports and other papers regarding the ownership and control of Oyster beds and of barren bottoms suitable for Oyster culture, and regarding the consolidating of the ownership with the control and regulation of such beds and barren bottoms, and vesting the same in the hands of the Dominion Government; olso a copy of all correspondence, reports, recommendations and other papers relating to the leasing or sale of such beds or barren bottoms or of portions of them, for the purpose of Oyster culture or cultivation. Also o copy of all correspondence and reports relating to the culture, cultivation asd conservation of oysters and other mollusks. Presented 11th January, 1911.—*Mr. Warburton.*

Printed for sessional papers.

68. Order of the House of Commons, dated 5th December, 1910, for a copy of all reports, evidence, correspondence, and other documents relating to an investigation into irregularities in the life saving station at Clayoquot, mentioned on page 353 of the Report of the Department of Marine and Fisheries for 1909 and 1910, sessional paper No. 22. Presented 11th January, 1911.—*Mr. Barnard.. .. ..Not printed.*

69. Return to an Order of the House of Commons, dated 14th December, 1910, for a Return showing how many employees of the custom house at Montreal have left the service since the 1st July, 1896, up to this date, with their names, duties, salaries and ages, respectively, and date of their leaving; the names, ages, salaries and duties of those who have replaced them, the date of their entry and their present salaries. Presented 11th January, 1911.—*Mr. Wilson (Laval).. .. ..Not printed.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

76. Return to an Order of the House of Commons, dated 14th December, 1910, for a Return showing all applications made to the Government during the period of agreement with Japan concerning Japanese immigrants, to admit such immigrants for special purposes, together with a copy of all correspondence in connection with the same. Presented 12th January, 1911.—*Mr. Taylor (New Westminster)*.. .. .. ..*Not printed.*

76*a*. Return to an Order of the House of Commons, dated 7th December, 1910, for a Return giving a list of the special immigration agents appointed by the government since the 31st March, 1909, in what portions of Great Britain and Irelond, the European Continent, or other country they are severally located, their addresses when they were so appointed the date of their appointment in each case their respective salaries and expenses, and any commissions that may have been paid to each or any since their appointment. Presented 12th January, 1911.—*Mr. Wilson (Lennox and Addington)*.. .. ..*Not printed.*

76*b*. Return to an Order of the House of Commons, dated 11th January, 1911, for a Return showing the number of immigrants who have come to Canada since the 31st March last up to the present time, the countries from which they came, the number from each such country, the number of males and the number of females in each case, the number under fourteen years of age, between fourteen and twenty-one years, between twenty-one and forty, and between forty and sixty in each case, their occupations before coming to Canada, their religion, their destination in Canada, their occupation when they arrived at such destination; also the number who have been prevented from landing, and the number deported. Presented 6th February, 1911.—*Mr. Wilson (Lennox and Addington)*.. .. ..*Not printed.*

76*c* Return to an Order of the Senate dated 24th January, 1911, calling for the production in detail of the accounts and claims fyled at the Department of the Interior or the Immigration Office, Quebec, by Mr. Jacques Dery; restaurant keeper, during the navigation season of 1910. Presented 7th February, 1911.—*Hon. Mr. Landry.*
Not printed.

76*d*. Return to an Order of the Senate dated 20th January, 1911, calling for the report received by the Immigration Department on the subject of the complaints brought against Mr. Jacques Dery, the keeper of the restaurant established in the immigration buildings at Quebec, and also of the correspondence exchanged and the inquiry held by the immigration agent with regard to the overcharges by the restaurant keeper, and of the refund which he had to make to immigrants of the price obtained for goods of bad quality. Presented 7th February, 1911.—*Hon. Mr. Landry.*
Not printed.

76*e*. Return to an Order of the Senate dated 25th January, 1911, for the production of a complaint, signed by a large number of persons employed at the Immigration Office and Immigration buildings at Quebec and addressed to the agent of the Department at that place, against Mr. Jacques Dery, the restaurant keeper, and also of the reply of the latter. Presented 7th February, 1911.—*Hon. Mr. Landry*.. .. .. ..*Not printed.*

76*f*. Return to an Order of the Senate dated 25th January, 1911, that an Order of this House do issue for the production of a letter dated 1st June, 1910, written by Mr. L. Stein, of Quebec, addressed to Mr. W. D. Scott, Superintendent of Immigration. Presented 10th February, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

77*k*. Interim Report of the Commissioners of the Transcontinental Railway for the nine months ended December 31, 1910. Presented 27th February, 1911, by Hon. G. P. Graham.. .. ..*Not printed.*

77*l*. Return to an Order of the Senate dated 18th January, 1911, for a Return showing:—A. As relates to the main line of the Transcontinental:—

1. The respective length in miles of each of the divisions of the Transcontinental, named Division A, Division B, &c., from Moncton to Winnipeg, and specifying in which province each of the divisions is located.

2. The estimated cost, at the outset, of the construction of the road in each division.

3. The actual price paid, on the 15th January instant, for the building of the line, sidings, bridges and other necessary works in each division.

4. The approximate cost in each division of the Transcontinental, of what remains to be constructed for the completion of the road.

B. As relates to the branch lines of the Transcontinental:—

1. The respective length of each of the said branch lines, specifying the district and the province within which the said branch lines are located.

2. The estimated cost, at the start, of the construction of each of the said branch lines.

3. The actual cost up to the 15th January instant of the construction of said branch lines.

4. The probable cost of the works to be executed on each of the said branch lines.

5. The indication of the special section of the Act which each branch line has been constructed.

6. The mention of all other branch lines proposed to be constructed by the Transcontinental Railway Commission or the Government, showing the length and probable cost thereof. Presented 8th March, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

77*m*. Return to an Order of the House of Commons, dated 23rd February, 1911, for a Return showing:—

1. What contracts outside of those numbered 1 to 21, inclusive, have been let for construction on the Transcontinental Railway at Winnipeg and St. Boniface of bridges, station buildings, freight houses, sheds, engine houses, turn tables, water tanks, section houses, work shops, or other buildings, erections, structures or plant.

2. Were these contracts all let after advertisement and upon tender.

3. What is the cost or estimated cost according to schedule or bulk tender in each case, and who is the contractor in each case.

4. Were tenders asked for both by schedule and on bulk tender basis, on which system was the contract awarded and for what reason in each case.

5. What alterations have been made in any of the works since letting of contract, and at what increased or decreased cost. Presented 9th March, 1911.—*Mr. White (Renfrew)*.. .. ..*Not printed.*

77*n*. Return to an Order of the House of Commons, dated 6th March, 1911, for a copy of the report of the engineers who investigated overclassification, overbreak, or other alleged over allowances on progress or final estimate, on the Eastern Division of the Transcontinental Railway, the evidence taken, or other data collected, and of all letters, instructions, agreements, plans, drawings, photographs, memoranda and writings sent, given, had or used in connection with said investigation, not already brought down, together with a reference to the previous return where papers are already down; also a copy of the previous report made by Messrs. Schreiber, Kelligher and Lumsden immediately before Mr. Lumsden's resignation. Presented 16th March, 1911.—*Mr. Lennox*.. .. ..*Not printed*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

12. How much a carload does the freight of sleepers sent from New Brunswick cost in the district of Quebec? Presented 3rd February, 1911.—*Hon. Mr. Landry.* *Not printed.*

84. Return to an order of the House of Commons, dated 11th January, 1911, for a return showing the respective quantities of each of the staple varieties of fish landed by Canadian Atlantic fishermen yearly, since 1870, and the respective yearly values thereof. Presented 16th January, 1911.—*Mr. Jameson.. .. ..Not printed.*

85. Return to an order of the House of Commons, dated 7th December, 1910, for a copy of all letters, telegrams, correspondence, resolutions, memorials, reports, and all other papers in the possession of the government, not already brought down, regarding otter, beaver, or steam trawling, and the operations of the trawlers *Wren* and *Coquette* in the waters of the Northumberland strait, or elsewhere, in Nova Scotia. Presented 16th January, 1911.—*Mr. Chisholm (Antigonish).. .. ..Not printed.*

86. Return to an order of the House of Commons, dated 7th December, 1910, for a return showing the revenue of the post offices of Acton Vale, Upton and St. Pie, in the county of Bagot, province of Quebec, since the year 1903 up to 1910 inclusively. Presented 17th January, 1911.—*Mr. Monk.. .. ..Not printed*

86*a*. Return to an order of the House of Commons, dated 16th January, 1911, for a copy of all instructions or communications from the Department of Public Works or any officer thereof, or the minister of public works. to the chief architect, or any other architect, with respect to the preparation of plans for the construction of a post office building at Parrsboro, Nova Scotia, and all other post office buildings or public buildings to be used wholly or in part by the Post Office Department, for which votes have been passed during the period from 1st January, 1908, to 31st December, 1910. Presented 20th April, 1911.—*Mr. Rhodes.. .. ..Not printed.*

87. Return to an address of the Senate dated 22nd April, 1910, for:—

1. Copies of all orders in council or of every order of the Department of Justice and of the Department of Public Works, and of all the correspondence exchanged between the government, the Departments of Justice and Public Works, the Bank of Montreal, the firm of Carrier & Lainé, of Lévis, and all other persons, on the subjects of—

(*a*) The acquisition by the government of the property of the firm of Carrier & Lainé, at the time of the sale thereof by the sheriff in 1908;

(*b*) the subsequent expropriation, for purposes of public utility, of the same property, which had fallen into the hands of the bank of Montreal;

(*c*) its definite purchase from the Bank of Montreal by the government;

(*d*) the appointment of an agent to represent the government at the sale by the sheriff;

(*e*) the appointment of experts for proceeding with the expropriation of the lands in question;

2. Copies of all reports submitted, directly or indirectly, to the government, or in its possession, by the experts hereinbefore mentioned, or by the arbitrators to whom the Bank of Montreal and the firm of Carrier & Lainé had submitted their differences, or by the various advocates or agents acting in the name and in the interests of the government.

3. Copies of the various contracts entered into between La Banque du Peuple and the People's Bank of Halifax in 1905, between the government and the bank of Montreal, in 1909, between the government and Mr. Ernest Cann, who had become the

CONTENTS OF VOLUME 23—*Continued.*

lessee of the government, for a period of thirty years, of the lands and buildings formerly the property of Carrier & Lainé.

4. Copies of all documents whatsoever and of a correspondence relating to the various transactions aforesaid, and also a statement showing all the sums of money paid by the government with respect to such transactions, with the names of the persons to whom such sums were paid, and the amounts paid to each of them, and for what particular object. Presented 11th January, 1911.—*Hon. Mr. Landry-*

Not printed.

87a. Supplementary return to an address of the Senate dated 22nd April, 1910, for:—

1. Copies of all orders in council or of every order of the department of justice and of the department of public works, and of all the correspondence exchanged between the government, the department of justice and public works, the bank of Montreal, the firm of Carrier & Lainé, of Lévis, and all other persons, on the subject of—

(*a*) The acquisition by the government of the property of the firm of Carrier & Lainé, at the time of the sale thereof by the sheriff in 1908;

(*b*) the subsequent expropriation, for purposes of public utility, of the same property, which had fallen into the hands of the Bank of Montreal;

(*c*) its definite purchase from the bank of Montreal by the government;

(*d*) the appointment of an agent to represent the government at the sale by the sheriff;

(*e*) the appointment of experts for proceeding with the expropriation of the lands in question;

2. Copies of all reports submitted, directly or indirectly, to the government, or in its possession, by the experts hereinbefore mentioned, or by the arbitrators to whom the bank of Montreal and the firm of Carrier & Lainé had submitted their differences, or by the various advocates or agents acting in the name and in the interests of the government.

3. Copies of the various contracts entered into between La Banque du Peuple, and the People's Bank of Halifax in 1905, between the government and the bank of Montreal, in 1909, between the government and Mr. Ernest Cann, who had become the lessees of the government, for a period of thirty years, of the lands and buildings formerly the property of Carrier & Lainé.

4. Copies of all documents whatsoever and of all correspondence relating to the various transactions aforesaid, and also a statement showing all the sums of money paid by the government with respect to such transactions, with the names of the persons to whom such sums were paid, and the amounts paid to each of them, and for what particular object. Presented 18th January, 1911.—*Hon. Mr. Landry.*

Not printed.

87b. Further supplementary return to an address of the Senate dated 22nd April, 1910, for

1. Copies of all orders in council or of every order of the Department of Justice and of the Department of Public Works, and of all the correspondence exchanged between the government, the Departments of Justice and Public Works, the Bank of Montreal, the firm of Carrier & Lainé, of Lévis, and all other persons, on the subjects of—

(*a*) The acquisition by the government of the property of the firm of Carrier & Lainé, at the time of the sale thereof by the sheriff in 1908;

(*b*) the subsequent expropriation, for purposes of public utility, of the same property, which had fallen into the hands of the bank of Montreal;

(*c*) its definite purchase from the Bank of Montreal by the government;

CONTENTS OF VOLUME 23—*Continued.*

(*d*) the appointment of an agent to represent the government at the sale by the sheriff;

(*e*) the appointment of experts for proceeding with the expropriation of the lands in question;

2. Copies of all reports submitted, directly or indirectly, to the government, or in its possession, by the experts hereinbefore mentioned, or by the arbitrators to whom the Bank of Montreal and the firm of Carrier & Lainé had submitted their differences, or by the various advocates or agents acting in the name and in the interests of the government.

3. Copies of the various contracts entered into between La Banque du Peuple and the People's Bank of Halifax in 1905, between the government and the Bank of Montreal in 1909, between the government and Mr. Ernest Cann, who had become the lessee of the government, for a period of thirty years, of the lands and buildings formerly the property of Carrier & Lainé.

4. Copies of all documents whatsoever and of all correspondence relating to the various transactions aforesaid, and also a statement showing all the sums of money paid by the government with respect to such transactions, with the names of the persons to whom such sums were paid, and the amounts paid to each of them, and for what particular object. Presented 27th January, 1911.—*Hon. Mr. Landry.*

Not printed.

87*c*. Supplementary return to an address of the Senate dated 22nd April, 1910, for copies:—

1. Copies of all orders in council or of every order of the Department of Justice and of the Department of Public Works; and of all the correspondence exchanged between the government, the Departments of Justice and Public Works, the Bank of Montreal, the firm of Carrier & Lainé, of Lévis, and all other persons, on the subjects of—

(*a*) The acquisition by the government of the property of the firm of Carrier & Lainé, at the time of the sale thereof by the sheriff in 1908;

(*b*) the subsequent expropriation, for purposes of public utility, of the same property, which had fallen into the hands of the bank of Montreal;

(*c*) its definite purchase from the Bank of Montreal by the government;

(*d*) the appointment of an agent to represent the government at the sale by the sheriff;

(*e*) the appointment of experts for proceeding with the expropriation of the lands in question;

2. Copies of all reports submitted, directly or indirectly, to the government, or in its possession, by the experts hereinbefore mentioned, or by the arbitrators to whom the Bank of Montreal and the firm of Carrier & Lainé had submitted their differences, or by the various advocates or agents acting in the name and in the interests of the government.

3. Copies of the various contracts entered into between La Banque du Peuple and the People's Bank of Halifax in 1905, between the government and the Bank of Montreal in 1909, between the government and Mr. Ernest Cann. who had become the lessee of the government, for a period of thirty years, of the lands and buildings formerly the property of Carrier & Lainé.

4. Copies of all documents whatsoever and of all correspondence relating to the various transactions aforesaid, and also a statement showing all the sums of money paid by the government with respect to such transactions, with the name of the persons to whom such sums were paid, and the amounts paid to each of them, and for what particular object. Presented 7th February, 1911.—*Hon. Mr. Landry.*

Not printed.

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Continued.*

CONTENTS OF VOLUME 23—*Concluded.*

CONTENTS OF VOLUME 24.

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

them, or any of their members, in reference to securing control by such provincial governments of the lands, timber, water powers, coal and other minerals, or any of the natural resources which exist within the respective boundaries of said provinces, other than school lands. Presented 20th February, 1911.—*Mr. Lake.. ..Not printed.*

107. Return to an order of the House of Commons, dated 23rd January, 1911, for a copy of all correspondence between the Minister of Justice and the Attorney General of Nova Scotia in respect to the proposed change in the constitution of the Admiralty Court for that province. Presented 30th January, 1911.—*Mr. McKenzie.. .. .. Not printed.*

108. Return to an address of the House of Commons, dated 5th December, 1910, for a copy of the proclamation of the Governor in Council naming a day for the coming into force of an Act intituled "An Act to amend the Railway Act, 1903," chapter 31 of the Statutes of Canada of 1904 as provided for by Section 2 of that Act. Presented 30th January, 1911.—*Mr. Lennox.. .. ..Not printed.*

109. Return to an address of the House of Commons, dated 11th January, 1911, for a statement giving a concise history of the negotiations in regard to reciprocal trade carried on since 1900 between the governments of Canada and of the Australian Commonwealth, together with a copy of official telegrams upon the same subject exchanged between the two governments, or between the official representatives thereof, since the Imperial Conference of 1907. Presented 31st January, 1911. —*Mr. Ames.. .. ..Not printed.*

109a. Tariff relations between the United States and the Dominion of Canada, 1911. Presented 1st February, 1911, by Hon. W. S. Fielding.. .. ..*Not printed.*

109b. Tariff relations between the United States and the Dominion of Canada, correspondence and statements, 1911. Presented 6th February, 1911, by Hon. W. S. Fielding.
Printed for both distribution and sessional papers.

109c. Return to an order of the House of Commons, dated 27th February, 1911, for a return showing respectively, the total trade, the imports, the exports for each year from 1846 to 1876, both inclusive, between the British North American possessions, except Newfoundland, and the United Kingdom, the United States of America and other countries respectively. Presented 14th March, 1911.—*Mr. Borden.. .. ..Not printed.*

110. Return to an order of the House of Commons, dated 16th January, 1911, for a copy of all correspondence between the Finance Department, or any of its officers ,or any members of the government, and any persons or corporotions with reference to the incorporation of the Farmer's Bank, or to circumstances in connection therewith. Presented 1st February, 1911.—*Hon. Mr. Foster.. .. ..Not printed.*

110a. Return to an order of the House of Commons, dated 23rd January, 1911, for a copy of all correspondence between the government or any member thereof, or any official of the Department of Finance, and any person or association, with reference to the conduct and affairs of the Farmer's Bank since the date of its organization. Presented 1st February, 1911.—*Hon. Mr. Foster.. .. ..Not printed.*

110b. Return to an order of the House of Commons, dated 23rd January, 1911, for a copy of the full report and finding of the curator of the Farmer's Bank, up to the time of his appointment as liquidator of the same by the shareholders for the requisition of which, authority is given to the Minister of Finance by Section 122 of the Bank Act. Presented 1st February, 1911.—*Hon. Mr. Foster.*
Printed for both distribution and sessional papers.

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

2. Of the French edition of the same.
3. Of the English edition of the Journals of the House of Commons.
4. Of the French edition of the same. Presented 14th February, 1911.—*Hon. Mr. Landry*.......... *Not printed.*

115*b*. Return to an order of the Senate dated 17th January, 1911, for a copy of a return showing, year by year, from 1900, up to the present day, the date of the publication and distribution to members of parliament:—
1. Of the English edition of the Jounrnals of the Senate.
2. Of the French edition of the same.
3. Of the English edition of the Journals of the House of Commons.
4. Of the French edition of the same. Presented 14th February, 1911.—*Hon. Mr Landry*.......... *Not printed.*

116. Return to an address of the Senate dated 17th January, 1911, for a statement of the number of applications for and number of divorces granted by the parliament of Canada from 1894 to 1910 inclusive. Presented 24th January, 1911.—*Hon. Mr. McSweeny*.......... *Not printed.*

117. Return to an address of the Senate dated 22nd April, 1910, showing the expenses incurred, and the date of each of the payments made by the government for the electric installation in each of the rooms of the immigration officer at Quebec during the years 1908 and 1909. Presented 31st January, 1911.—*Hon. Mr. Landry.* 1911.—*Mr. Lennox*.......... *Not printed.*

118. Return to an order of the House of Commons, dated 16th January, 1911, for a return showing what amount the government paid Mr. F. H. Chrysler, K.C., for professional services between May, 1896, and 31st March, 1909, and what amount during the financial year ending 31st March, 1910; what amount since 31st March, 1910; what amount is now due by the government to Mr. Chrysler; and in what transactions or cases Mr. Chrysler is now engaged in for the government. Presented 6th February. 1911.—*Mr. Blain*.......... *Not printed.*

119. Return to an order of the House of Commons, dated 25th January, 1911, for a statement showing:—

1. How much wheat was exported from Canada for the crop years ending 31st August, 1908, 1909 and 1910.

2. How much wheat was exported from Canada through United States ports during 1908, 1909 and 1910, naming said ports, and amount exported from each port.

3. How many terminal grain elevators are there at Port Arthur and Fort William, and what is the name of each.

4. How much grain was shipped through each elevator at Port Arthur and Fort William during each year 1908, 1909 and 1910, and what are the names of the elevators respectively.

5. How much wheat was exported from Canada during each crop year 1908, 1909 and 1910, not passing through the terminal elevators at Port Arthur and Fort William.

6. How many men are employed by the government in connection with the terminal elevators at Port Arthur and Fort William, and what is the total salary paid the men per year Presented 7th February, 1911.—*Mr. Schaffner.*
Printed for sessional papers.

120. Return to an order of the House of Commons, dated 18th January, 1911, for a return showing how many appointments have been made by the government from the con-

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

125. Return to an order of the Senate dated 18th January, 1911, showing:—

1. In 1884, did a federal statute (47 Vict., ch. 78) confirm the legal existence of the Quebec Bridge Company?

2. In 1901, did not another federal statute (1 Edward VII, ch. 81), give birth to a company known as "The Quebec Terminal and Railway Company"?

3. In 1903, after having been, for two years, completely distinct from one another, did not the two above-mentioned companies amalgamate, constituting a new company, to which a federal statute (3 Edward VII, ch. 177) gave the name of "The Quebec Bridge and Railway Company"?

4. Was it not during the same year 1903, that were signed between the Quebec Bridge and Railway Company, the agreements which gave to the government the power to substitute itself to the bridge company and to complete at a certain date the colossal enterprise of the construction of a bridge over the St. Lawrence near Quebec?

5. Was not this substitution of the government to a private company confirmed by federal legislation in 1908 at the time of the adoption by parliament of chapter 59 of 7-8 Edward VII?

6. Under the said legislation, has the government passed an order in council enacting that it take hold of the whole of the undertaking, assets, properties and concessions of the said Quebec Bridge and Railway Company?

7. When was this order in council passed?

8. What composes the whole of the undertaking, assets, properties and concessions of the said company mentioned in the laws?

9. Has any part of the said whole of the undertaking, assets, properties and concessions of the company been transferred to the Grand Trunk Pacific Railway Company, or to the National Transcontinental Commission?

10. What was the part so transferred?

11. Does it comprise the bridge or some of the railway lines from the bridge and ending at the city of Quebec or at some place on the line of the Canadian Pacific railway, on the north, and of the Grand Trunk railway on the south of the river?

12. Are not the construction of the bridge and of the railway lines from the bridge, north and south of the St. Lawrence river, under the exclusive jurisdiction of the government who have kept the entire control thereof? Presented 14th February, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

125a. Return to an address of the Senate dated 22nd February, 1911, for a copy of the order in council, dated 17th August, 1908, authorizing the transfer to the government of the Quebec bridge, and of all the assets, franchises and privileges then the property of the Quebec Bridge and Railway Company. Presented 8th March, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

126. Return to an order of the House of Commons, dated 7th December, 1910, for a copy of all papers, reports, valuations, plans, documents, contracts, advertisements, tenders, offers, and letters, relating to the sale and disposition of the property purchased by the government for a barracks site at Toronto, and recently sold by the government, generally known as the Baby Farm or property; and more particularly, all correspondence, valuations or opinions as to the value of the said property, and as to the method of disposal thereof; and also a copy of advertisements, number of insertions, and names of papers in which same appeared, in the possession of the Department of Militia, or any other department of the government. Presented 10th February, 1911.—*Mr. Macdonell*.. .. ..*Not printed.*

CONTENTS OF VOLUME 24—*Continued.*

127. Return to an order of the Senate dated 17th January, 1911, for a return showing, in as many distinct columns:—

1. The names of all departments obliged by law to lay before parliament reports of their annual operations.

2. The date fixed by law for the laying of the said reports before parliament.

3. The date on which the said reports have been laid for the fiscal year ending 31st March, 1910, stating whether it was the English or the French edition which was so laid.

4. The date of the publication and distribution of the French edition of the said reports.

5. The title of the reports which, up to the 15th January, 1911, nine months and a half, after the fiscal year ending the 31st March, 1910, have not yet been published in French.

6. The titles of the reports which, up to the 15th January, 1911, twenty-one months and a half after the fiscal year ending the 31st March, 1909, have not yet been published in French. Presented 16th February, 1911.—*Hon. Mr. Landry.. ..Not printed.*

128. Return to an order of the House of Commons, dated 26th January, 1911, for a return showing the date of incorporation, a copy of the Act of incorporation, and any subsequent amendments thereto, all petitions, correspondence, applications and other papers or data asking for or relating to the grant of subsidy thereto, a copy of all contracts for construction, the subsidies granted and the several payments of the same, the dates of payment and the persons to whom cheques were issued therefor, a copy of engineer's reports and certificates on which payment was authorized in each case, the number of miles completed, the number now being operated, the number of miles still to be finished, the total cost to date and the estimated cost of completion, and the present condition of the road, in the case of the Atlantic, Quebec and Western Railway Company, the Quebec and Oriental R. R. Company and the new Canadian company. Also the shareholders, directors and officers of each of these companies, the capital subscribed and paid up by each subscriber, the amounts paid out each year to directors and officers as fees and salaries, the amount paid for promotion or other expenses, in detail, for each of the above companies. In the case of any mileage operated, the yearly revenues and working expenses. Presented 17th February, 1911.—*Hon. Mr. Foster.. .. ..Not printed.*

128a. Supplementary return to an order of the House of Commons, dated 23rd January, 1911, for a return showing the date of incorporation, a copy of the Act of incorporation, and any subsequent amendments thereto, all petitions, correspondence, applications and other papers for data asking for or relating to the grant of subsidy thereto, a copy of all contracts for construction, the subsidies granted and the several payments of the same, the dates of payment and the persons to whom cheques were issued therefor, a copy of engineer's reports and certificates on which payment was authorized in each case, the number of miles completed, the number now being operated, the number of miles still to be finished, the total cost to date and the estimated cost of completion, and the present condition of the road, in the case of the Atlantic, Quebec and Western Railway Company, the Quebec and Oriental R. R. Company and the new Canadian company. Also the shareholders, directors and officers of each of these companies, the capital subscribed and paid up by each subscriber, the amounts paid out each year to directors and officers as fees and salaries, the amount paid for promotion or other expenses, in detail, for each of the above expenses. In the case of any mileage operated, the yearly revenues and working expenses. Presented 17th March, 1911.—*Hon. Mr. Foster.. .. ..Not printed.*

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

or their officers, in connection with the Quebec bridge. Presented 20th April, 1911.—*Mr. Ames*.. .. ..*Not printed.*

137d. Return to an order of the Senate dated 24th November, 1910, calling for a copy of all correspondence between the government, some of its members or employees, and the engineers oppointed to prepare the plans of the new bridge to replace the one which collapsed at Quebec in the year 1907. Presented 20th April, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

138. Report of the Ottawa Improvement Commission for the fiscal year ending 31st March, 1910, &c. Presented 21st February, 1911, by Hon. W. S. Fielding. .. .. ..*Not printed.*

139. Fourth Joint Report of the Commissioners for the demarcation of the meridian of the 141st degree of west longitude (Alaskan boundary) appointed in virtue of the first article of the convention between Great Britain and the United States, signed at Washington on the 21st April, 1906. Presented 21st February, 1911, by Rt. Hon. Sir Wilfrid Laurier.. .. ..*Printed for sessional papers.*

140. A return to an address of the Senate dated 20th January, 1911, calling for copies of all orders in council and ordinances, and of all correspondence exchanged between the parties interested in the subject:—

1. Of the lease, before 1896, to Mr. Georges Tanguay of a military property belonging to the government and situated on des Ramparts street at Quebec.

2. Of the requests made by other persons at that time, to purchase or lease the property in question.

3. Of the sale of the same property to the same Georges Tanguay. agreed to by the present government about 1897. Presented 21st February, 1911.—*Hon. Mr. Landry.* *Not printed.*

141. Return to an order of the House of Commons, dated 7th December, 1910, for a statement showing the disposition made by the government during the past year of the following:—public lands, timber limits, mineral areas, water-powers and fishing rights. Presented 22nd February, 1911.—*Mr. Sharpe (Lisgar)*.. .. .. ..*Not printed.*

141a. Supplementary return to an order of the House of Commons, dated 7th December, 1910, for a statement showing the disposition made by the government during the past year of the following:—public lands, timber limits, mineral areas, water-powers and fishing rights. Presented 19th May. 1911.—*Mr. Sharpe (Lisgar)*.. ..*Not printed.*

142. Return to an order of the House of Commons, dated 11th January, 1911, for a return showing the concessions granted to Canada by British countries, the products of which may be imposed into Canada under the preferential tariff. Presented 23rd February, 1911.—*Mr. Ames*.. .. ..*Not printed.*

143. Order in council, correspondence, &c., in respect to a resolution of the Legislative Assembly of the province of Saskatchewan, declaring it desirable that the parliament of Canada should create out of the public domain within the province, a suitable land grant for the University of Saskatchewan. Presented 23rd February, 1911, by Rt. Hon. Sir Wilfrid Laurier.. .. ..*Not printed.*

144. Return to an order of the House of Commons, dated 23rd January, 1911, for a return showing:—1. All grants, leases, licenses, and concessions given to individuals or corporations of water power rights or privileges on the Winnipeg river at present in force. 2. The names and descriptions of such power sites. 3. The terms and conditions upon which they are respectively held. 4. The dates upon which these powers

CONTENTS OF VOLUME 24—*Continued.*

CONTENTS OF VOLUME 24—*Continued.*

152a. Supplementary return to an order of the House of Commons, dated 6th February, 1911. for a copy of the curators' reports in the cases of all banks for which curators have been appointed. Presented 2nd May, 1911.—*Hon. Mr. Foster.. .. ..Not printed.*

153. Return to an order of the House of Commons, dated 23rd January, 1911, for a copy of the by-laws, rules and regulations of the Canadian Bankers' Association as approved by the Treasury Board and now in effect. Presented 27th February, 1911.—*Hon. Mr. Foster.. .. ..Printed for sessional papers*

154. Return to an order of the House of Commons, dated 30th January, 1911, for a return showing the total amount of money that has been expended on the Seybold building for alterations and repairs, or in installation of elevators, heating apparatus or other fixtures, by the government during the term of the present lease, and also under the former lease, when used for census purposes.

2. The particulars of expenditures and to whom were the several amounts paid. Presented 6th March, 1911.—*Mr. Goodeve.. .. ..Not printed.*

155. Return to an order of the House of Commons, dated 20th February, 1911, for a copy of all applications made by employees of the North Atlantic collieries for a conciliation board within the past six months, and of all letters, telegrams, documents, statements and other papers and documents touching the same, or having any relation thereto, including all correspondence received by the government or any department of the government from the said North Atlantic collieries or from the employees thereof touching the matter aforesaid. Presented 27th February, 1911.—*Mr. Maddin. Not printed.*

156. Return to an order of the House of Commons, dated 2nd February, 1911, for a return showing the amount of money paid for provisions, supplies, repairs, work or any other service for the year ending 31st March, 1910, to the following firms in the city of Kingston, respectively: Eliott Brothers, McKelvey & Birch, C. Livingstone & Bros., R. Crawford, James Redden & Co., R. Carson, and James Crawford. Presented 27th February, 1911.—*Mr. Edwards.. .. ..Not printed.*

157. Orders in council, correspondence, &c., touching any proposal or Bill to erect dams, or other similar works across the River St. Lawrence, or part of the said river, at or near the Long Sault, or in the vicinity thereof. Presented 27th February, 1911, by Rt. Hon. Sir Wilfrid Laurier.. .. ..*Printed for sessional papers.*

157a. Partial return to an address of the House of Commons, dated 8th February. 1911, for a copy of all correspondence, memoranda, reports, memorials, plans, orders in council treaties, conventions, agreements, documents and papers of every kind, touching any proposal or Bill to erect dams or other similar works across the River St. Lawrence, or part of the said river, at or near the Long Sault, or in the vicinity thereof; including all statutes of the state of New York and the United States of America relating thereto, and all Bills now before the Congress of the United States of America touching the same, and all the procedings upon all such Statutes and Bills. Presented 9th March. 1911.—*Mr. Borden.. .. ..Not printed.*

158. Return to an order of the House of Commons, dated 6th February, 1911, for a return giving the names of all persons receiving fishery bounties, and the amount received by each, at each of the following ports:—Bauline, Little Lorraine, Main-á-Dieu and Scaterie, in the county of Cape Breton, Nova Scotia. Presented 28th February, 1911. —*Mr. Maddin.. .. ..Not printed.*

CONTENTS OF VOLUME 24—*Continued.*

158*a*. Return to an order of the House of Commons, dated 16th April, 1911, for a return showing the names of all persons in the province of New Brunswick who have received fishing bounties during the year ending 31st March, 1911, with the amount received by each. Presented 2nd May, 1911.—*Mr. Daniel*.. .. ..*Not printed.*

159. Return to an order of the House of Commons, dated 20th January, 1911, for a copy of all reports, correspondence, and documents, not already brought down, including report of survey made in 1909 of the harbour of Cape John and Tatamagouche Bay, in the counties of Pictou and Colchester, in the province of Nova Scotia, relating to the route of the winter steamers between Prince Edward Island and the mainland of Canada, and suggesting or recommending a change or changes on such route, and an increase in the number of trips daily of such winter steamers; also a copy of all similar papers, not already brought down, relating to the route of the summer mail steamers between Charlottetown and the mainland of Canada, and suggesting a change in that route and an increase in the number of trips daily; and also with regard to connecting such suggested route with a point on the Intercolonial railway. Also for a copy of all similar papers, if any, relating to or suggesting the route between Cape Traverse in Prince Edward Island and Cape Tormentine in the mainland, as a route for the winter and summer steamers. Also for a copy of all reports, papers and correspondence relating to additional or improved aids to navigation of the harbour of Charlottetown and entrance thereto and in Tatamagouche bay and harbour. Presented 6th March, 1911.—*Mr. Warburton*.. .. .. ..*Not printed.*

160. Return to an address of the House of Commons, dated 20th February, 1911, for a copy of all correspondence, recommendations, orders in council, or other documents relating to the case of R. E. Curran, a railway mail clerk, who was fatally injured in an accident at Owen Sound, on the 29th May, 1908, and with regard to which application was made for a compassionate grant or allowance to his heirs or family. Presented 7th March, 1911.—*Mr. Macdonell*.. .. ..*Not printed.*

161. Return to an address of the House of Commons, dated 27th February, 1911, for a copy of all orders in council, reports, correspondence, documents and papers touching the dismissal of the sub-collector of customs at Mahone bay, Nova Scotia. Presented 13th March, 1911.—*Mr. Taylor (Leeds)*.. .. ..*Not printed.*

162. Return to an order of the House of Commons, dated 20th February, 1911, for a return showing:—1. The nature of the subsidy which has been granted to the Vancouver Dry Dock Company.

2. The nature of payment of interest or of a guarantee of such subsidy. Presented 13th March, 1911.—*Mr. Barnard*.. .. ..*Not printed.*

163. Return to an order of the House of Commons, dated 6th March, 1911, for a copy of all papers, reports of appraiser, letters and correspondence relating to the appraising and passing the customs of the vessel *Wanda*, owned by one William R. Travers, Toronto, on the 20th October, 1909. Presented 14th March, 1911.—*Mr. Sharpe (Ontario)*.. .. ..*Not printed.*

164. Statement of the affairs of the British Canadian Loan and Investment Company (Limited) for the year ended 31st December, 1910.

Also, a list of the shareholders on 31st December, 1910, in accordance with chapter 57 of 39 Victoria. Presented (Senate) 14th March, 1911, by the Hon. the Speaker. *Not printed.*

CONTENTS OF VOLUME 24—*Continued.*

165. Return to an order of the House of Commons, dated 27th February, 1911, for a return showing:—

1. How many fisheries officers have been appointed in connection with the Ontario fisheries service within the last year?

2. What are their names, their rank, and the limits territorially of the jurisdiction of each?

3. What is the salary of each, and what is the length of time or duration of such appointments?

4. Do the duties of these officers in any, and in what cases duplicate the services if similar officers appointed by the Ontario legislature?

5. Has anything been done, and what, to prevent the duplication of this service?

6. What is the total revenue derived during the years 1909 and 1910 from fisheries for the province of Ontario, and what was the total expenditure?

7. What will be the total expenditure for the year 1911?

8. Is any, and what, system followed in making appointments to this service as to efficiency. Presented 17th March, 1911.—*Mr. Porter*.. .. ..*Not printed.*

165*a*. Return to an order of the House of Commons, dated 16th February, 1911, for a return showing how many wardens for the protection of fisheries were appointed in Victoria county, N.S., between July and December in the years 1906, 1907, 1909 and 1910.

2. Their names, length of service and amount paid to each. Presented 24th March, 1911.—*Mr. Maddin*.. .. ..*Not printed.*

166. Return to an order of the House of Commons, dated 23rd January, 1911, for a copy of all correspondence between the Post Office Department and any of the officials or other persons, relative to making an allowance for the transportation of letter carriers on the tramway system in New Westminster. Presented 17th March, 1911.—*Mr. Taylor (New Westminster)*.. .. ..*Not printed.*

167. Return to an address of the Senate dated 23rd February, 1911, for a copy of all the documents relating to the case of cholera reported in November last as to the Russian Said Godlieb, to the quarantining of this person, and to his detention until this date on Grosse Isle, with a history of the case, day by day, up to this date. Presented 16th March, 1911.—*Hon. Mr. Landry*.. .. .. *Not printed.*

168. Return to an address of the Senate dated 17th January, 1911, for a statement of the number of divorces granted by the parliament of Canada since 1891 to 1910 inclusive, together with the number of divorces granted by each of the courts of Nova Scotia, New Brunswick, Prince Edward Island, and British Columbia; also the population of each of those provinces according to census of 1901; and the aggregate population of Ontario, Quebec, Manitoba, and the Northwest Territories according to census in 1901. Presented 16th March, 1911.—*Hon. Mr. Power*.. .. ..*Not printed.*

169. Return to an order of the Senate dated 17th February, 1911, for a return showing the correspondence exchanged, the report made by the captain and the log kept by him relating to the trip just made by the steamer *Montcalm* in the lower St. Lawrence, the island of Anticosti and to the Baie des Sept Isles, &c. Presented 16th March, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed*

170. Return to an address of the Senate dated 10th March, 1911, calling for a statement showing:—

1. Who are among the judges of the Superior Court of the province of Quebec, those whose place of residence is fixed by the commission appointing them, and what is, for each of these judges, the place so fixed.

CONTENTS OF VOLUME 24—*Continued.*

2. Who are the judges whose place of residence has been fixed or changed by order in council, and what is for each of these judges, the place of residence now fixed.

3. Who are the judges whose place of residence has never been fixed, neither in the commission nor by any subsequent order in council. and what is the judiciary district to which they were appointed. Presented 21st March, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

171. Return to an order of the House of Commons, dated 30th January, 1911, for a copy of all advertisements, letters, contracts, complaints, reports of inspectors and other correspondence regarding mail routes Trout creek to Loring and Powassan to Nipissing or Restoule. Presented 24th March, 1911.—*Mr. Arthurs*.. .. ..*Not printed*

173. Return to an order of the House of Commons, dated 27th February, 1911, for a return showing what ministers of the Crown were abroad in 1908, 1909 and 1910, on public business and on what business; what expenses were incurred by each while engaged on public business; what persons, if any, accompanied each minister on public business whose expenses were paid by the government, and the amount of such persons expenses. Presented 24th March, 1911.—*Mr. Sharpe (Ontario)*.. .. .. ..*Not printed*

173. Return to a order of the House of Commons, dated 27th February, 1911, for a return showing the value, respectively, of the following products of the country, by provinces, during the years 1909 and 1910, agricultural products of all kinds, including field products of every kind, fruit, vegetables, live stock, &c., dairy products, &c.; timber of all kinds; minerals of all kinds; fish of all kinds; and manufactured goods of all kinds. Presented 24th March, 1911.—*Mr. Macdonell*.. .. ..*Not printed.*

174. Report of the Manitoba Fisheries Commission, 1910-11. Presented 24th March, 1911, by Hon. L. P. Brodeur... .. ..*Not printed.*

175. Return to an order of the House of Commons, dated 14th December, 1910, for a return showing what amount has been paid by the government during the last fiscal year for cab hire and street railway fares in the city of Ottawa for the following persons, with the names and the amounts in each case: ministers of the Crown; speaker of the Senate and House of Commons; civil servants of all grades from deputy ministers down; all other persons employed in any government work or other service. Presented 27th March, 1911.—*Mr. Taylor (Leeds)*.. .. ..*Not printed.*

175*a*. Return to an order of the House of Commons, dated 14th December, 1910, for a return showing what amount has been paid by the government during the last fiscal year for travelling expenses with the names and the expenditure in each case, under the following heads, viz.: railway, steamship, and other lines of transportation; private cars; Pullman cars; tips to waiters; meals and hotel expenses; for the following persons: Ministers of the Crown; civil servants of all grades; immigration agents; and other persons employed by the government on any special or other work. Presented 20th April, 1911.—*Mr. Taylor (Leeds)*.. .. ..*Not printed.*

175*b*. Supplementary return to an order of the House of Commons, dated 14th December, 1910, for a return showing what amount has been paid by the government during the last fiscal year for travelling expenses with the names and the expenditure in each case, under the following heads, viz.: railway, steamship, and other lines of transportation; private cars; Pullman cars; tips to waiters; meals and hotel expenses, for the following persons: Ministers of the Crown; civil servants of all grades; immigration agents; and other persons employed by the government on any special or other york. Presented 20th July, 1911.—*Mr. Taylor (Leeds)*.. .. ..*Not printed.*

CONTENTS OF VOLUME 24—*Continued.*

176. Papers referring to the organization of a Secretariat, as follows:—1. Despatch to the governors of the self-governing colonies relative to the reorganization of the Colonial Office.

2. Note on a visit to Australia, New Zealand and Fiji in 1909, by Sir Charles Lucas, K.C.M.G., C.B., assistant under secretary of state for the Colonies.

3. Report of the Dominions Department of the Colonial Office for the year 1909-1910.

4. Imperial Copyright Conference, 1910, memorandum of the proceedings.

5. Further correspondence relating to the Imperial Conference.

6. Correspondence relating to th Imprial Confrence, 1911. Presented, 28th March, 1911, by Rt. Hon. Sir Wilfrid Laurier.. .. ..*Not printed.*

177. Return to an order of the House of Commons, dated 20th February, 1911, for a copy of the application by or on behalf of the Glace Bay Bait Association, Glace Bay, N.S., for moneys in connection with the cold storage building for the storage of bait, at Glace Bay, N.S.; also a copy of all correspondence between the said association or anyone on its behalf and the government, any department of the government, or anyone on behalf of the government or any of its departments. Presented 28th March, 1911.—*Mr. Maddin*.. .. ..*Not printed.*

177a. Return to on order of the House of Commons, dated 3rd April, 1911, for a copy of all the correspondence in connection with the building of bait freezers at Louisburg and Lingan in the riding of South Cape Breton. Presented 20th April, 1911.—*Mr. Mackenzie*.. .. ..*Not printed.*

178. Return to an address of the Senate dated 8th March, 1911, that an order of the Senate do issue for the production of a copy of the complaint made by the commandant of the 61st Regiment against the commandant of the 7th Military District, of the reply of the latter and of all correspondence on the subject between the authorities at Ottawa and those at Quebec and Montreal, together with a copy of the report of the Inspector General respecting the case. Presented 28th March, 1911.—*Hon. Mr. Landry*.. .. ..*Not printed.*

179. Return to an order of the House of Commons, dated 16th March, 1911, for a return showing the average prices of butter and of eggs in London, England, for the past five years in comparison with the prices, respectively, in eastern provinces, in Montreal, in Toronto, in Minneapolis, in Chicago, in Detroit, in Buffalo, in Boston and in New York. Presented 30th March, 1911.—*Mr. Sharpe (Ontario)*.. .. .. ..*Not printed.*

179a. Return to an order of the House of Commons, dated 23rd March, 1911, for a return showing the quantity and value of butter, eggs, poultry, chilled or frozen meat, bacon, lard, apples, vegetables, wheat, barley, cattle, horses and potatoes imported into Canada during the six months ending 1st March, 1911, the countries from which the same were imported and the duty collected thereon. Presented 6th April, 1911.—*Mr. Middlebro*.. .. ..*Not printed.*

179b. Supplementary return to an order of the House of Commons, dated 23rd March, 1911, for a return showing the quantity and value of butter, eggs, poultry, chilled or frozen meat, bacon, lard, apples, vegetables, wheat, barley, cattle, horses and potatoes imported into Canada during the six months ending 1st March, 1911, the countries from which the same were imported and the duty collected thereon. Presented 8th May, 1911.—*Mr. Middlebro*.. .. ..*Not printed.*

180. Return to an order of the House of Commons, dated 14th December, 1910, for a return showing the total payments made by the government to the Eclipse Manufacturing

CONTENTS OF VOLUME 23—*Continued.*

Company, Limited, for year 1909-10, and how these contracts were let; the total payments made by the government to the Office Specialty Manufacturing Company, Limited, for year 1909-10, and how these contracts were let; the total payments made by the government to Messrs. Ahearn & Soper for year 1909-10, and how these contracts were let. Presented 3rd April, 1911.—*Mr. Sharpe (Lisgar)*.. .. ..*Not printed.*

181. Return to an order of the Senate dated 22nd February, 1911, for a copy of all orders in council and of all orders issued by the Minister of the Interior giving, from time to time, to the commissioner for the Northwest Territories, since his appointment as such, the instructions which he is to follow in the exercise of his executive in so far as concerns the government of the Northwest Territories. Presented 4th April, 1911. *Hon. Mr. Landry*.. .. ..*Not printed.*

182. Return to an order of the Senate dated 16th March, 1911, calling for a copy of all correspondence relating to the stranding in August, 1910, of the ship *Manchester Engineer* near the Strait of Belle Isle, and of the investigation held with reference thereto at Quebec during the month of September or October last. Presented 4th April, 1911. —*Hon. Mr. Landry*.. .. ..*Not printed.*

183. Return to an order of the House of Commons, dated 15th February, 1911, for a return showing all communications, telegrams, letters, petitions or plans relating to the rifle range at Bear River, N.S., received since January, 1909.

2. From whom received and upon what dates respectively? Presented 5th April, 1911. —*Mr. Jameson*.. .. ..*Not printed.*

184. Return to an order of the House of Commons, dated 14th December, 1910, for a return showing what total amount has been annually expended in each province since 1880 by the Department of Public Works for harbours and rivers, together with the annual totals of said expenditure for the whole of Canada; also that the Department of Public Works prepare and lay upon the Table of this House with this Return a map for each province, showing the location of all wharves, piers, breakwaters, &c., constructed or purchased by the federal government, and presently owned by the Dominion of Canada. Presented 6th April, 1911.—*Mr. Ames*.. .. ..*Not printed.*

185. Return to an order of the Senate dated 22nd February, 1911, for:—

1. Copies of all papers relating to the appointment of Martin Dickie to the command of the 76th Regiment of the counties of Colchester and Hants.

2. Copies of all papers relating to the recommendation of Major J. L. Barnhill by Lieut. General Drury and others to the command of the said regiment.

3. Copies of all documents relating in any way to the reasons or causes why the said Major Barnhill as the senior officer of said regiment should not have been appointed to the command of the same.

4. Copies of all correspondence and other popers and documents relating to the recent reorganization of the 78th Colchester, Hants and Pictou Regiment of "Highlanders." Presented 4th April, 1911.—*Hon. Mr. Lougheed*.. .. ..*Not printed.*

186. Return to an order of the House of Commons, dated 27th March, 1911, for a return showing the mileage of railways owned, controlled or operated in the United States by the Grand Trunk, the Canadian Pacific and other Canadian railway companies.

2. Also the mileage of railways owned, controlled or operated by the United States railway corporations in Canada. Presented 10th April, 1911. *Mr. Rutan.* *Not printed.*

187. Return to an order of the House of Commons, dated 3rd April, 1911, for a copy of all correspondence, declarations, telegrams, mailing lists, and other documents relating

CONTENTS OF VOLUME 24—*Continued.*

to an application asking for the granting of statutory postal privileges to a newspaper published at New Glasgow, Nova Scotia, called the Guysborough *Times*. Presented 10th April, 1911.—*Mr. Sinclair*.. .. ..*Not printed.*

188. Return to an order of the House of Commons, dated 23rd January, 1911, for a copy of all memorials, reports, correspondence and documents in the possession of the government, not already brought down, relating to a survey of a route for a tunnel under the Straits of Northumberland between the province of Prince Edward Island and the mainland of Canada, and also relating to the construction of such tunnel. Presented 12th April, 1911.—*Mr. Richards*.. .. ..*Not printed.*

189. Return to an order of the House of Commons, dated 27th February, 1911, for a copy of all enactments, regulations, documents, papers and information of every kind setting forth or showing the systems or method by which the census is taken in the United Kingdom, the British Dominions and foreign countries, respectively; and showing in what respect, if any, the principle, system or method adopted in the United Kingdom, the British Dominions, and foreign countries differs from that proposed for the approaching census in Canada. Presented 12th April, 1911.—*Mr. Borden*.. .. ..*Not printed.*

189*a*. Forms of schedules, &c., in connection with the census to be taken during the year 1911. Presented 21st April, 1911, by Hon. S. A. Fisher.. .. ..*Not printed.*

189*b*. Supplementary return to an order of the House of Commons, dated 27th February, 1911, for a copy of all enactments, regulations, documents, papers and information of every kind setting forth or showing the systems or method by which the census is taken in the United Kingdom, the British Dominions and foreign countries, respectively; and showing in what respect, if any, the principle, system or method adopted in the United Kingdom, the British Dominions, and foreign countries differs from that proposed for the approaching census in Canada. Presented 10th May, 1911.—*Mr. Borden*.. .. ..*Not printed.*

190. Return to an order of the House of Commons, dated 6th February, 1911, for a return showing:—1. How many employees were connected with the Printing Bureau in 1896?

2. The names of those employees connected with the Printing Bureau who were dismissed between 1896 and 1911, and the date of dismissal and the cause in each case?

3. The names of those employees, who resigned or died between the years 1896 and 1911, and the date of resignation or death in each case.

4. The names of those who have been appointed to positions in connection with the Printing Bureau between 1896 and 1911, and the date of appointment in each case. Presented 12th April, 1911.—*Mr. Edwards*.. .. ..*Not printed.*

191. Return to an address of the Senate dated 17th January, 1911, for the production of a copy of the agreements concluded between the government and the former proprietor of the Stadacona farm at St. Félix du Cap Rouge, with reference to the purchase of the said farm, and of operating the same in the future as an experimental farm, and of all correspondence on these two matters. Presented 19th April, 1911.—*Hon. Mr. Landry* .. .. *Not printed.*

192. Return to an order of the House of Commons, dated 27th March, 1911, for a copy of all the correspondence, contracts, assignments and other documents with regard to what is called the Percy Aylwin irrigation grant, granted to him under order in council dated 1st September, 1908. Presented 8th May, 1911.—*Mr. Campbell*..*Not printed.*

CONTENTS OF VOLUME 24—*Continued.*

193. Return to an order of the House of Commons, dated 27th February, 1911, for a copy of all letters, papers, telegrams, documents, vouchers and pay sheets, showing the names of all persons who supplied materials or worked, and the prices and rates of wages, and sums paid to each, in connection with the construction of a wharf at Deep Brook, N.S. Presented 28th April, 1911.—*Mr. Jameson*.. .. .. ..*Not printed.*

194. Return to an address of the House of Commons, dated 10th April, 1911, for a copy of all papers, documents, memoranda and correspondence relating to the parliament site in the city of Winnipeg for the province of Manitoba, including the reservations made in the Crown grants to the Hudson's Bay Company, and the purpose for which the same were made, and also a copy of the Dominion order in council, dated the 23rd January, 1872, and all subsequent orders in council and correspondence dealing with the site for both provincial and Dominion purposes. Presented 1st May, 1911. —*Mr. Haggart (Winnipeg)*.. .. ..*Not printed.*

194*a*. Supplementary return to an address of the House of Commons, dated 10th April, 1911, for a copy of all papers, documents, memoranda and correspondence relating to the parliament site in the city of Winnipeg for the province of Manitoba, including the reservations made in the Crown grants to the Hudson's Bay Company, and the purpose for which the same were made, and also a copy of the Dominion order in council, dated the 23rd January, 1872, and all subsequent orders in council and correspondence dealing with the site for both provincial and Dominion purposes. Presented 20th July, 1911.—*Mr. Haggart (Winnipeg)*.. .. ..*Not printed.*

195. Return to an address of the House of Commons, dated 23rd January, 1911, for a copy of all orders in council, regulations and rules of the several departments of the government respecting the participation by employees of the government in civic or municipal affairs, and especially with regard to their disability from serving in civic or municipal councils; and all correspondence, documents and papers since the first day of January, 1900, touching the operation of the said orders in council, rules and regulations. Also a list of all employees of the government who have been elected to or have served in city or municipal councils during the said period from the first day of January, 1900. up to the present time, including all those now so serving and those who have been prevented by the government from serving. Presented 1st May, 1911.—*Mr. Borden*.. .. ..*Not printed.*

195*a*. Supplementary return to an address of the House of Commons, dated 23rd January, 1911, for a copy of all orders in council, regulations and rules of the several departments of the government respecting the participation by employees of the government in civic or municipal affairs, and especially with regard to their disability from serving in civic or municipal councils; and all correspondence, documents and papers since the first day of January, 1900, touching the operation of the said orders in council, rules and regulations. Also a list of all employees of the government who have been elected to or have served in city or municipal councils during the said period from the first day of January, 1900, up to the present time, including all those now so serving and those who have been prevented by the government from serving. Presented 3rd May, 1911.—*Mr. Borden*.. .. ..*Not printed.*

196. Return to an address to His Excellency the Governor General of the 3rd April, 1911 for a copy of all orders in council, memoranda, papers and documents, relating to the transfer, or any negotiations concerning the transfer, of a charter known as the Manitoba and South Eastern Railway Company. Presented 2nd May, 1911.—*Mr. McCarthy*.. .. ..*Not printed*

CONTENTS OF VOLUME 24—*Continued.*

197. General rule and order of the Exchequer Court of Canada in regard to seals. Presented 2nd May, 1911, by Hon. Charles Murphy.. .. ..*Not printed.*

198. Return to an order of the House of Commons, dated 18th January, 1911, for a return showing how many aliens there are in the service of the government of Canada who are residing out of Canada, their names, nationality, the nature of the service, term of service, residence, and salary.

2. The same information as to aliens now residing in Canada who have been in the service of the government of Canada for a period of three years or more, and the date and length of service.

3. The same information in regard to aliens in the service of the government of any province or provinces of Canada. Presented 9th May, 1911.—*Mr. Lennox.*
Not printed.

199. Return to an order of the House of Commons, dated 1st May, 1911, for a return giving the names of the gentlemen appointed as judges by the present government of Canada since they came into power in 1896, the residences of these gentlemen at the time of appointments, the positions to which they were respectively appointed, and in each case where the appointee had a predecessor in the position, the time which the position was vacant. Presented 11th May, 1911.—*Mr. Lennox*.. .. ..*Not printed.*

200. Return to an order of the House of Commons, dated 16th January, 1911, for a copy of all correspondence, telegrams, reports, contracts, papers and memorials in the possession of the government relating to the establishment of a fast Atlantic service between Canada and any other country; also with reference to an all red route, cable, or telegraph service, between Canada and any other country, within the past fifteen years. Presented 16th May, 1911.—*Mr. Armstrong*.. .. ..*Not printed*

201. Return to an order of the House of Commons, dated 18th May, 1911, for copies of any correspondence between the government of New Brunswick, or any member or members thereof, and the government of Canada, or any member thereof, with reference to changing the Subsidy Act, 1910, with respect to a subsidy for a line of railway from Grand Falls in the province of New Brunswick to the city of St. John in the same province. Presented 19th May, 1911.—*Mr. Carrell*.. .. ..*Not printed.*

202. Copy of report of Board of Conciliation and Investigation in the matter of the Western Coal Operators' Association and its employees. Presented 19th July, 1911, by Hon. W. L. Mackenzie King.. .. ..*Not printed.*

203. Return to an order of the House of Commons, dated 23rd January, 1911, for a return—

1. Showing in tons the east-bound and the west-bound traffic on the Intercolonial railway for the five years ending 30th June, 1910.

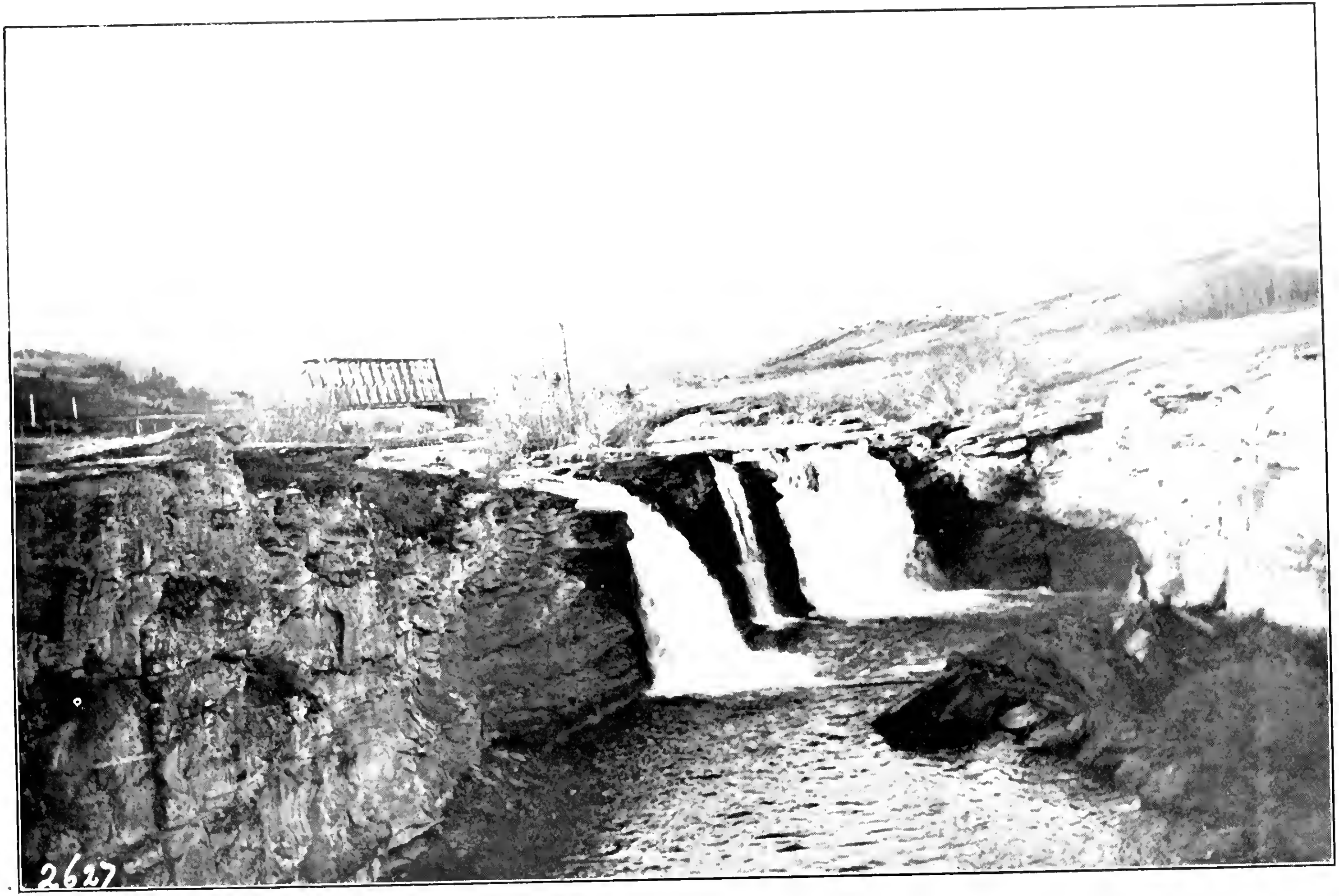
2. The miles of main trunk line and branches of the Intercolonial railway in each province through which it passes, distinguishing the trunk line from the branches.

3. Showing in tons the west-bound traffic originating in each of the maritime provinces during the period of five years ending 30th June, 1910. Presented 18th July, 1911.—*Mr. Sinclair*.. .. ..*Not printed.*

204. Return to an order of the House of Commons, dated 13th March, 1911, for a copy of all correspondence, telegrams, &c., during the past twelve months between Mr. E. J. Walsh, C.E., and the Minister of Department of Railways and Canals in regard to the Newmarket Canal. Presented 18th July, 1911.—*Mr. Wallace* .. .. ..*Not printed*

CONTENTS OF VOLUME 24—*Concluded.*

Frontispiece.



Falls on Crowness River near Lundbreck, Alta.

DEPARTMENT OF THE INTERIOR

DOMINION OF CANADA.

REPORT

OF

PROGRESS OF STREAM MEASUREMENTS

FOR

THE CALENDAR YEAR 1910

BY

P. M. SAUDER, C. E.

PRINTED BY ORDER OF PARLIAMENT

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY.
1912

[No. 25*d*—1912.]

CONTENTS

ILLUSTRATIONS

To His Excellency, the Right Honourable Sir Albert Henry George, Earl Grey, G.C.M.G., &c.,
Governor-General of Canada.

MAY IT PLEASE YOUR EXCELLENCY.

The undersigned has the honour to lay before your Excellency the report of the progress of Stream Measurements for the year 1910.

Respectfully submitted,

FRANK OLIVER,
Minister of the Interior.

OTTAWA, July 4, 1911.

DEPARTMENT OF THE INTERIOR,
OTTAWA, July 3, 1911.

The Honourable FRANK OLIVER,
Minister of the Interior.

SIR:—

I have the honour to submit the report of Stream Measurements for the year 1910, and to recommend that it be published as the second of a series of progress reports.

I have the honour to be, Sir,
Your obedient servant,

W. W. CORY,
Deputy of the Minister of the Interior.

FORESTRY AND IRRIGATION BRANCH,
Department of the Interior,
OTTAWA, June 30, 1911.

W. W. CORY, ESQ., C.M.G.,
Deputy Minister of the Interior.

SIR:—

I beg to submit herewith the progress report of Stream Measurements for the year 1910, submitted by Mr. P. M. Sauder, C.E., and would recommend that it be published, and that a sufficient number of copies be printed to permit of its being widely distributed among those interested in the question of the water supply of Western Canada.

Respectfully submitted,

R. H. CAMPBELL,
Superintendent of Forestry and Irrigation.

DEPARTMENT OF THE INTERIOR,
IRRIGATION OFFICE,

CALGARY, ALTA., June 4th, 1911.

SIR,—

I transmit herewith the manuscript of the Report of Progress of Stream Measurements for the Calendar Year, 1910.

In this report is given a brief outline of the methods of obtaining and compiling the data contained therein, but owing to the want of space and time many of the details had to be omitted. It gives in a tabulated form the records of stream flow during 1910, and all discharge measurements made by the irrigation surveys which were not published in the Report of Progress of Stream Measurements for the Calendar Year 1909.

I request that this manuscript be published as the second of a series of Reports of Progress of Stream Measurements.

Respectfully submitted,

P. M. SAUDER,
Chief Hydrographer.

R. H. CAMPBELL, ESQ.,
Superintendent of Forestry and Irrigation,
Department of the Interior,
OTTAWA.

REPORT

ON THE

PROGRESS OF STREAM MEASUREMENTS FOR THE CALENDAR YEAR 1910.

By P. M. SAUDER.

INTRODUCTION.

ORGANIZATION AND SCOPE OF WORK.

Water is an all-essential resource upon which the habitability of our country depends, and the steady growth of population and the general development of science and industry have given rise to an increasing demand for it. In the arid and semi-arid regions, the limit of agricultural development is determined to a considerable extent by the amount of water available for irrigation, while in all parts of the country the increase in the population of cities and towns makes necessary, additional water supply for domestic and industrial uses. The notable advances made in electric transmission of power have led to the utilization of water powers for the operation of manufacturing establishments, railroads, and municipal lighting plants, many of which are some distance from the places at which the power is developed.

The usefulness of the hydrographic work is legion, but among the most important information obtained are the following:

(1.) General information relating to and governing the flow of surface waters.
(2.) The magnitude of floods and the minimum flow of streams.
(3.) The formation and profile of river beds.
(4.) The effect of very dry or very wet seasons on the country's water supply.

This information is obtained by a series of observations at regular gauging stations which are established at various points. The selection of sites for these gauging stations and their maintenance depend largely on the physical features and needs of the locality. If water is to be used for irrigation purposes the summer flow receives special attention; where it is required for power purposes, it becomes necessary to determine the minimum flow; if water is to be stored, information is obtained regarding the maximum flow. In all cases the duration of the different stages of the streams is noted. Throughout the country gauging stations are maintained for general statistical purposes, to show the conditions existing through long periods. They are also used as primary stations, and their records in connection with short series of measurements will serve as bases for estimating the flow at other points in the drainage basin.

As the result of an increased appropriation this work was greatly extended during the past year. Considerable reconnaissance work was done, and a number of new gauging stations were established. In the spring of 1910, field operations were commenced with 68 regular stations, and at present the regimen of flow is being studied at 98 regular stations distributed along the various streams in Southern Alberta and Saskatchewan.

The methods of carrying on the survey were similar to those of the previous year. Local residents were engaged to observe the gauge height at regular gauging stations. These observations were recorded in a book supplied by the survey and at the end of each week the observer copied the week's records on a postal card which was sent to the Chief Hydrographer by the first convenient mail. The district hydrographers made regular visits to the gauging stations usually once in every three or four weeks. They examined the observers' records, and collected such information as would be of use in making estimates of the daily flow at the station. The results of the gaugings were transmitted to the Chief Hydrographer by a postal card. The reports of the gauge height observers and the hydrographers were copied from the postal cards to regular forms in the office of the survey and filed. At the close of the season, the engineers returned to the office and made the final computations and estimates of discharge and run-off. Gauge height-area, gauge height-mean velocity, and gauge height-discharge curves were plotted, and tables of mean daily gauge height, daily discharge, and monthly discharge were then compiled. These are embodied in this report.

The organization in 1910, was very similar to that of the previous year. The territory covered by the survey was very much increased during the year, and the staff was therfore increased to include eight assistant engineers, a clerk and a draftsman. The irrigation tract was divided for administrative purposes, into five districts; viz: Calgary, Macleod, Milk River, Maple Creek, and Moose Jaw, and in each district there was one or two hydrographers. Each hydrographer had at least one assistant and was equipped with a team, light waggon, light camping outfit, and the necessary gauging and surveying instruments.

CALGARY DISTRICT.

J. C. Keith, a graduate of the School of Practical Science, who had previous experience with the survey as an assistant was placed in charge of the field work in this district. He commenced his duties about the 5th of May.

The district was fairly well reconnoitered in 1909 but the proposed regular stations had not all been established. Regular gaugings were therefore made at these stations which were already established and new stations were added from time to time during the season, as opportunity afforded itself.

Records were obtained at the following regular stations during 1910:—

Bow River at Banff.
Bow River at Calgary.
Bow River near Namaka.
C. P. R. Co. Canal near Calgary.
Elbow River at Calgary.
Fish Creek near Priddis.
Highwood River at High River.
Jumpingpound Creek near Jumping Pound P.O.
Mosquito Creek near Nanton.
Nanton Creek near Nanton.
North Branch of Sheep River at Millarville.
South Branch of Sheep River near Black Diamond.
Sheep River near Okotoks.

The following gauging stations were established during 1910, and records were obtained at them from the time they were established until the end of October:—

Bow River near Laggan.
Bow River near Morley.
Devils Creek near Bankhead.
Little Bow Ditch at High River.
Red Deer River near Innisfail.
Spray River near Banff.

At the end of September Mr. Keith was granted leave of absence for five months to return to the School of Practical Science to take a post graduate course in Hydraulics and Theory of Construction. Mr. Carscallen was therfore placed in charge of the field work in this district on the first of October.

Early in November when additional funds were provided it was arranged to continue field work in this district during the winter and records of the flow were obtained from that date to the end of the year at the following regular stations:—

Bow River near Laggan.
Bow River at Banff.
Bow River near Morley.
Bow River at Calgary.
Devils Creek near Bankhead.
Elbow River at Calgary.
Spray River near Banff.

A large number of miscellaneous measurements of the discharge of tributaries of Bow River and other streams in this district were also made during the year, and will be valuable as general information.

I was assisted in the final computations and report for this district by H. R. Carscallen and H. C. Ritchie.

Records of the flow of Bow River are of very great importance. A study of the flow of this stream indicates that the whole of the normal flow has already been granted for irrigation purposes, and any future development must be based on the storage of high water and flood flow. Already this river is being harnessed for power and as industries increase and a large market is created, there will be more power development. For this purpose records of minimum flow are essential. Minimum flow occurs during the winter season, and the records obtained during the past winter are very valuable. The flow was however somewhat less than anticipated and it is very important that further studies be made. The regimen of flow in Bow River at Calgary varies from 700 sec. ft. in midwinter to an estimated 60,000 sec. ft. at extreme flood stages. There are a number of feasible storage sites in the mountains which can be utilized to augment the winter flow sufficiently to keep up a continuous flow several hundred sec. ft. higher than the natural minimum flow. Bow River is by far the most important stream in the irrigation tract and a comprehensive study of the hydrography of this stream and its tributaries is of direct value in the commercial and agricultural development of the country. I am also of the opinion that one engineer should spend all his time on the main stream and its immediate tributaries.

I would also suggest that the Calgary district be extended to include Red Deer River and its tributaries and that two hydrographers be placed in this district at an early date. As soon as time and funds permit regular stations should also be established on branches of Highwood River and included in the district.

MACLEOD DISTRICT.

H. C. Ritchie, graduate of the School of Practical Science, was in charge of the field work in this district in 1909 and again in 1910. The district has been fairly well reconnoitered by both Mr. Ritchie and myself and gauging stations have been established at almost all the important points. Oldman River and its tributaries are very important and several additional gauging stations were established on these streams during the past year.

Records were obtained at the following regular stations during 1910:—

Belly River near Stand Off.
Connelly Creek near Lundbrek.
Cow Creek at Ross' Ranche.
Crooked Creek near Waterton Mills.
Crowsnest River near Lundbrek.
Mami Creek at Mountain View.
Muddypound Creek near Cowley.
Pincher Creek at Pincher Creek.
Southfork River near Cowley.
Todd Creek at Cecil Elton's Ranche.
Trout Creek at Stevenson's Farm.
Waterton River at Waterton Mills.
Willow Creek near Macleod.

The following gauging stations were established during 1910, and records were obtained at them from the time they were established until the end of October.

Canyon Creek near Mountain Mill.
Crowsnest River near Frank.
Crowsnest River near Coleman.
Mill Creek near Mountain Mill.
Oldman River near Macleod.

A large number of miscellaneous measurements which will be very valuable as general information were also made by Mr. Ritchie during the year.

About the first of December when additional funds were provided it was arranged to carry on field work in this district during the winter. W. H. Greene was placed in charge of the field work in this district during December, January and February. During the month of March Mr. Greene was employed in reconnaissance work on North Saskatchewan River and J. E. Degnan was in charge of the field work in the Macleod district during the month of March.

Winter records were obtained at the following regular stations:—

Crowsnest River near Frank.
Crowsnest River near Lundbrek.
Oldman River near Cowley.
Southfork River near Cowley.
St. Mary River at Kimball.
Waterton River at Waterton Mills.
Belly River near Stand Off.

I was assisted in the final computations and report of the work in this district by H. .C Ritchie and Jos. Cawthorn.

Mr. Ritchie did not use a camp at all last summer, and many of the gauging stations can be reached by train. It is proposed to include the stations on Belly and Waterton Rivers in the Western Milk River District in future. The engineer in charge of the Macleod district can then travel by train and hire liveries by the day. His monthly expenses will be a little higher than formerly but he will accomplish a great deal more work and the actual cost of the individual gaugings will be less.

It is very important that winter observations should be continued in this district.

MILK RIVER DISTRICT.

F. H. Peters, C.E., D.L.S., who was engaged on special investigations on Milk and St. Mary Rivers, also had charge of the hydrographic work on these two rivers and their tributaries. In 1909, Mr. Peters and the writer reconnoitred most of the district and established almost all the gauging stations necessary to obtain complete records of the flow of these two streams. Therefore, only a few new stations were established during 1910, but very complete records of the flow at the regular stations were obtained.

One engineer could not cover the whole of this district and it was therefore divided, and two engineers were employed on hydrographic work. L. J. Gleeson, B.Sc., was in charge of the field work in the western portion of the district and N. M. Sutherland, graduate of the Royal Military College, was in charge of the field work in the eastern portion of the district.

Records were obtained at the following regular stations during 1910:—

Lee Creek at Cardston.
Lodge Creek at Willow Creek Police Detachment.
North Branch of Milk River at Peter's Ranche.
North Branch of Milk River at Knight's Ranche.
North Branch of Milk River at Mackie's Ranche.
Milk River at Milk River.
Milk River at Writing-on-Stone Police Detachment.
Milk River at Pendant d'Oreille Police Detachment.
Milk River at Spencer's Lower Ranche.
South Branch of Milk River at Mackie's Ranche.
St. Mary River at Kimball.
Sage Creek at Wild Horse Police Detachment.

The following gauging stations were established during 1910, and records were obtained at these from the time they were established until the end of October:—

A. R. & I. Canal near Kimball.
Battle Creek at Nash's Ranche.
Frenchman River at Huff's Ranche.

A large number of miscellaneous discharge measurements were also made during 1910, which will be valuable as general information.

The work in the western end of this district is not very heavy and it is therefore being arranged to have the engineer in this portion of the district include Belly and Waterton Rivers in his route, so as to make a more equal division of the territory, and relieve the engineer in the Macleod district of a long drive from Macleod.

CYPRESS HILLS DISTRICT.

A large irrigation development in the Cypress Hills has caused urgent need for very complete records of the flow of the streams in this district. In 1909 H. R. Carscallen, B.A.Sc., was in charge of the field work in this district and established a large number of regular gauging stations. In the spring of 1910 it was realized that one engineer could not cover the whole of this district and it was therefore divided by a north and south line into two districts. The eastern district was fairly well reconnoitered by Mr. Carscallen in 1909, and almost all the necessary gauging stations were established during that year. There was, however, considerable reconnaissance work to be done in the Western district and only a few regular stations had been established. Mr. Carscallen was, therefore, placed in charge of the field work in the Western portion of the district, and R. G. Swan, B.A.Sc., was engaged to take charge of the field work in the Eastern portion of the district. Mr. Carscallen commenced field work about the 1st of April and Mr. Swan about the 10th of May.

Records were obtained at the following regular stations during 1910:—

Battle Creek at Tenmile Police Detachment.
Bear Creek near Unsworth's Ranche.
East Branch of Bear Creek at Johnson's Ranche.
West Branch of Bear Creek at Bertram's Ranche.
Belanger Creek at Garrison's Ranche.
Blacktail Creek at Garrisere's Ranche.
Bone Creek at Lewis Ranche.
Bridge Creek near Skull Creek.

Bullshead Creek near Dunmore Junction.
Davis Creek at Drury's Ranche.
Enright and Strong's Ditch near East End.
Fairwell Creek at Bolton's Ranche.
Frenchman River near East End.
Gap Creek at Small's Ranche.
Hay Creek at Fauquier's Ranche.
Jones Coulee at Read's Ranche.
Lonepine Creek at Hewitt's Ranche.
Maple Creek at Maple Creek.
Middle Creek at Ross' Ranche.
Mackay Creek at Walsh.
McShane Creek at Small's Ranche.
Oxarart Creek at Wylie's Ranche.
Piapot Creek at Cumberland's Ranche.
North Branch of Frenchman River at Cross' Ranche.
Ross Creek at Irvine.
Sixmile Coulee at Soderstrom's Ranche.
Skull Creek near Skull Creek P.O.
Sucker Creek at Whitecomb and Zeigler's Ranche.
Swift-Current Creek at Pollock's Ranche.
Tenmile Creek at Tenmile Police Detachment.

The following gauging stations were established during 1910, and records were obtained for part of the year:—

Battle Creek at Wilson's Ranche.
Boxelder Creek near Walsh.
Gap Creek near Maple Creek.
Lindner's Ditch near Battle Creek P.O.
Manyberries Creek at Hooper and Huckvale's Ranche.
Maple Creek near Maple Creek.
Middle Creek at Hammond's Ranche.
Middle Creek at McKinnon's Ranche.
Sevenpersons River at Medicine Hat.
Swift-Current Creek at Sinclair's Ranche (upper station).
Swift-Current Creek at Sinclair's Ranche (lower station).
Swift-Current Creek at Swift Current.

A large number of miscellaneous measurements were also made for purposes of general information.

About the latter part of September, owing to Mr. Keith leaving temporarily, and for purposes of economy. Mr. Carscallen was placed in charge of the Calgary District and Mr. Swan took charge of the field work in the whole of the Cypress Hills District.

Mr. Swan resigned about the end of November and I was assisted in the final computations and estimates of daily discharge by Messrs. H. R. Carscallen and G. H. Whyte.

There is still a portion of this district which is not covered by the survey. A reconnaissance of the country surrounding Old Fort Walsh and including the heads of Battle, Lodge, Mackay, Ross, and Bullshead Creeks will be made during the present year.

MOOSEJAW DISTRICT.

For some time it has been realized that as the country becomes more thickly populated and the towns spring up there are portions of the West which will not have a sufficient water supply for domestic and industrial purposes.

The Council and Board of Trade of Moosejaw for 1909, were among the first to realize that while there is a sufficient water supply in the district, it is allowed to run off into the larger rivers, in the freshets, and the district is left with an inadequate supply during the remainder of the year. They petitioned the Government to investigate and report on the resources of the Moosejaw Creek and the best methods for the development of same.

This work was undertaken early in the spring of 1910, and a survey party was organized, with Chas. M. Teasdale, D.L.S., in charge, to make a hydrographic and topographic survey of Moosejaw Creek. About the first of May Mr. Teasdale resigned. Mr. W. H. Greene, a graduate of the S.P.S., was then placed in charge of the field party and M. H. French was engaged as assistant.

Two gauging stations were established on the creek; one at a bridge on the N.W. ¼ Sec. 16, Tp. 16, Rge. 26 W. 2 M; and the other at a bridge on the road allowance between Secs. 14 and 15, Tp. 15, Rge. 25, W. 2nd Mer. Daily records were obtained at these stations, and the total annual run-off computed. A careful stadia survey was made of the valley from Moosejaw to a point a few miles above Rouleau, and a map showing the configuration of the surface of the ground by contours of 10 foot intervals, was prepared. While the topographic survey was in progress, a careful reconnaissance was made to discover the most inviting places for the locations of dams and reservoirs. Cross-sections were taken at four dam sites offering the best opportunities for storage. The contour map shows the lands which would be flooded by the erection of a dam of any feasible height, and tables showing the flooded areas and capacities of the reservoirs were also prepared. A report of this survey is given under the heading of Moosejaw Creek Drainage Basin.

The water supply in the vicinity of Regina, Moosejaw, and along the Soo Line of the Canadian Pacific Railway is limited and it is very important that we should continue a study of the regimen of flow of Moosejaw Creek for several years. This district will be extended during the coming year to include Souris, Qu'Appelle, and South Saskatchewan Rivers. Souris River, which heads in Canada, crosses the International boundary into the United States and then re-crosses into Canada and finally empties into Assiniboine River east of Brandon. This river traverses a large territory in Canada and is the only stream in that district. It is proposed to divert it for irrigation purposes, in North Dakota, which may affect Canadian interests.

OFFICE WORK.

As above intimated the reports of the gauge height observers and the hydrographers were transmitted to the Chief Hydrographer by postal cards.

These were entered on office forms and filed in a suitable cabinet where they can be referred to at any time without any trouble. As the engineers completed their computations, the results were entered on convenient forms and filed in the same cabinet.

The accounts of the survey were kept in a combined day book and journal, approved by the Accountant of the Department. Statements of expenditures were prepared and sent to the Superintendent of Forestry and Irrigation at the end of each month.

Miss G. E. Corrigan acted as clerk in the office during 1910. Besides typing and filing the correspondence, she entered and filed the cards, posted the day-book and ledger and prepared the monthly statements.

When it was decided to continue two engineers in the field during the winter, it was found that the remaining staff of engineers could not complete the maps, curves and office computations before spring. Mr. Joseph Cawthorn was therefore engaged as draftsman. Since joining the staff, he has prepared the maps, and assisted in plotting curves, checking computations, and copying the records for the Annual Report of the Survey.

There has been a slight tendency in the past to make a very big showing in the field work and to overlook the importance of the office work. Sufficient staff should be provided to thoroughly check all the reports and field books as they are received. I, therefore, strongly recommend that the office staff be increased to include a computer. The Chief Hydrographer could then keep a much better check on the work of his assistants and when the engineers return to the office their field notes would be ready to be plotted and the data for the report could be compiled in much better shape and at an earlier date.

FUTURE WORK.

A number of applications have been received for water rights on streams in the vicinity of Wood Mountain and the lower part of Frenchman River. Very little information is available regarding the water supply or the possibility of irrigation in this district. There do not appear to be any permanent or large streams in the district but there are indications of considerable run-off at certain seasons of the year, and of possibilities of storing water for irrigation purposes. An engineer will be placed in the field as soon as possible to study and report on the water supply in this district

During the month of March, Mr. Greene made miscellaneous discharge measurements of the North and South Saskatchewan Rivers, and arrangements are being made now to establish regular stations on these streams as soon as possible. These are large and important streams, for they carry almost all the run-off of Southern Alberta and Saskatchewan. Records on them will be very useful, locally, for power studies, and generally for statistical purposes, to show the conditions existing over large areas. They may also be used as primary stations, and their records in connection with short series of measurements will serve as bases for estimating the flow at other points in the drainage basin.

The records of the survey are being used quite extensively now by engineers and I think the time is near at hand when the field of operations should be extended to include other parts of the Dominion. I would like to make miscellaneous gaugings of some of the streams in Eastern Manitoba, such as Winnipeg, Whitemouth, and Red Rivers. The United States Geological Survey have established a gauging station on Rainy River at International Falls and have records covering the period from March 1st, 1907, to the present. This is an international stream and important for power purposes, and I would suggest that the Department consider the advisability of taking records of the flow of this stream. I would also suggest that we might do some work in the Railway Belt of British Columbia.

In all investigations of water resources the most important factor is the available supply. It is also the factor that requires the longest time to determine satisfactorily, owing to the great fluctuations in stream flow from year to year. The stream gaugings already undertaken should, therefore, be continued for a number of years in order that the records may be long enough to show extremes of flow as well as a reliable mean.

The low flow of 1910 has demonstrated the part that municipal water supply and sewage disposal have in the use of rivers and therefore data should be compiled to show the amount of such water supply and sewage and the source of the former (where in surface waters) and the disposal of the latter.

I do not think it necessary to elaborate on the importance of continuing observations during the winter on the more important streams. The minimum flow occurs during that season and should be determined for use in considering power schemes.

Next in importance to a knowledge of the available water supply is a knowledge of the fall of the streams, and the possibilities of storage. This is necessary to determine the value of the river for irrigation, water power, as an outlet for drainage ditches, and as an available channel for flood prevention work. River profile and Reservoir site surveys should therefore be commenced as soon as possible on the more important streams of the West.

DEFINITIONS.

The volume of water flowing in a stream is known as run-off or discharge. In expressing it various units are used, depending upon the kind of work for which the data are needed. Those used in this report are "Second-feet," "acre-feet," "run-off per square mile" and "run-off in depth in inches" and may be defined as follows:

"Second-foot," is an abbreviation for cubic foot per second and is the body of water flowing in a stream one foot wide and one foot deep at the rate of one foot per second.

The "acre-foot" is the unit capacity used in connection with storage for irrigation work, and is equivalent to 43,560 cubic feet. It is the quantity required to cover an acre to a depth of one foot.

The expression "second-feet per square mile" means the average number of cubic feet of water flowing each second from every square mile of drainage area on the assumption that the run-off is uniformly distributed.

"Depth in inches" means the depth of water in inches that would have covered the drainage area, uniformly distributed, if all the water could have accumulated on the surface. This quantity is used for comparing run-off with rain-fall, which quantity is usually given in depth in inches.

It should be noticed that "acre-feet and depth in inches" represent the actual quantities of water which are produced during the periods in question while "second-feet" on the contrary, is merely a rate of flow per second.

EXPLANATION AND USE OF TABLES.

The data obtained and the estimates made therefrom have been compiled in tabulated form and for each regular gauging station are given, as far as available, the following data:—

1. Description of station.
2. List of discharge measurements.
3. Daily gauge height and discharge table.
4. Table of monthly discharges and run-off.

The description of stations gives such general information about the locality and equipment as would enable the reader to find and use the station. It also gives, as far as possible, a complete history of all the changes that have occurred since the station was established and that might affect the records in any way.

The list of discharge measurements gives the results of all the discharge measurements that have been made at or in the vicinity of the gauging station or have been used in completing the records for the gauging station. It gives the date on which the measurement was made, the name of the hydrographer, the width and area of cross-section, the gauge height and the discharge in second feet.

The table of daily gauge heights and discharges given in this report is a combination of two tables kept in the office of the survey, namely the table of daily gauge heights and the station rating table. The table of daily gauge heights gives the daily fluctuations of the surface of the water above the zero of the gauge, as reported by the observer. During high water, two observations of the gauge were made at some stations and the gauge height given in the table is the mean of the observations for the day. The discharge measurements and gauge heights are the base data from which the other tables are computed. The table of the daily discharges is the discharge in second-feet, corresponding to the stage of the stream, as given by the station rating table.

In the table of monthly discharge the column headed "Maximum" gives the mean flow for the day when the mean gauge height was highest. As the gauge height is the mean for the day, there might have been short periods when the water and the corresponding discharge were greater than given in this column. Likewise, in the column "Minimum" the quantity given is the mean flow for the day when the mean gauge height was lowest. The column headed "Mean" is the average flow for each second during the month. The computations for the quantities in the remaining columns have been based upon this mean. The drainage area for each gauging station was marked off on the sectional maps of the Department and the area taken off with a planimeter. In many districts, information regarding topographical features is very incomplete and the computed areas are only approximate. As the surveys of the Department are extended and completed these computations will be checked and, if necessary, corrected.

CONVENIENT EQUIVALENTS.

The following is a list of convenient equivalents for use in hydraulic computations:—

1 second-foot equals 35.7 British Columbia miner's inches, or one British Columbia miner's inch equals 1.68 cubic feet per minute.
1 second-foot equals 6.23 British imperial gallons per second; equals 538,272 gallons for one day.
1 second-foot equals 7.48 United States gallons per second; equals 646,272 gallons for one day.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet; equals 724 acre-feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.
100 British Imperial gallons per min. equals 0.268 second-foot.
100 United States gallons per min. equals 0.223 second-foot.
1,000,000 British Imperial gallons per day equals 1.86 second-feet.
1,000,000 United States gallons per day equals 1.55 second-feet.
1,000,000 British Imperial gallons equals 3.68 acre-feet.
1,000,000 United States gallons equals 3.07 acre-feet.
1,000,000 cubic feet equals 22.95 acre-feet.
1 acre-foot equals 43,560 cubic feet.
1 acre-foot equals 271,472 British Imperial gallons.
1 acre-foot equals 325,850 United States gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 acre equals 43,560 square feet.
1 cubic foot equals 6.23 British Imperial gallons.
1 cubic foot equals 7.48 United States gallons.
1 cubic foot of water weighs 62.5 pounds.
1 foot per second equals 0.682 miles per hour.
1 horse power equals 550 foot pounds per second.
1 horse power equals 746 watts.
1 horse power equals 1 second-foot falling 8.80 feet.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horse power on water wheel, realizing 80 per cent of theoretical power.

METHODS OF MEASURING STREAM FLOW.

There are three distinct methods of determining the surface flow of streams: (1) By measurements of slope and cross-section and the use of Chezy's and Kutter's formulae; (2) by means of weirs, which include any device or structure that by measuring the depth on a crest or sill of known length and form, the flow of water may be determined; (3) by measuring the velocity of the current and the cross-section. The third method is the one most commonly used by this survey. The second is used when the flow is too small to be accurately determined by the third, while the first is only used in making estimates of the discharge of a stream when the only data available are the cross-section and slope.

SLOPE METHOD OF DETERMINING DISCHARGE.—The slope of a stream, or rather of a section of a stream, is the difference in elevation between the upper and lower ends of the section, commonly called the fall, divided by the distance or the length of the section. Slope sections vary in length from two or three hundred feet to several hundred feet, depending largely upon the nature of the stream.

It is difficult to ascertain accurately the slope of the water surface in a stream, since in nearly all streams there are pulsations in the water, causing the surface to rise and fall locally. In most streams the slope of the bottom is far from uniform, and the flow of water in any given section is more or less influenced by the flow in the adjacent section, above or below. For this reason it is a good plan to consider a number of adjacent sections, comprising a considerable length of the stream in one computation, being careful to take into account the diversity of cross-section at various places in the length.

In determining the slope of the surface of a stream, levels are taken of the water surface at each end of the slope section, and referred to some datum or bench mark. A good plan is to set firmly a stout wooden stake below the water surface at each end of the slope section, and then to drive a nail into the top of each stake, so that the nail-head will exactly coincide with the water surface. The difference in elevation between the two nail-heads, divided by the distance between the stakes, will give the slope.

The wetted perimeter is that portion of a stream channel that is in contact with the water. The form or outline of the wetted perimeter of a stream has an important influence upon the velocity of the current. It is usually determined graphically from the plotted cross-section or may be measured by means of a flexible tape or chain after the flood has subsided.

The hydraulic radius, which is sometimes called the mean radius of the channel below the water surface is found by dividing the area of the cross-section (in sq. ft.) by the length of the wetted perimeter (in feet).

The Chezy formula, which is the fundamental formula for stream discharge, is:

$$Q = A\ V$$

in which Q = the discharge of the stream in sec. ft.
A = the area of the cross-section in sq. ft.
V = the mean velocity of flow, in ft. per sec.

In applying this formula to the determination of stream discharge, the mean velocity of a stream s considered a function of the slope and of the wetted perimeter of the stream. This may be expressed by formula as follows:

$$V = C\sqrt{rs}$$

in which r = the hydraulic radius of the channel.
s = the surface slope.
and C is a variable coefficient, depending upon the nature of the channel.

In determining the value of C for any given case it is customary to make use of Kutter's formula, which is:—

$$C = \frac{41.6 + \frac{.00281}{s} + \frac{1.811}{n}}{1 + \left\{41.6 + \frac{.00281}{s}\right\}\frac{n}{\sqrt{r}}}$$

In this formula r and s have the same significance as in the Chezy formula and the new factor n is called the coefficient of roughness. It is a variable coefficient, and its value is dependent upon the size, shape, slope and degree of roughness of the channel. Tables of values of n are given in various text books, but it is difficult to choose the correct value. It is therefore advisable whenever possible to compute the value of n from a measured discharge. As the slope method of determining discharge is seldom employed except to estimate flood discharge, a current meter measurement is very often made at the slope section, during low water. Having determined the mean velocity, slope and hydraulic radius at the time of the metering, the value of C may be found from the formula $V = C\sqrt{rs}$ or $C = \frac{V}{\sqrt{rs}}$ Trautwine's Pocket Book for Civil Engineers and other texts contain tables giving the value of n for different values of r, s, and c. From these tables we can interpolate the proper value of n for a particular section of the stream, at low water stage. In most cases this value of n is applicable to high water and flood conditions of the stream also and is used with values of r and s for the high water or flood cross-section to determine the value of C at the higher stage. Having determined the value of C the computation of the discharge is simple.

The results obtained by the slope method are in general only roughly approximate, owing to the difficulty in obtaining accurate data and the uncertainty of the value of n to be used.

Weir Method of Determining Discharge.—As yet no permanent weirs have been constructed by this survey, and the only regular weir measurements have been on small streams by means of a temporary weir. The weir used consists of a wooden base of 2-inch plank, to which is bolted a rectangular notch of three-eighths inch steel with bevelled edges. (See photo.)

In making a measurement by means of a temporary weir, the following directions should be followed as far as possible. The weir should be placed perpendicular and at right angles to the bed of the stream with the crest level. The discharge should be free in so much as the nappe should have sufficient fall to allow air to have free circulation underneath it, and the head or depth on the crest should not exceed one-third of the length. The channel of approach should be several times as wide as the opening and the depth of water in the bay or pond should be at least twice the head on the weir, so as to eliminate velocity of approach and cross-currents. In choosing a site for a weir, a point should be chosen that will fulfil the above conditions and give a good sized bay or pond.

To set up a temporary weir, a dam of sods and earth are thrown across the stream, the weir set in place and the sods tramped firmly around it to stop all leakage. On a stream with a sandy bed sods or clay must be placed on the bottom for a few feet upstream to form a mattress to prevent the undermining of the dam.

After the bay has filled up the head of the water is observed by taking the difference in elevation of the crest of the weir and the elevation of the water surface in the bay at a distance of 4 to 10 feet from the weir, with an engineer's level. Two common methods of getting the elevation of the water surface are (1) hold the levelling rod on a stone or other solid body under water and subtract the depth of water on the rod from the sight on the rod; (2) drive a pin divided into tenths of feet into the bed of the stream so that an even tenth is level with the surface of the water, then hold the levelling rod on the top of the pin and add the length of pin above the water to the sight on the rod.

When the head of water has been determined, the discharge is computed by using one of the standard formulae which will suit the case. Tables giving the discharges for different heads and lengths of crests are published in many engineering texts.

The formula used by this survey for rectangular sharp-crested weirs is:

$Q = 3.33\ (L - .2H)\ H^{3/2}$ being a modification of Francis' formula, to allow for end contractions and elimination of velocity of approach.

in which Q = discharge in sec. ft.; L = length of crest in feet; H = head in feet.

Measurements by means of temporary weirs should be made some distance above or below the gauge. If they are made close to a gauge, the gauge must be read before the weir is placed in the stream and the pond must be allowed to run off after the weir is removed before the gauge is re-read.

Velocity Method of Determining Discharge.—There are two methods of determining the velocity of flow of a stream, namely, direct and indirect. In the direct method by which the velocity is determined by means of floats, the liability of error is large, and the results far from satisfactory. This method is seldom used except for very rough estimates or when a current meter cannot be used. There are three common kinds of floats, viz: surface, sub-surface and tube or rod floats. In each the procedure is the same. A straight piece of channel is selected for the run and two cross-sections taken at some convenient distance apart, usually from 100 to 200 feet. They are then divided into strips by means of a tagged wire. The velocity in each strip is then measured by noting the time taken by the float in traversing the run or distance between the two cross-sections. As the time and distance are both known the velocity can easily be computed. The velocity, whether measured by surface, sub-surface or tube floats, must be multiplied by a coefficient less than unity to reduce the mean velocity before being used to compute the discharge.

The indirect or current meter method is the most reliable and most widely used method of determining the velocity of the flow of a stream. The meter used by this survey is the Price Patent, manufactured by W. & L. E. Gurley, Troy, N.Y. It consists of six cups attached to a vertical shaft which revolves on a conical hardened steel point when immersed in moving water. The number of revolutions is indicated electrically. The rating or relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From this data a rating table is prepared which gives the velocity per second of moving water for any number of revolutions in a given time interval.

The accuracy of a discharge measurement taken at a velocity-area station is dependent on two factors, the accuracy with which the area of the cross-section and the mean velocity of the flow normal to that section are measured. There is no special difficulty in measuring the first factor, but the second, the velocity, is very difficult to measure accurately, because it is constantly changing. It varies not only from the surface to the bottom but from one bank of the stream to the other, making it necessary to measure it at a number of points.

In making a measurement with a current meter, a number of points, called measuring points, are measured off above and in the plane of the measuring section, at which observations of depth and velocity are taken. These points are spaced equally for those parts of the section where the flow is uniform and smooth, but should be spaced unequally for other parts according to the discretion and judgment of the engineer. In general, the points should not be spaced farther apart than 5 per cent. of the distance between piers, nor farther apart than the approximate mean depth of the section at the time of measurement.

The measuring points divide the total cross-section into elementary strips at each end of which observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the ends, the width of the strip, and the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream.

Methods of Determining Mean Velocity.

There are a number of different methods of determining the mean velocity at the ends of these strips, or, as it is commonly called, the mean velocity in a vertical, namely, multiple-point, single-point, and integration. These three principal multiple-point methods in general use are the vertical velocity-curve, three point, and two point method.

Vertical Velocity Curve Method of Determining Mean Velocity.—In this method the centre of the meter is held as close to the surface of the water as is possible, being careful to keep it out of reach of all surface disturbances, and then at a number of different depths throughout the vertical. The velocity at each position of the meter is recorded. These observations are then plotted with velocities in feet per second as abscissae and their corresponding depths in feet as ordinates and a mean curve is drawn through the points. The mean velocity for the vertical is obtained by dividing the area bounded by the curve and its axis by the depth. In the absence of a planimeter for measuring the area, the depth is divided into 5 to 10 equal parts, and the velocities of the centre ordinates of these parts are noted. The mean of these velocities will very closely approximate the mean in the vertical.

It is often more convenient, when the depth is a number of feet and a fraction, as 7.4, to divide the depth into 7 parts of a foot width, and a part of 0.4 foot width. Then the velocity to enter for the narrow part is 0.4 of the velocity at the centre of it.

The vertical velocity curve is useful in studying the manner in which velocities occur in a vertical. From a study of a number of these curves the other shorter methods of determining mean velocity are deduced. This method is not used in general routine measurements, except during the winter, on account of the length of time taken to complete a measurement, for a change of stage is almost sure to occur during a measurement on a large stream which counter balances the increased accuracy. For this reason its use is limited to the determination of the coefficient to be used in the reduction of values obtained by other methods of measuring velocity to the true value, to the measurement of velocities under new and unusual conditions of flow, and for measurements under ice.

Three-Point Method of Determining Mean Velocity.—This method gives the greatest accuracy outside of the vertical velocity curve and is the method most commonly used by this survey during the open season. The meter is held at 0.2, 0.6 and 0.8 depth. The mean velocity is then obtained by dividing by 4 the sum of the velocities at 0.2 and 0.8 depth plus twice the velocity at 0.6 depth. It is the best method to use during low water or in wide shallow streams having a rough bed where the thread of mean velocity varies considerably from the 0.6 depth.

Two-Point Method of Determining Mean Velocity.—In studying the vertical curves made at a number of different points and under varied conditions it has been found that the mean of the velocities occurring at 0.2 and 0.8 depth gives very nearly the mean velocity in the vertical. Use is made of this fact in the two-point method of determining mean velocity, the meter being held at 0.2 and 0.8 depth in the vertical. This method has been found more accurate than the single point method and the time required for a metering is not very much greater. This method has been found to give, also, a very close approximate to the mean velocity in measurements of ice-covered streams, although these flow under very different conditions from those of open water.

Single-Point Method of Determining Mean Velocity.—Experiments made under most favourable conditions and extending over a long period have established the point of mean velocity in a vertical at 0.6 of the depth. Therefore the error resulting from the use of the 0.6 depth as the depth of mean velocity is very small though in some few cases a study of the vertical velocity curve will show the need of a coefficient to reduce the observed velocities to the mean. The variation of the coefficient from unity in individual cases is, however, greater than the two or three point method and the general results are not as satisfactory. For that reason this method is not employed very extensively by the survey.

In the other principal single-point method the meter is held near the surface, at from 0.5 to 1 foot below the surface; care being taken to sink the instrument below the influence of wind or waves. The resulting velocities must be multiplied by a coefficient to reduce them to mean velocities. This coefficient as found by a large number of experiments, varies from 0.78 to 0.98, depending upon the depth and speed of the stream. The deeper the stream and the greater the velocity the larger the coefficient. In flood work coefficients varying from 0.90 to 0.95 should be used. This method in only used when the current is too strong to permit the sinking of the meter to any great depth below the surface of the water. It is often employed at times of flood, or when a stream is carrying a lot of drift wood or ice.

Integration Method of Determining Mean Velocity.—This method of determining the mean velocity in a vertical consists in moving the meter at a slow uniform speed from the bed of the stream to the surface and return in a vertical direction, the time and revolutions being observed. In travelling through all parts of the vertical the meter is acted upon by each and every thread of velocity from the bed to the surface of the stream, and the resulting observations determine the mean in that vertical.

This method is very useful in checking the results of other methods. It is, however, seldom used by this survey as the Price meter is not suited to observations by this method, since the vertical motion of the meter causes the wheel to revolve.

Gauging Stations.

The first step is to select a suitable locality for a gauging station. Although apparently simple, this is really a difficult task. Not only must the water be moving in nearly straight lines over a solid bed and between well defined banks, but the place must be accessible at moderate cost and there must be living near a competent person who can be engaged to serve as observer. Permanent gauging stations should only be selected after a very thorough reconnaissance. In the irrigation districts and in more thickly populated districts there is more or less diversion of water. This is apt to complicate matters for the hydrographer, or a gauging station above all works may not include all the tributaries of the stream and it is often necessary to establish gauging stations at several points along the streams, and on tributaries, canals and pipe lines, in order to obtain complete information regarding the water supply in a particular stream.

There are three classes of gauging stations, namely, wading, bridge and cable stations. The wading station can of course only be used in the case of small streams having a maximum depth at its highest stage of 3 feet or less. The equipment for a wading station is small, consisting usually of a plain staff gauge, graduated to feet and hundredths, and fixed vertically to one of the banks of the stream. For convenience a measuring line, usually a wire with tags, may be fixed permanently at this section. When taking the reading, the hydrographer should stand below and to one side of the meter so as to not cause eddies in the water.

Bridge stations because of their permanency and the freedom of movement allowed the hydrographer, are much preferred. Very often, however, more particularly in swift currents, the piers materially affect the accuracy of the results. When the gauge cannot be attached to a pier, it is often attached horizontally to the guard-rail or floor of the bridge and the height of the stream is found by lowering a weight by a chain over a pulley. It is indicated by a marker on the chain. Distances of three, five or ten feet according to the size of the stream are marked on the lower chord of the down stream side of the bridge, to serve as a measuring line.

Frequently it is impossible to establish a permanent gauging station at a bridge. In that case the wire cable of a ferry can be utilized, or, if that is not available, a permanent wire cable is stretched across the river. For spans of average length a galvanized wire cable three-fourths of an inch in diameter is safe. It is supported at each bank by means of high struts or by passing it through the crotch of a tree. The cable is run into the ground and anchored securely to a "dead man" buried at least six feet below the surface, or if convenient it is anchored to the lower part of the trunk of a tree. A turnbuckle is inserted in the cable between the strut and anchorage to permit tightening the cable when it begins to sag. A permanent measuring line, usually a wire, with tags 5 or 10 feet apart, is stretched across the stream just above the cable. A cage large enough to carry two men and instruments is constructed and suspended from the cable by means of cast iron pulleys. The cage is moved from point to point by hand. A stay line, usually quarter-inch guy wire, is stretched across the stream about thirty to forty feet upstream from the cable, and securely fastened. By passing a sash cord through a pulley hung on this stay line the current meter is prevented from being carried down stream.

Low Velocity Limitations.

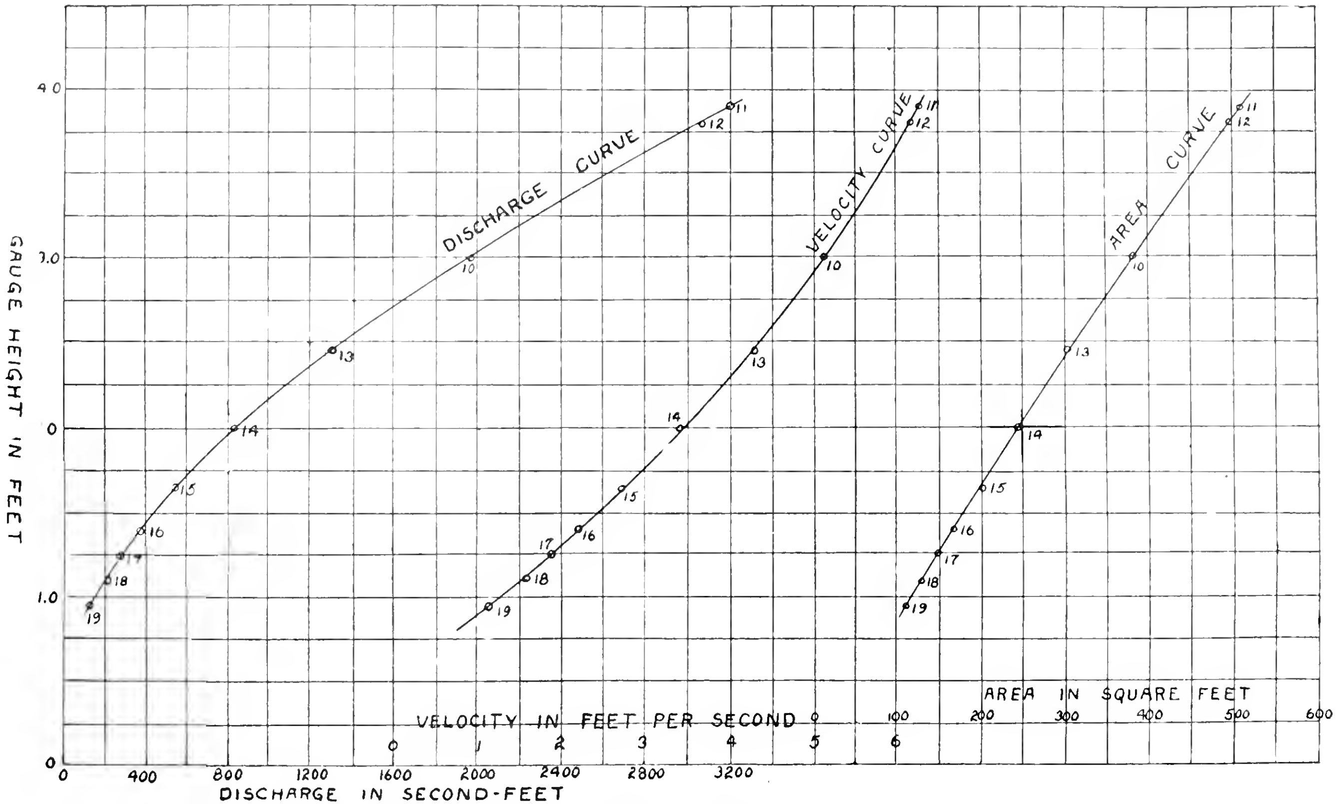
Owing to the presence of a slight amount of friction in the current meter, a certain definite velocity is required to make the wheel revolve, *i.e.*, to overcome the frictional resistance of the wheel. For this reason the meter is unsuitable for the measurement of low velocities, approaching this value. This velocity, which is required to overcome friction, and which is obtained from the meter rating curve, is called the velocity of no flow for the particular meter referred to. It varies in different types of meters, and also slightly in meters of the same type, according to the time the meter is in use, but very seldom exceeds 0.2 foot per second in any meter. From a number of observations the low velocity limit, below which values of velocity are unreliable, is found to be 0.5 foot per second. In many cases at low stages the gauging station on a stream becomes unsuitable for a discharge measurement owing to the mean velocity in the section falling below the safe limit. In such instances where it is possible to wade the stream a suitable gauging section may be located within a reasonable distance of the regular station and the discharge measurements made at this point. When a gauging is made at a cross-section other than the regular station, sufficient soundings should be made at the latter at the time of the gauging to develope the cross-section and compute the area. The measurement is thus referred to the regular gauging station and the mean velocity and area at the regular section is reported and used in the office computations.

Winter Measurements.

Previous to the season of 1910-11, no records were taken of the winter flow. During the past winter daily gauge height records were collected for a number of the more important streams in the Calgary and Macleod districts. Discharge measurements were made at these stations at intervals of from two to three weeks.

The laws governing the flow of stream in open channels have, through extensive investigations, become well defined, but the flow under an ice cover has been but little investigated. In winter as in summer the daily discharge of a stream is computed from frequent discharge measurements and daily gauge height observations. In most cases, however, the vertical velocity curve method is used for the determination of the mean velocity in the vertical, as the mean velocity varies considerably. In fact, there are usually two points in the vertical at which the thread of mean velocity occurs under an ice cover. These points are near 0.2 and 0.8 depths and two-point method will give fairly accurate results, but in this report all discharges are based on computations from vertical velocity curves.

Plate No. 2.



DISCHARGE, AREA, AND MEAN-VELOCITY CURVES OF BELLY RIVER AT STAND OFF, ALTA., FOR 1909.

The discharge measurements are made through holes in the ice from 5 to 10 feet apart, and large enough to allow the meter to pass through freely. The measurement is then taken in the same manner as at open sections, except that the depth of the stream is taken as the distance from the bottom of the ice to the bed of the stream. The soundings, however are always referred to the surface of the water in the holes, the distance from the surface of the water to the bottom of the ice being measured and subtracted from the sounding to obtain the depth. The meter should be kept in the water continuously to prevent the wheel from freezing and sticking.

The gauge is read once a day, the observer noting the elevation of the water as it rises in a hole cut through the ice, the height of the top of the ice, the thickness of the ice, presence of needle or slush ice, snow on top of ice, ice jams, and also any sudden changes in temperature. To do this observers are provided with an ice chisel for chopping holes, and a square to measure the thickness of the ice. Any form of gauge may be used but the chain gauge is the most satisfactory, as the staff gauge being frozen to the ice, heaves with it.

Some of the cross-sections used in the summer were found to be unsuitable for winter measurements. This was usually caused by the cross-section filling up with slush, needle or anchor ice. There is a flow through this ice and it is impossible to measure it. The most suitable stations for winter measurements are those where there is a long stretch of very smooth sluggish water above the station and a rapid fall below.

Re-Rating of Current Meters.

Each meter is rated before being used, in order to determine the relation between the revolutions of the wheel and the velocity of the water. The meter is driven at a uniform rate of speed through still water for a given distance, and the number of revolutions of the wheel and the time are recorded. From this data the number of revolutions per second and the corresponding velocity per second are computed. Tests are made for speeds varying from the slowest which will cause the wheel to revolve to several feet per second. The results of these runs, when plotted with revolutions per second as abscissae and velocity in feet per second as ordinates, locate points that define the meter rating-curve, which for all meters is practically a straight line. From this curve a meter rating table is prepared. Theoretically, the rating for all meters of the same make and type should be the same, but as a result of slight variations in construction, and in bearing of the wheel on the axis at different velocities, the ratings differ. After a meter has been in use for some time the cups may have received small injuries, or the bearing of the wheel on the axis may have changed owing to unavoidable rough usage. These changes will affect the running of the meter and change its rating. As a consequence each meter is re-rated at regular intervals and a new rating curve and table prepared. During 1910 several meters were re-rated by F. H. Peters by means of a gasoline launch on Chestermere Lake, and with only one exception the meters varied but little from the original rating.

The boat method of rating meters is, however, very crude, and Mr. Peters has designed an up-to-date rating station consisting of a concrete lined tank, 250 feet long, 6 feet wide, and 5½ feet deep, and a car operated by a motor. This will be constructed at once and all the meters will be carefully re-rated at regular intervals.

OFFICE COMPUTATIONS.

Rating Curves and Tables.—When a series of discharge measurements has been made at a gauging station a rating curve is constructed for that station, showing graphically the discharge corresponding to any stage of the stream within the limits covered by the gaugings. This curve, as it is usually drawn, has as abscissae, the discharges in second-feet and as ordinates, the corresponding gauge heights at which the discharges were made. A smooth curve is drawn through the resulting set of points and from this curve the discharges at any stage within the limits of the curve are taken. Some measurements may be more reliable than others, owing to more or less favourable conditions at different times of gauging, or to other causes. In order to obtain the weight of the different measurements, curves with area and mean velocity, as abscissae, and gauge heights as ordinates, are also drawn. From a study of these curves any discrepancies in a measurement, either in its area or mean velocity, may be detected. Should it be necessary to extend the rating curve beyond the limits of actual discharge measurements the area and mean velocity curves may be constructed to the stages for which the discharge curve is desired and the latter found by taking the product of the two curves. The discharge curve under natural conditions of flow is always convex to the gauge height axis. The area curve is either a straight line or is convex to the gauge height axis, except in the case of overhanging banks when it becomes concave to the axis. The mean velocity curve is always concave to the gauge height axis, except in cases where standing water occurs below the stage of no-flow. In this case the curve will assume a reverse form, starting from the gauge height of zero flow with a curve convex to the gauge height axis and gradually reversing to a curve concave to this axis. In plotting all three curves the horizontal and vertical scales should be so chosen that the curves may be used within the limits of accuracy for the work, and in their critical position will make, as nearly as possible, angles of 45 degrees with each axis.

The rating curve being constructed it becomes necessary to prepare a station rating table, giving the discharge at any stage of the stream within the limits of the daily gauge height observations on record. From this rating table the daily discharges corresponding to the daily gauge heights are read and tabulated. The rating table is constructed for tenths, half-tenths, or hundredths of feet, according to the readings of the gauge to which it is to be applied. The discharges for this table are read directly from the rating curve and are then adjusted so that the differences for successive stages shall be either constant or gradually increasing, but never decreasing, unless the station is affected by backwater.

Daily Discharge, Monthly Mean, and Run-Off.—The rating table being made to cover the range of daily gauge height observations, the next procedure in the computations is to make out a table of daily discharges from this rating table. The daily gauge heights are copied as they were sent in by the observer and opposite each the corresponding discharge is filled in from the rating table. The monthly discharge is found by totalling the daily discharges for the month in question and the monthly mean is obtained by dividing this total by the number of days in the month.

The run-off is computed with two different sets of units, depending upon the kind of work for which the data is intended, as follows: (1) Run-off in inches is the depth to which a plane surface equal in extent to the drainage area would be covered if all the water flowing from it in a given time were conserved and uniformly distributed thereon; it is used for comparing run-off with rain-fall, which is usually expressed in depth in inches. The mean run-off in second-feet per square mile for each month is used. The monthly mean run-off in second-feet is divided by the area of the drainage basin in square miles to find the monthly mean run-off per square mile. This result, reduced to run-off in depth in inches for the monthly period, is in the form required.

(2) The run-off in acre-feet is the form of most use in connection with storage. An acre-foot is equivalent to 43,560 cubic feet, and is the quantity of water required to cover an acre to the depth of one foot. The monthly mean run-off in second-feet is used for the computation of run-off in acre-feet. The monthly mean is reduced to cubic feet per month and this quantity divided by 43,560 gives the run-off in acre-feet.

The run-off of the stream being computed both in depth ,in inches and in acre-feet for each month, the run-off for the period, during which observations of run-off were made, is found by the summation of the amounts of run-off for the several months making up this period.

Changing Conditions of Channel.—On streams such as Milk River, whose bed is in a constant state of motion, measurements of discharge should be made every few days, otherwise considerable data relating to changes cannot be obtained. For discharges on days other than those on which measurements are taken, the interpolation method is used. The two methods of interpolation in general use are the Stout and Bolster Methods.

The Stout method deals with the correction of the gauge heights. A curve is drawn, using the difference between the actual gauge heights at the time of measurement and the gauge height corresponding to the measured discharge as ordinates and the corresponding days of the month as abscissae. From an irregular curve drawn through these points corrections for gauge heights can be made for days on which there was no discharge measurement. When the discharge is greater than that given by the curve the correction is positive and vice-versa. Each daily gauge height is corrected by the amount shown on the correction curve, and the corresponding discharge taken from an approximate rating curve for the station.

The Bolster method deals more particularly with the modification of the discharge. Results of discharge measurements covering a whole year or season are plotted, and though considerably scattered, will define one or more regular curves, called standard curves, the number and position of each indicating the radical changes. Where the river bed changes from day to day, the position of the standard curve also varies and must pass through the points indicating the different days. The points indicating two successive measurements are joined by a line,which for short distances on the cross-section paper is a straight line and otherwise a curve. This line is divided into a number of equal parts, each indicating an intervening day, the assumption being that as the change during this period is gradual the daily rating must pass through each point, or day, as represented by the divisions. A simple and convenient way of making these interpolations and moving the daily rating curve is to make a tracing of the standard curve with a vertical line of reference. By keeping the lines of reference coincident this curve can be shifted into any desired position and the discharge read for any gauge height.

ACKNOWLEDGEMENTS.

When the Hydrographic Survey was being organized, and on various occasions since, very valuable assistance was received from members of the staff of the United States Geological Survey, particularly M. O. Leighton, Chief Hydrographer, J. C. Hoyt, Asst., Chief Hydrographer, and Robert Follansbee, District Engineer. The U.S. Geological Survey have been studying the surface flow of water for several years and have thoroughly systematized the work and developed some new and useful methods. We have been fortunate in having the benefit of their experience in organizing our survey. They have issued a large number of very interesting and useful Water-Supply Papers. Copies of many of these have been received and have been freely used.

There are a number of very good text books on Hydraulics, but "River Discharge" by Hoyt and Grover, and "Hydrographic Surveying," by S. H. Lea, deal more fully with stream measurement work than any other texts. These have been used by the survey and are recommended to anyone wishing to make a study of this subject.

Plate No. 3.

Canyon on Cascade River near Bankhead, Alta.

Plate No. 4.

Thirty-Six inch sharp-crested rectangular weir used on small streams.

RED DEER RIVER DRAINAGE BASIN.

General Description.

The Red Deer River rises in the Sawback Range of the Rockies in the Northern portion of the Rocky Mountain Park, near the boundary between the Provinces of Alberta and British Columbia. It flows Eastward for about 40 miles, then North-Eastward for 70 or 80 miles to a point near Red Deer, Alta. From here the river flows in a South-Easterly and Easterly direction to its junction with the South Saskatchewan River just East of the Fourth Meridian in Tp. 22, Rge. 28, W. 3rd Mer. It has a length of approximately 400 miles.

The valley of the Red Deer is wide and deep, the banks being very rough and cut up with a large number of deep coulees, draining into the river. Near its source the basin is well timbered and a good growth of timber is found along its banks for some distance out into the prairie. Seams of coal, well suited for domestic use, are found in the valley and form the principal source of fuel supply for the settlers along the stream in the prairie section.

The river carries a considerable supply of water at all times of the year, but the volume is subject to sudden variations due to the melting of snow in the mountains and heavy summer rains.

Of the tributaries of the Red Deer, the most important are the Panther River, near its head, the Little Red Deer entering in Tp. 36, Rge. 1, W. 5th Mer., and the Rosebud River emptying into it in Tp. 28, Rge. 19, W. 4th Mer. In addition there are innumerable small streams draining into the main river in the Western portion of the basin. From the mouth of the Rosebud River Eastward there is very little drainage into the river.

Irrigation on the Red Deer and its branches is practically unknown. There are only a few small schemes on some of the smaller tributaries. The land along the valley, though lacking moisture, is extremely fertile, and with the help of irrigation much of it might be cultivated and fine crops produced. The irrigation of the bench land from the river would be difficult on account of the small fall in the river, the depth of the valley, and the rolling nature of the lands in the drainage basin.

Very little hydrographic work has been done in this basin, except that a few miscellaneous measurements have been made at different times. A gauging station was established on the Red Deer River near Innisfail, in 1910. It is expected that during the coming year more time will be devoted to the streams in this basin.

RED DEER RIVER NEAR INNISFAIL.

This station was established September 28th, 1910, by H. R. Carscallen. It is located at the traffic bridge on the N.E. quarter Sec. 6, Tp. 36, Rge. 28, W. 4th Mer. The bridge is about four miles North-West of Innisfail. It is a three-span steel structure, supported by timber, rock-filled piers and abutments, with a short approach at the South end of the bridge.

The channel above the station is straight for about 600 yards. An island divides the stream into two channels and extends to within about 300 yards of the station. The channel down stream is straight for about 400 yards. The current is moderate over most of the cross-section, although fairly swift in the right channel. The current is moderate up stream becoming more swift below the station.

The right bank is high and sandy. The left bank is comparatively low and may overflow at very high stages of the stream. Both banks are covered with a dense growth of timber and brush. The bed of the stream is composed of sand and gravel. There is a gravel bar between the two centre piers and at low water there is no flow in this channel. At high water stages the stream is divided into three channels, by the piers of the bridge.

The initial point for soundings is the right face of the left abutment. Discharge measurements are made from the down stream side of the bridge and distances are marked with red paint every five feet along the bottom chord of the bridge.

The gauge is a plain staff, 2″ x 4″ x 10′, graduated to feet and hundredths, spiked to the right abutment on the down stream side of the bridge. It is referred to bench marks as follows: (1) Three spike heads in the cribbing of the right abutment; elevation 14.25. (2) Two spikes in side of large poplar tree on right bank about 50 feet below the bridge; elevation 12.50.

Arrangements were made with Mr. F. F. Malcolm, a building contractor living within 300 yards of the bridge, to take daily gauge height observations of the river. Mr. Malcolm was called away from home almost immediately afterwards, and in consequence no gauge height observations were made. It is expected that regular observations will be made during the coming year. Several discharge measurements at this station were made during the season and a list of these is published below.

DISCHARGE MEASUREMENTS of Red Deer River near Innisfail in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 23	J. C. Keith	339	802.32	3.12	....	2503.88
July 25	do	295	660.54	2.31	....	1522.86
Aug. 29	do	292	619.90	2.41	....	1493.22
Sept. 28	H. R. Carscallen	294	659.92	2.45	1.28	1618.99
Nov. 2	do	264.5	483.87	1.63	0.69	789.88

MISCELLANEOUS DISCHARGE MEASUREMENTS of Red Deer River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		*Sec.-ft.*
Aug. 26	Blood Indian Creek	10-23-8-4	H. R. Carscallen	3.5	1.70	0.73
" 24	Berry Creek East Branch	12-23-12-4	do	....	....	Dry
" 24	Berry Creek	27-23-13-4	do	3.4	0.33	0.13
May 5	do do	33-22-12-4	J. Stewart	....	....	10.07
June 25	Blindman River	Blackfalls, Alta.	J. C. Keith	97.0	286.50	107.78
Aug 25	Hallam's Ditch	3-23-8-4	H. R. Carscallen	5.0	1.50	0.56
June 24	Red Deer River	21-38-27-4	J. C. Keith	265.0	810.10	2566.63
" 25	do do	32-26-28-4	do	165.5	681.10	2187.51

BOW RIVER DRAINAGE BASIN.

General Description.

Bow River heads in Lakes Bow and Hector, elevations 6,420 feet and 5,694 feet respectively above mean sea level, lying just East of the Great Divide in the Rocky Mountain Park of Canada, and flows in South and Easterly direction to Calgary. Here it takes a big bend to the south and then again takes a South and Easterly course to its junction at the Grand Forks with Belly River. From the confluence of these two streams it is known as the South Saskatchewan River.

The principal tributaries are the Spray, Cascade, Kananaskis, Ghost, Elbow, Sheep and Highwood Rivers. Cascade and Ghost Rivers drain that portion of the basin lying North of Bow River and Spray, Kananaskis, Elbow, Sheep and Highwood Rivers drain the Southern portion. In addition to these large streams, however, are numerous creeks which drain from the mountains along the upper part of its course. No drainage of any account, however, reaches the river East of the mouth of Highwood River, consequently almost all the run-off comes from the mountains and foothills. As a result, Bow River possesses a normally steady flow throughout the year, but is subject to sudden freshets caused by melting snow and heavy rains in the mountains. The period of minimum flow is during January and February.

The valley of the Bow is deep and fairly wide, the banks in the mountain section being rocky and high, and in the prairie section high and clayey. The upper portion of the basin is heavily timbered, but this all disappears in the lower prairie portion. The bed of the stream is of rock, gravel or sand, and is free from vegetation. The water is clear and pure.

Considerable water is being diverted from Bow River for irrigation purposes, and more will be used in the near future. The Canadian Pacific Irrigation Company are preparing to irrigate about 3,000,000 acres of land lying North of their main line and between Calgary and the line between Ranges 10 and 11, West 4th Mer. The water is being diverted about two miles East of Calgary and also at Bassano. All of their ditch has not been constructed yet, but the work is being rushed to completion. Besides this, the Southern Alberta Land Company has been granted water rights to irrigate about 380,000 acres of land lying to the West of Medicine Hat. The headgates of their canal and their reservoir are near Gleichen.

Many favorable sites for power development are located on the Bow and its tributaries, but up to the present only one of any importance has been developed. This belongs to the Calgary Power and Transmission Company, and is for the purpose of supplying Calgary with electric power. Their dam and power house is just below Kananaskis Falls, their transmission line running a distance of fifty miles to Calgary. At present only 12,000 H.P. is to be developed, but ultimately this will be raised to 30,000 H.P., their power plant being designed to accomodate this increase.

In addition to these projects the city of Calgary draws its domestic water supply from Elbow River. The intake is about 12 miles south-West of Calgary, above which point the course of the river is through a wild and unsettled country, thus insuring the purity of the water supply.

BOW RIVER NEAR LAGGAN.

This station was established July 18th, 1910, by J. C. Keith. It is located at an old traffic bridge on the N.E. quarter Sec. 28, Tp. 28, Rge. 16, W. 5th Mer., about one-third of a mile West of Laggan station, and about 150 yards South of the main line of the Canadian Pacific Railway. The bridge is a low, log structure of two spans, supported by two abutments and a central pier, constructed of heavy timber and filled with rock. A small North channel which carries no water except in high stages is bridged by a small one-span log structure, similar to that over the main stream.

The channel is straight for about one-half mile above the station, except for a slight bend, a short distance above the bridge. The channel is straight for about 900 feet below the station, then bends gradually to the left. The current is swift at the station, making accurate soundings difficult to obtain.

The right bank is low near the water's edge,but rises rapidly; the left bank is low with a gradual rise to the Canadian Pacific Railway tracks. Both banks are covered with brush. The bed of the stream is composed of gravel and large stones. The centre pier divides the stream into two channels in addition to the small North channel mentioned above.

The initial point for soundings in the main channel is a bolt on the North end of the guard timber; the initial point for sounding in the North channel is the inside edge of the north abutment of the small bridge which spans it. Discharge measurements are made from the down stream sides of the two bridges.

The gauge is a plain staff. graduated to feet and hundredths nailed securely to the lower side of the North abutment of the bridge spanning the main channel. It is referred to bench marks as follows:—(1) Top of bolt head at the North end of the guard timber on the up stream side of the bridge; elevation 8.45. (2) Topof bolt head in the guard timber, thirty feet from the South end of the bridge on the up-stream side; elevation 7.75.

It was impossible to get a satisfactory observer during 1910, and therefore only the discharge measurements are published.

DISCHARGE MEASUREMENTS of Bow River near Laggan, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec. ft.*
July 18	J. C. Keith	112.3	300.45	5.832	3.43	1752.30
Aug. 12	do	111.3	243.50	4.974	3.02	1202.24
Sept. 2	do	73.2	99.70	3.328	2.12	331.79
Sept. 24	do	97.8	127.22	3.142	2.285	399.75
Oct. 20	H. R. Carscallen	85.6	104.74	3.25	2.14	340.63
Nov. 8	do	42.0	66.43	2.68	1.66	178.02
Dec. 5	do	42.0	57.88	2.084	1.33	120.62
Dec. 29	do	42.0	50.33	1.814	1.26	91.31

BOW RIVER AT BANFF.

This station was established May 25th, 1909, by P. M. Sauder. It is located at the highway bridge in the village of Banff, about one mile from the Canadian Pacific Railway Station. It is on the quartering line in the S. ½, Sec. 35, Tp. 25, Rge. 12, W. 5th Mer., about a half mile above the mouth of the Spray River, and a short distance below the Vermilion Lakes.

The channel is straight for about 300 feet above and 400 feet below the station. The current is sluggish above the station, becoming swifter as it approaches the bridge and breaking into rapids a short distance down stream, reaches the Spray Falls about a quarter of a mile below.

The stream is divided into four channels by the piers supporting the bridge. Both banks are low and covered with brush and timber, but are not liable to overflow. The bed of the stream is composed of gravel and boulders, the latter making it difficult to obtain accurate soundings at some points. There is a deep hole at the station near the right bank, but the greater part of the cross-section is uniform.

Discharge measurements are made from the down stream side of the bridge. The initial point for soundings is one and one-half feet from the North end of the bridge. The distances are marked on the bottom chord of the down-stream side of the bridge.

A plain staff gauge, graduated to feet and tenths, is attached vertically to the down-stream side of the centre pier, It is referred to a bench mark on the top of the same pier; elevation 7.52. The gauge was read once daily by N. B. Sanson, Meteorological Observer, at Banff.

Discharge Measurements of Bow River at Banff, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 13	I. C. Keith	304	1107.59	2.553	2.375	2827.20
June 3	do	317	1255.45	2.99	2.865	3745.43
June 17	do	322	1595.86	4.205	3.94	6710.95
July 15	do	320	1528.68	3.927	3.72	6003.60
Aug. 11	do	315	1265.85	2.94	2.925	3727.37
Aug. 31	do	274	864.19	1.62	1.83	1403.57
Sept. 22	do	278	867.97	1.58	1.81	1378.02
Oct. 19	H. R. Cascallen	283	884.98	1.61	1.90	1428.02
Nov. 5	do	239.5	729.80	1.16	1.22	844.26
Dec. 1	do	119	517.85	0.86	*0.82	496.63
Dec. 23	do	59	182.80	2.23	*0.52	406.85

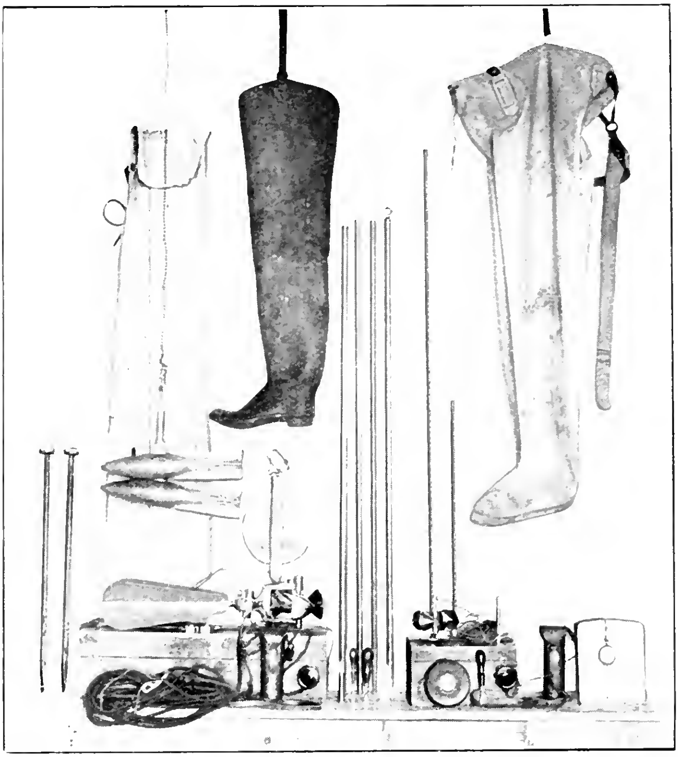
* Ice Conditions.

Daily Gauge Height and Discharge of Bow River at Banff, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			1.75	1,978	2.85	3,708	3.45	5,190
2			1.65	1,865	3.05	4,165	3.4	5,045
3			1.65	1,865	2.9	3,815	3.3	4,760
4			1.7	1,920	2.7	3,400	3.3	4,760
5			1.8	2,035	2.7	3,400	3.3	4,760
6			2.15	2,490	2.9	3,815	3.25	4,620
7			2.4	2,865	3.25	4,657	3.25	4,620
8			2.6	3,210	3.2	4,530	3.35	4,902
9			2.7	3,400	3.1	4,285	3.3	4,760
10	.3		2.65	3,305	3.1	4,285	3.3	4,760
11	.3		2.45	2,947	3.7	5,980	3.3	4,760
12	.35		2.35	2,788	4.35	8,120	3.4	5,045
13	.5		2.35	2,787	4.05	7,100	3.5	5,335
14	.4		2.3	2,710	3.65	5,782	3.65	5,783
15	.35		2.2	2,560	3.6	5,630	3.7	5,935
16	.4		2.1	2,420	3.8	6,250	3.75	6,092
17	.4		2.1	2,420	3.9	6,575	3.8	6,250
18	.4		2.25	2,635	4.1	7,265	3.8	6,250
19	.5		2.25	2,635	3.7	5,935	3.65	5,783
20	.75		2.2	2,560	3.85	6,413	3.5	5,335
21	.8		2.2	2,560	1.05	7,088	3.45	5,190
22	.8		2.3	2,710	3.65	5,782	3.35	4,902
23	.85		2.7	3,400	3.35	1,903	3.25	1,620
24	1.15		3.0	4,045	3.2	4,480	3.15	4,343
25	1.55		3.35	4,915	3.1	4,205	2.95	3,792
26	1.9	2,155	3.7	5,940	3.1	5,045	2.9	3,655
27	2.1	2,120	3.55	5,475	3.7	5,935	2.75	3,243
28	2.1	2,420	3.2	4,530	3.8	6,250	2.7	3,105
29	1.95	2,220	2.95	3,930	3.75	6,092	2.6	2,855
30	1.85	2,095	2.75	3,500	3.55	5,483	2.6	2,855
31			2.7	3,400			2.7	3,105

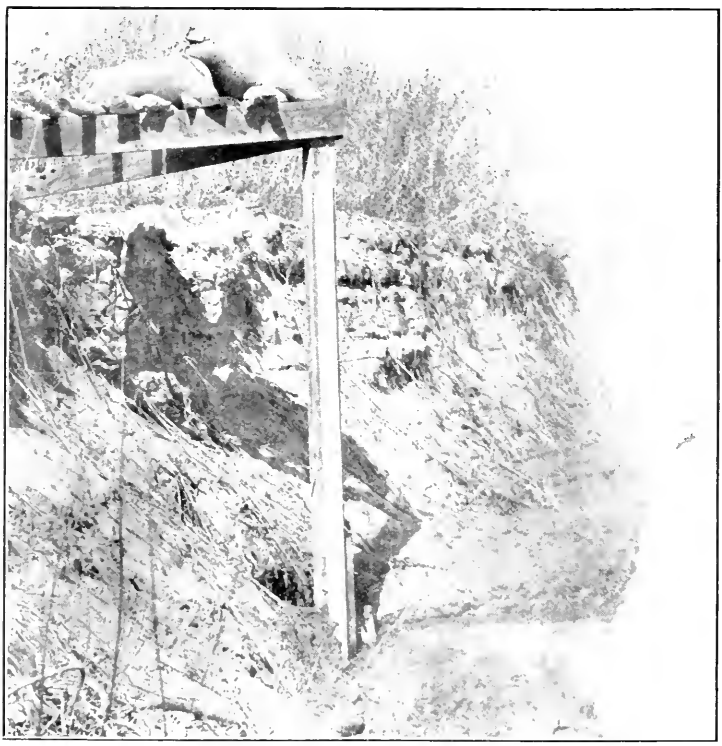
From April 10th to 25th, curve not sufficiently defined to read discharge.

PLATE No. 5.



Meters and equipment for measuring the discharge of a stream by the velocity method.

PLATE No. 6.



Gauge on Milk River at Spencer's Lower Ranche.

Daily Gauge Height and Discharge of Bow River at Banff, for 1910.—*Continued.*

Day.	August.		September.		October.		November.		December.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.* *	*Sec.-ft.*
1	2.7	3,105	1.8	1,370	1.5	1,055	1.3	905	0.82	496
2	2.65	2,980	1.8	1,370	1.5	1,055	1.3	905	......	......
3	2.55	2,732	1.8	1,370	1.5	1,055	1.3	905	......	......
4	2.6	2,855	1.9	1,500	1.45	1,015	1.25	872	0.75	475
5	2.75	3,243	1.85	1,435	1.4	975	1.2	840	......	......
6	3.1	4,205	1.95	1,573	1.4	975	1.2	840	0.79	487
7	3.1	4,205	1.85	1,435	1.6	1,150	1.2	840	0.77	481
8	2.95	3,792	1.8	1,370	1.55	1,102	1.2	840	0.8	490
9	3.0	3,930	1.7	1,255	1.6	1,150	1.2	840	0.79	487
10	3.0	3,930	1.7	1,255	1.9	1,500	1.2	840	0.68	454
11	2.95	3,793	1.6	1,150	1.9	1,500	1.2	840	0.6	430
12	2.9	3,655	1.6	1,150	1.85	1,435	1.1	780	0.73	469
13	2.85	3,517	1.6	1,150	1.8	1,370	1.15	810	0.75	475
14	2.8	3,380	1.5	1,055	1.75	1,313	0.8	630	0.70	460
15	2.75	3,243	1.5	1,055	1.75	1,312	1.05	753	0.64	442
16	2.6	2,855	1.5	1,055	1.8	1,370	0.9	675	0.67	451
17	2.55	2,732	1.5	1,055	1.85	1,435	÷	......	0.71	463
18	2.45	2,498	1.55	1,102	1.9	1,500	......	......	0.66	448
19	2.4	2,385	1.6	1,150	1.85	1,435	......	......	0.64	442
20	2.5	2,610	1.65	1,203	1.8	1,370	......	......	0.60	430
21	2.45	2,497	1.75	1,312	1.8	1,370	......	......	0.66	448
22	2.4	2,385	1.8	1,370	1.7	1,255	......	......	0.50	404
23	2.35	2,283	1.8	1,370	1.7	1,255	......	......	0.57	421
24	2.25	2,085	1.85	1,435	1.6	1,150	......	......	0.68	454
25	2.15	1,900	1.75	1,313	1.6	1,150	......	......	0.65	445
26	2.05	1,727	1.7	1,255	1.55	1,103	......	......	0.65	445
27	2.0	1,645	1.6	1,150	1.35	940	......	......	0.64	442
28	2.0	1,645	1.6	1,150	1.45	1,015	......	......	0.60	430
29	1.9	1,500	1.6	1,150	1.45	1,015	......	......	0.59	427
30	1.85	1,435	1.6	1,150	1.45	1,015	......	......	0.63	439
31	1.8	1,370	......	......	1.4	975	......	......	0.44	392

* Ice conditions during all the month of December. ÷ No gauge height observations from Nov. 17 to Dec. 1.

Monthly Discharge of Bow River at Banff, for 1910.

Drainage area, 845 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April 26-30	2,420	2,095	2,262	2.68	.498	22,433
May	5,940	1,865	3,090	3.66	4.22	190,018
June	8,120	3,400	5,345.8	6.32	7.05	318,098
July	6,250	2,855	4,722.9	5.59	6.445	290,400
August	4,205	1,370	2,778	3.29	3.79	170,816
September	1,573	1,055	1,257	1.49	1.66	74,806
October	1,500	940	1,203.7	1.42	1.637	74,010
November 1-16	905	630	819	.97	.577	26,014
December, 28 days	496	392	451	.53	.55	25,047
The period						1,391,642

Bow River Near Morley.

This station was established May 25th, 1910, by J. C. Keith. It is located at the traffic bridge on Sec. 22, Tp. 25, Rge. 7, W. 5th Mer., in the Stony Indian Reserve, a short distance from the Indian Agency and about ¾ of a mile North of the Village of Morley.

Discharge measurements are made from the down-stream side of the bridge, which is a two span steel structure, supported by concrete abutments and pier, with a short wooden approach on the South side, supported by piles. The initial point for soundings is the anchor bolt in the bed plate on the North pier, and distances are marked to every five feet on the bottom chord of the bridge.

The channel is straight for about 600 feet above the station, then curves slightly to the right, but is almost straight for more than half-a-mile. It is straight for about 500 feet below the station, then curves sharply to the left. The right bank is low and partly covered with brush, but is not liable to overflow. The left bank is high, steep, gravelly and free from brush. The bed of the stream is composed of sand and gravel. The current is swift but smooth.

The gauge is the standard chain type, and is fixed to the floor of the bridge near the centre pier. The length of chain from the bottom of the weight to the marker is 19.17 feet. The gauge is referred to bench marks as follows:—(1) A wooden block nailed to the down-stream pile in the first row supporting the approach on the left bank; elevation 12.09. (2) The top of a nut on a bolt in the pile nearest to the South abutment, elevation 8.58. It is read once each day by S. Christianson, who lives about 350 yards south-East of the bridge.

DISCHARGE MEASUREMENTS of Bow River near Morley, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
May 26	J. C. Keith	222.7	1,466.59	6.44	4.90	9,443.54
June 21	do	235.7	1,610.50	7.49	5.55	12,066.97
July 14	do	217.7	1,422.58	5.96	4.74	8,476.01
Aug. 9	do	207.4	1,207.23	4.96	3.80	5,990.30
Aug. 30	do	182.2	933.94	3.26	2.37	3,047.86
*Sept. 21	do	182.2	926.86	3.22	2.38	2,987.93
†Sept. 21	do	182.2	926.86	3.23	2.38	2,989.38
Oct. 17	H. R. Carscallen	179.5	903.80	3.06	2.30	2,767.68
Nov. 4	do	175.5	799.30	2.29	1.63	1,829.87
Nov. 30	do	155.5	733.35	1.61	1.22	1,177.06
Dec. 22	do	154.0	463.81	1.83	1.16	847.19

* One point method used.
† Two point method used.

DAILY GAUGE HEIGHT AND DISCHARGE of Bow River near Morley, for 1910.

Day.	May. Gauge Height.	May. Discharge.	June. Gauge Height.	June. Discharge.	July. Gauge Height.	July. Discharge.	August. Gauge Height.	August. Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			4.15	6,910	4.85	9,255	3.45	5,185
2			4.4	7,660	4.9	9,440	3.4	5,070
3			4.25	7,195	4.6	8,350	3.3	4,850
4			4.05	6,635	4.55	8,175	3.25	4,740
5			3.85	6,115	4.5	8,000	3.55	5,415
6			4.0	6,500	4.5	8,000	4.0	6,500
7			4.45	7,830	4.45	7,830	4.05	6,635
8			4.55	8,175	4.5	8,000	4.0	6,500
9			4.4	7,660	4.55	8,175	3.85	6,115
10			4.4	7,660	4.45	7,830	3.85	6,115
11			4.8	9,070	4.45	7,830	3.75	5,875
12			5.65	12,475	4.55	8,175	3.75	5,875
13			5.7	12,680	4.7	8,700	3.7	5,760
14			5.2	10,640	4.85	9,255	3.65	5,645
15			5.05	10,040	4.85	9,255	3.6	5,530
16			5.35	11,245	4.95	9,640	3.5	5,300
17			5.5	11,860	4.8	9,070	3.35	4,960
18			5.8	13,090	4.9	9,440	3.25	4,740
19			5.35	11,245	4.75	8,885	3.2	4,630
20			5.35	11,245	4.55	8,175	3.1	4,410
21			5.7	12,680	4.45	7,830	3.1	4,410
22			5.4	11,450	4.4	7,660	3.05	4,305
23			5.0	9,840	4.3	7,340	3.0	4,200
24			4.65	8,525	4.2	7,050	2.95	4,095
25	4.6	8,350	4.45	7,830	3.9	6,240	2.75	3,685
26	5.1	10,240	4.7	8,700	3.95	6,370	2.65	3,485
27	5.15	10,440	5.0	9,840	3.8	5,990	2.55	3,305
28	4.8	9,070	5.25	10,840	3.7	5,760	2.55	3,305
29	4.4	7,660	5.25	10,840	3.8	5,990	2.45	3,115
30	4.2	7,050	5.0	9,840	3.77	5,921	2.38	2,986
31	4.0	6,500			3.8	5,990	2.36	2,952

Daily Gauge Height and Discharge of Bow River near Morley, for 1910.—*Continued.*

Day.	September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.33	2,901	2.1	2,520	1.67	1,888	1.2	*1,150
2	2.28	2,816	2.08	2,490	1.7	1,930	1.4	*1,380
3	2.18	2,648	2.0	2,370	1.65	1,860	1.38	*1,340
4	2.27	2,799	2.0	2,370	1.7	1,930	1.28	*1,210
5	2.35	2,935	1.95	2,295	1.64	1,846	1.47	*1,430
6	2.45	3,115	1.9	2,220	1.66	1,874	1.49	*1,440
7	2.5	3,210	2.0	2,370	1.6	1,790	1.55	*1,510
8	2.43	3,077	2.1	2,520	1.5	1,660	1.46	*1,380
9	2.25	2,765	2.05	2,445	1.53	1,699	1.45	*1,350
10	2.2	2,680	2.2	2,680	1.55	1,725	1.53	*1,440
11	2.23	2,731	2.3	2,850	1.52	1,686	1.5	*1,400
12	2.13	2,568	2.35	2,935	1.53	1,699	1.25	*1,080
13	2.12	2,552	2.25	2,765	1.45	1,595	1.45	*1,300
14	2.07	2,475	2.27	2,799	1.5	1,660	1.4	*1,220
15	2.07	2,475	2.15	2,600	1.45	*1,595	1.25	*1,030
16	2.1	2,520	2.15	2,600	1.4	*1,530	1.23	*1,000
17	2.23	2,731	2.3	2,850	1.34	*1,440	1.27	*1,020
18	2.25	2,765	2.38	2,986	1.25	*1,320	1.3	*1,050
19	2.3	2,850	2.32	2,884	1.37	*1,470	1.2	* 920
20	2.35	2,935	2.24	2,748	1.37	*1,460	1.2	* 920
21	2.33	2,901	2.2	2,680	1.36	*1,440	1.19	* 890
22	2.4	3,020	2.15	2,600	1.33	*1,390	1.15	* 840
23	2.44	3,096	2.1	2,520	1.34	*1,400	1.25	* 870
24	2.33	2,901	2.04	2,430	1.45	*1,520	1.25	* 800
25	2.4	3,020	2.05	2,445	1.0	* 970	1.3	* 770
26	2.37	2,969	2.0	2,370	1.0	* 960	1.47	* 900
27	2.25	2,765	1.93	2,265	1.0	* 950	1.6	* 990
28	2.15	2,600	1.86	2,160	1.03	* 980	1.55	* 860
29	2.11	2,536	1.8	2,070	1.15	*1,100	1.7	* 970
30	2.06	2,460	1.75	2,000	1.23	*1,190	2.35	* 980
31	......	......	1.73	1,972	......	......	2.25	* 990

* Changing conditions due to ice: Nov. 15th to Dec. 31st.

Monthly Discharge of Bow River near Morley, for 1910.

Drainage area, 2,099 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
May (25-31)	10,440	6,500	8,472.8	4.03	1.04	117,639
June	13,090	6,115	9,543.8	4.54	5.06	567,894
July	9,640	5,760	7,858.7	3.74	4.31	483,211
August	6,635	2,952	4,828.8	2.30	2.65	297,916
September	3,210	2,460	2,793.8	1.33	1.48	166,244
October	2,986	1,972	2,509.9	1.20	1.38	154,324
November	1,930	950	1,518.6	.72	.80	90,366
December	1,510	770	1,110.6	.53	.61	68,287
The period						1,945,881

Bow River at Calgary.

This station was established May 5th, 1908, by P. M. Sauder. It is located at the Cushing traffic bridge on the North side of Sec. 12, Tp. 24, Rge. 1, W. 5th Mer. It is below the mouths of Elbow River and Nose Creek, and the Intake of the Canadian Pacific Railway Company's Canal.

At ordinary stages the stream is divided into two channels by the first pier from the right bank, and at high water and flood stages it is divided into three channels by the piers. The right bank is high and does not overflow, but some years ago the flat on the East side was submerged for a short period during an excessive flood. In recent years a dyke was built along the left bank to confine the stream within its banks at all stages. The bed and banks are liable to shift during high water and flood stages of the stream. The channel is straight for 300 feet above the station; above this there is a gravel bar, around which the stream shifts from time to time. The channel is straight to a point about 400 feet below the station, beyond which it gradually turns towards the left.

Discharge measurements are made from the bridge at all stages. The initial point for soundings is the West side of the left abutment. The distances are marked at every five feet on the bottom chord of the down-stream side of the bridge.

The gauge which is of the standard chain type is read daily by James Millen, who lives about 200 yards from the West end of the bridge. The length of the chain is 20.30 feet. The gauge is referred to a bench mark on the first pier from the left bank; elevation 9.91.

DISCHARGE MEASUREMENTS of Bow River at Calgary, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 12	J. C. Keith	224.5	1,739.00	3.90	5.31	6,774.50
May 28	do	282.5	2,082.38	5.77	6.58	12,020.62
June 16	do	281.5	2,093.18	5.38	6.585	11,265.10
June 22	do	296.0	2,120.70	5.87	7.145	12,455.85
July 12	do	255.5	1,819.72	4.45	5.895	8,100.98
Aug. 6	do	227.0	1,733.50	3.90	5.475	6,755.10
Aug. 18	do	220.5	1,599.68	3.18	4.95	5,081.93
Sept. 20	do	207.0	1,451.90	2.50	4.20	3,640.74
Oct. 14	H. R. Carscallen	200.0	1,434.11	2.41	4.17	3,457.45

DAILY GAUGE HEIGHT AND DISCHARGE of Bow River, at Calgary, for 1910.

DAY.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			4.6	4,860	5.8	8,380
2			4.5	4,620	6.0	9,070
3			4.2	3,930	6.1	9,430
4			4.2	3,930	5.8	8,380
5			4.2	3,930	5.6	7,710
6			4.1	3,700	5.9	8,720
7	2.7	760	4.6	4,860	5.9	8,720
8	2.9	1,160	5.1	6,190	6.3	10,170
9	2.9	1,160	5.2	6,480	6.1	9,430
10	2.9	1,160	5.5	7,390	6.0	9,070
11	2.9	1,160	5.6	7,710	6.2	9,800
12	2.9	1,160	5.4	7,080	7.1	13,240
13	2.9	1,160	5.2	6,480	7.3	14,020
14	2.9	1,160	5.1	6,190	6.8	12,070
15	2.9	1,160	5.0	5,910	6.7	11,680
16	2.9	1,160	4.9	5,640	6.7	11,680
17	2.9	1,160	4.9	5,640	*6.7	11,560
18	2.9	1,160	4.8	5,360	*7.3	13,640
19	2.9	1,160	4.9	5,640	*7.1	12,760
20	3.0	1,360	4.9	5,640	*6.9	11,800
21	3.0	1,360	4.9	5640	*6.9	11,680
22	3.1	1,560	4.8	5,360	7.0	11,880
23	3.2	1,760	5.0	5,910	6.6	10,430
24	3.2	1,760	5.6	7,710	6.3	9,390
25	3.5	2,380	5.9	8,720	6.1	8,710
26	4.0	3,470	6.5	10,920	6.1	8,710
27	4.2	3,930	6.8	12,070	6.4	9,730
28	4.5	4,620	6.6	11,300	6.6	10,430
29	4.7	5,110	6.5	10,920	6.6	10,430
30	4.6	4,860	6.0	9,070	6.5	10,080
31			5.8	8,380		

* Changing conditions.

DAILY GAUGE HEIGHT AND DISCHARGE of Bow River, at Calgary, for 1910.—*Continued.*

Day.	July.		August.		September.		October	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	6.5	10,080	4.8	4,910	4.1	3,310	3.9	2,900
2	6.3	9,390	4.8	4,910	4.0	3,100	3.9	2,900
3	6.1	8,710	4.8	4,910	4.0	3,100	3.9	2,900
4	6.1	8,710	4.8	4,910	4.0	3,100	3.9	2,900
5	6.0	8,380	4.9	5,160	4.1	3,310	3.8	2,710
6	5.9	8,060	5.475	6,745	4.3	3,740	3.8	2,710
7	5.9	8,060	5.7	7,430	4.3	3,740	3.9	2,900
8	5.9	8,060	5.6	7,120	4.3	3,740	4.0	3,100
9	5.9	8,060	5.4	6,520	4.2	3,520	4.0	3,100
10	5.9	8,060	5.4	6,520	4.1	3,310	4.0	3,100
11	5.9	8,060	5.4	6,520	4.0	3,100	4.2	3,520
12	5.9	8,060	5.4	6,520	4.0	3,100	4.2	3,520
13	5.9	8,060	5.4	6,520	4.0	3,100	4.3	3,740
14	6.0	8,380	5.4	6,520	4.0	3,100	4.2	3,520
15	6.1	8,710	5.4	6,520	4.1	3,310	4.2	3,520
16	6.3	9,390	5.3	6,230	4.1	3,310	4.1	3,310
17	6.3	9,390	5.2	5,950	4.3	3,740	4.2	3,520
18	6.3	9,390	5.0	5,420	4.3	3,740	4.2	3,520
19	6.3	9,390	4.8	4,910	4.3	3,740	4.3	3,740
20	6.3	9,390	4.8	4,910	4.3	3,740	4.2	3,520
21	6.3	9,390	4.8	4,910	4.3	3,740	4.2	3,520
22	6.1	8,710	4.8	4,910	4.3	3,740	4.1	3,310
23	5.9	8,060	4.7	4,660	4.3	3,740	4.0	3,100
24	5.7	7,430	4.7	4,660	4.3	3,740	4.0	3,100
25	5.5	6,820	4.5	4,190	4.3	3,740	4.0	3,100
26	5.3	6,230	4.4	3,960	4.3	3,740	3.9	2,900
27	5.2	5,950	4.3	3,740	4.2	3,520	3.8	2,710
28	5.0	5,420	4.2	3,520	4.1	3,310	3.7	2,520
29	4.9	5,160	4.1	3,310	4.0	3,100	3.6	2,330
30	4.8	4,910	4.1	3,310	3.9	2,900	3.6	2,330
31	4.8	4,910	4.1	3,310			3.6	2,330

MONTHLY DISCHARGE of Bow River at Calgary, for 1910.

Drainage area, 3,900 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April 6-31	5,110	760	1,952	0.500	0.446	92,925
May	12,070	3,700	6,683	1.710	1.970	410,935
June	14,020	7,710	10,427	2.670	2.980	620,429
July	10,080	4,910	7,961	2.040	2.350	489,480
August	7,430	3,310	5,279	1.350	1.560	324,094
September	3,740	2,900	3,441	0.882	0.984	204,730
October	3,740	2,330	3,094	0.793	0.914	190,216
The period						2,332,809

CANADIAN PACIFIC RAILWAY COMPANY'S CANAL NEAR CALGARY.

This station was established May 9, 1908, by P. M. Sauder. It is about four miles from the intake, at the bridge (No. 2) on the road allowance on the East side of Sec. 36, Tp. 23, Rge. 1, W. of the 5th Mer.

A plain staff gauge, graduated to feet and hundredths, is fastened to a pile on the up-stream side of the bridge. Discharge measurements are made from the down-stream side of the bridge. The initial point for soundings is the inside of the first plank of the floor on the North end of the bridge. The right bank of the ditch is composed of a mixture of clay and gravel, while the bottom and left bank is composed of clay only. The bottom of the ditch is below grade at this point The canal carries water only during the irrigating season. There are no laterals from the ditch above the gauging station.

As no observer was available at the regular station during 1910, an auxiliary gauge was established on the S. E. ¼ Sec. 13, Tp. 24, Rge. 1, W. 5th Mer., at a point about 400 yards below the headgates of the canal. It is in the left bank and is referred to bench marks as follows:— (1) Top of concrete pyramid about 40 feet North-East of the gauge 16.84. (2) On top of a square timber post 15 feet North of the gauge; elevation 11.14. It was read by A. Hatcher, head ditch rider for the Company.

Discharge measurements were made near the gauge when the canal could be waded and during the higher stages at bridge No. 2.

DISCHARGE MEASUREMENTS of Canadian Pacific Railway Company's Canal near Calgary, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge. height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 9	J. C. Keith	54.5	156.9	1.78	2.4	279.46
May 21	do	63.5	70.02	2.2	1.55	154.18
June 15	do	55.0	133.27	1.54	2.0	205.25
June 27	do	55.5	200.98	2.15	3.3	432.28
July 13	do	56.0	226.46	2.15	3.64	486.75
Aug. 8	do	56.0	220.78	2.226	3.6	491.5
Aug. 27	do	56.0	184.73	1.87	2.7	343.45
Sept. 10	do	55.5	150.32	1.54	2.245	231.7
Oct. 3	H. R. Carscallen	60.7	206.79	1.9	3.01	391.94
Oct. 14	do	11.0	5.48	0.651	0.45	3.57

DAILY GAUGE HEIGHT AND DISCHARGE of Canadian Pacific Railway Company's Canal near Calgary, for 1910.

DAY.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	....	....	1.8	186	2.0	216
2	....	....	1.8	186	1.25	106
3	....	....	1.75	178	0.25	....
4	....	....	1.7	171	0.65	28
5	....	....	1.7	171	1.3	113
6	....	....	1.7	171	1.6	156
7	....	....	1.75	178	1.7	171
8	....	....	1.9	201	1.7	171
9	....	....	2.35	271	1.7	171
10	....	....	2.4	279	1.7	171
11	....	....	1.65	163	1.8	186
12	....	....	1.6	156	2.05	224
13	....	....	1.5	141	2.1	231
14	....	....	1.5	141	2.1	231
15	....	....	1.5	141	2.0	216
16	....	....	1.5	141	2.7	328
17	....	....	1.5	141	2.7	328
18	....	....	1.5	141	0.0	....
19	....	....	1.4	127	1.85	194
20	....	....	1.5	141	1.6	156
21	....	....	1.5	141	2.0	216
22	....	....	1.5	141	2.2	247
23	....	....	1.9	201	2.2	247
24	....	....	1.9	201	2.5	295
25	....	....	2.2	247	2.65	320
26	....	....	2.2	247	3.05	388
27	1.8	186	2.2	247	3.3	432
28	1.8	186	2.0	216	3.3	432
29	1.9	201	2.0	216	3.3	432
30	1.85	193	2.0	216	3.35	441
31	....	....	2.0	216	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Canadian Pacific Railway Company's Canal near Calgary, for 1910.—*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.4	449	3.8	521	2.3	263	2.77	340
2	3.45	458	3.8	521	2.3	263	2.85	354
3	3.6	485	3.6	485	2.25	255	2.9	362
4	3.9	539	3.6	485	2.35	271	3.0	379
5	4.15	586	3.6	485	2.35	271	2.65	320
6	4.3	615	3.6	485	2.35	271	2.15	240
7	4.3	615	3.6	485	2.3	263	1.62	159
8	4.3	615	3.6	485	2.3	263	.80	46
9	4.3	615	3.6	485	2.3	263	.55	17
10	4.3	615	3.6	485	2.3	263	.35	*
11	4.0	558	3.09	395	2.35	271	....	....
12	3.7	503	2.54	302	2.33	268	....	....
13	3.7	503	2.53	300	1.65	164	....	....
14	3.85	530	2.25	255	1.0	72	....	....
15	4.3	615	2.25	255	1.0	72	....	....
16	4.5	653	2.2	247	.92	62	....	....
17	4.35	625	2.0	216	.93	63	....	....
18	4.3	615	2.15	240	.95	66	....	....
19	3.8	521	2.3	263	1.8	186	....	....
20	3.7	503	2.25	255	2.52	299	....	....
21	3.7	503	2.2	247	2.38	276	....	....
22	3.7	503	2.2	247	2.5	295	....	....
23	3.6	485	2.35	271	2.0	216	....	....
24	3.8	521	2.6	312	2.0	216	....	....
25	4.05	567	2.65	320	2.0	216	....	....
26	4.0	558	2.7	328	2.0	216	....	....
27	4.1	577	3.05	388	1.97	212	....	....
28	4.05	567	3.5	467	1.95	209	....	....
29	4.0	558	3.0	379	2.35	271	....	....
30	3.8	521	3.0	379	2.75	337	....	....
31	3.8	521	3.0	379	....	....	....	....

* Canal closed for the season.

MONTHLY DISCHARGE of Canadian Pacific Railway Company's Canal near Calgary, for 1910.

Month.	Discharge in Second-Feet.			Total Discharge in acre-feet.
	Maximum.	Minimum.	Mean.	
April (27-30)	201	186	191.5	1,519
May	297	141	184.3	11,333
June	432	....	228.2	13,578
July	653	449	551.6	33,918
August	521	216	366.7	22,547
September	337	62	221.1	12,055
October (1-10)	379	....	221.7	4,396
The period				99,346

BOW RIVER NEAR NAMAKA.

This station was established in September, 1909, by P. M. Sauder. It is located near the dam and headgate of the Southern Alberta Land Company, on Sec. 31, Tp. 21, Rge. 25, W. 4th Mer. It is 11 miles by trail from Namaka and 15 miles from Langdon.

The river is divided into two channels at this point by an island. The greater volume of water flows through the South or right channel. In 1909, the Southern Alberta Land Company constructed a dam across the North channel and during the period covered by the records in this report there was no flow in this channel. When the dam is constructed across the South channel water will flow in both channels again, and if it is decided to continue observations at this point, a gauging station will be established on the North channel.

Discharge measurements are made on the South channel from a cable about 1,000 feet below the intake of the Southern Alberta Land Company's ditch. The channel is straight for 600 feet above and 800 feet below the cable. Both banks are high, free from brush, and not liable to overflow. The bed is composed of gravel and may shift during high stages of the stream. The current is fairly swift but uniform.

The gauge which is a plain staff, graduated to feet and hundredths, is fixed in a stilling box, in the right bank, about 400 feet up-stream from the cable. It is referred to a bench mark on the North end of the Headgate of the S. A. L. Co.'s Ditch; elevation 23.28. It is read by F. A. Wallace, C.E., Resident Engineer for the Southern Alberta Land Co.

The records at this station do not include the water diverted by the Canadian Pacific Railway Company.

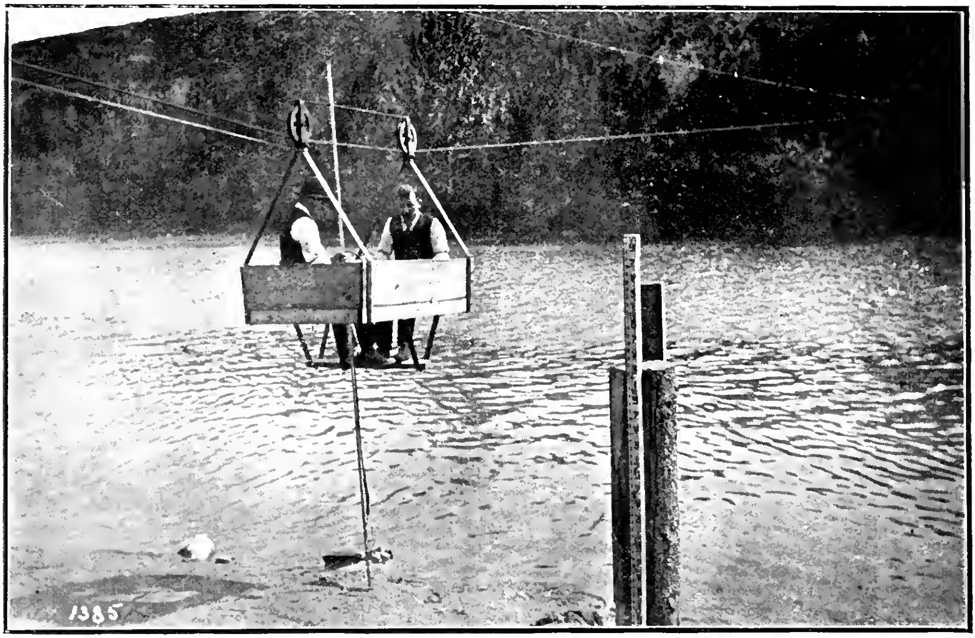
DISCHARGE MEASUREMENTS of Bow River near Namaka, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
May 17	P. M. Sauder	351	1,364.6	4.499	1.84	6,137.76
May 31	J. C. Keith	363	1,723.95	5.68	2.9	9,799.24
June 13	do	380	2,176.75	6.81	4.075	14,820.54
July 27	do	355	1,267.25	4.8	2.295	6,079.05
Aug. 25	do	348	1,045.15	4.29	1.67	4,488.78
Sept. 17	do	345	976.75	4.19	1.53	4,091.01
Nov. 15	H. R. Carscallen	303	764	3.07	0.31	2,342.66

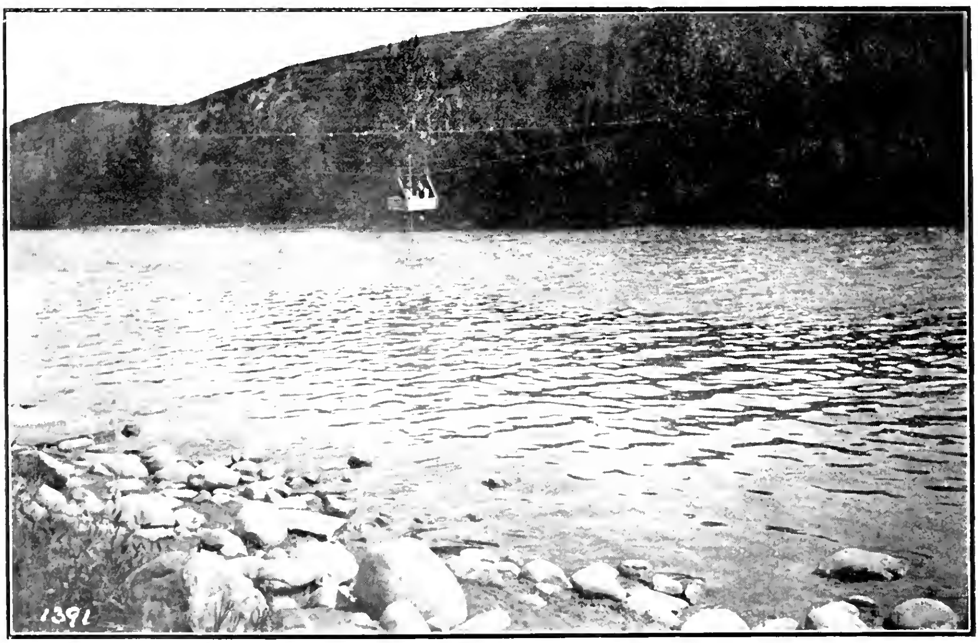
DAILY GAUGE HEIGHT AND DISCHARGE of Bow River, near Namaka, for 1910.

DAY.	March.		April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			0.05	2,333	1.4	4,965	2.75	9,218
2			0.02	2,232	1.28	4,679	2.88	9,722
3			0.2	1,985	1.25	4,610	2.86	9,644
4			0.3	1,855	1.1	4,275	2.82	9,488
5			0.09	2,134	1.07	4,209	2.8	9,410
6			0.13	2,079	1.12	4,319	2.7	9,025
7			0.19	1,999	1.3	4,725	2.8	9,410
8			0.19	1,998	1.7	5,745	2.93	9,918
9			0.19	1,999	2.1	6,915	2.98	10,116
10			0.13	2,078	2.3	7,575	3.15	10,798
11			0.07	2,162	2.45	8,095	3.05	10,395
12			0.17	2,026	2.3	7,575	3.4	11,810
13			0.15	2,057	2.15	7,075	*4.04	14,670
14			0.08	2,148	2.06	6,793	3.95	14,140
15			0.12	2,093	2.01	6,640	3.65	12,660
16			0.13	2,079	1.97	6,522	3.5	11,870
17			0.15	2,057	1.85	6,170	3.75	12,820
18			0.17	2,026	1.76	5,913	3.95	13,560
19			0.12	2,093	1.9	6,315	3.82	12,820
20			0.01	2,274	1.95	6,462	3.8	12,580
21			0.14	2,467	1.95	6,463	3.8	12,400
22			0.22	2,592	1.92	6,374	4.0	13,080
23	2.5	8,270	0.25	2,640	1.9	6,315	3.4	10,330
24	3.0	10,195	0.3	2,720	2.18	7,171	3.2	9,340
25	2.9	9,800	0.35	2,805	2.65	8,835	*3.05	8,577
26	2.7	9,025	0.55	3,158	3.1	10,595	3.1	8,760
27	1.9	6,315	0.90	3,845	3.5	12,225	3.2	9,140
28	1.7	5,745	1.24	4,587	3.65	12,875	3.3	9,530
29	1.55	5,345	1.6	5,475	3.4	11,810	3.35	9,730
30	0.9	3,845	1.53	5,293	3.1	10,595	3.50	10,340
31	0.55	3,157			2.88	9,722		

* Changing conditions, June 13th to June 25th. Bolster method used.



Cable Car and Gauge on Elbow River at Calgary, Alta.



Cable and Car on Elbow River at Calgary, Alta.

DAILY GAUGE HEIGHT AND DISCHARGE of Bow River, near Namaka, for 1910.—*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.4	9,930	2.0	5,265	1.25	3,620	1.25	3,620
2	3.25	9,335	2.0	5,265	1.25	3,620	1.25	3,620
3	3.2	9,140	1.95	5,138	1.22	3,569	1.26	3,637
4	3.2	9,140	1.9	5,010	1.2	3,535	1.15	3,455
5	3.15	8,950	1.8	4,760	1.2	3,535	1.2	3,535
6	2.95	8,218	2.1	5,530	1.2	3,535	1.2	3,535
7	2.95	8,218	2.7	7,360	1.4	3,885	1.2	3,535
8	2.9	8,040	2.7	7,360	1.6	4,290	1.2	3,535
9	2.9	8,040	2.6	7,030	1.55	4,183	1.4	3,885
10	2.9	8,040	2.6	7,030	1.53	4,139	1.3	3,705
11	2.9	8,040	2.5	6,705	1.55	4,183	1.4	3,885
12	2.87	7,937	2.47	6,609	1.55	4,182	1.5	4,075
13	2.9	8,040	2.45	6,545	1.55	4,183	1.55	4,182
14	2.95	8,217	2.45	6,545	1.53	4,139	1.5	4,075
15	3.05	8,578	2.4	6,385	1.53	4,140	1.4	3,885
16	3.1	8,760	2.35	6,232	1.53	4,139	1.32	3,741
17	3.1	8,760	2.28	6,024	1.45	3,980	1.33	3,759
18	3.15	8,950	2.05	5,398	1.4	3,885	1.35	3,795
19	3.2	9,140	2.0	5,265	1.3	3,705	1.4	3,885
20	3.1	8,760	1.98	5,214	1.3	3,705	1.46	3,999
21	3.0	8,395	1.9	5,010	1.35	3,795	1.3	3,705
22	2.85	7,867	1.9	5,010	1.38	3,849	1.26	3,637
23	2.7	7,360	1.8	4,760	1.4	3,885	1.2	3,535
24	2.6	7,030	1.72	4,568	1.45	3,980	1.09	3,360
25	2.5	6,705	1.6	4,290	1.45	3,980	1.06	3,315
26	2.45	6,545	1.55	4,182	1.5	4,075	1.05	3,300
27	2.4	6,385	1.45	3,980	1.5	4,075	0.98	3,196
28	2.3	6,080	1.3	3,705	1.55	4,183	0.95	3,153
29	2.2	5,800	1.22	3,569	1.3	3,705	0.9	3,080
30	2.1	5,530	1.24	3,603	1.25	3,620	0.82	2,968
31	2.0	5,265	1.28	3,671	....	....	0.8	2,940

MONTHLY DISCHARGE of Bow River near Namaka, for 1910.

Month.	Discharge in Second-Feet.			Run-Off.
	Maximum.	Minimum.	Mean.	Total in acre-feet.
March 23-31	10,195	3.157	6855.2	122,374
April	5,475	1,855	2576.3	153,302
May	12,875	4,209	7179.3	441,437
June	14,670	8,577	10843.4	645,204
July	9,930	5,265	7909.5	486,339
August	7,360	3,569	5387.7	331,277
September	4,290	3,535	3910.0	232,660
October	4,182	2,940	3597.8	221,220
The period				2,633,813

ELBOW RIVER AT CALGARY.

This station was established May 8th, 1908, by P. M. Sauder. It is located near the old General Hospital in Calgary, in the S.E. ¼ Sec. 15, Tp. 24, Rge. 1, W. 5th Mer. There are no tributaries below this station and there is no water diverted from the river except that used by the City of Calgary, whose intake is about eleven miles up-stream.

The stream is confined to one channel. The left bank is high and does not overflow. The right bank is covered with brush and may overflow at extreme flood stage of the stream. The bed of the stream is composed of boulders and gravel and is not liable to change at the station, but may do so further up the stream where there is a small ripple. The channel is straight for about 500 feet below and above the station. The current is slow in low water stages of the stream but fairly swift in the higher stages.

Discharge measurements are made by means of a cable-car, tagged wire, and stay wire. The initial point for soundings is the zero of the tagged wire, at its fastening to the cable support, on the left bank.

The gauge is a plain staff gauge, graduated to feet and hundredths, attached to a twelve inch post sunk in the bed of the stream at the left bank. It is referred to a bench mark on a post on the left bank about 31 feet North of the cable; elevation 15.26, and to a bench mark on the hydrant on the corner of 13th Ave., and 6th St. E.; elevation 19.62. It was read daily during 1910 by Mrs. I. S. White.

Discharge Measurements of Elbow River at Calgary, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec*	*Feet.*	*Sec.-ft.*
May 11	J. C. Keith	135	306.5	1.06	1.04	325.39
May 27	do	139	371.05	1.48	1.50	548.04
June 15	do	136	350.95	1.28	1.33	450.55
July 11	do	135	298.70	0.925	0.965	276.27
Aug. 6	do	135	298.75	0.93	0.97	278.74
Aug. 26	do	134	284.25	0.825	0.86	234.87
Sept. 19	do	140	395.45	1.64	1.655	647.00
Oct. 6	H. R. Carscallen	106	316.05	1.03	1.06	326.97
Nov. 3	do	133	278.20	0.81	0.80	225.58
Nov. 24	do	104	255.25	0.385	0.84	98.29*†
Dec. 14	do	126	221.70	0.57	1.10	126.43*
Dec. 31	do	120	210.95	0.333	1.00	70.32*

* Ice conditions.
† Measurement taken at Bridge 400 yards down stream.

Daily Gauge Height and Discharge of Elbow River at Calgary, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge. Height.	Discharge.
	Feet.	*Sec. ft.*	*Feet*	*Sec. Feet.*	*Feet.*	*Sec. Ft.*	*Feet.*	*Sec.-ft.*
1	.00	76	.55	160	1.10	336	1.21	387
2	.00	.76	.54	158	1.36	468	1.20	382
3	.00	.76	.53	156	1.30	434	1.18	372
4	.00	76	.53	156	1.25	407	1.15	358
5	.00	76	59	170	1.18	372	1.08	328
6	.00	.76	.61	174	1.15	358	1.05	315
7	.00	76	.70	196	1.13	349	1.03	307
8	.00	76	.82	230	1.35	462	1.02	302
9	.00	76	1.15	358	1.32	445	1.00	294
10	.00	76	1.17	368	1.35	462	.99	290
11	.00	76	1.13	349	1.34	456	.98	286
12	.00	76	1.12	345	1.65	650	.94	270
13	.00	76	1.07	323	1.55	582	.92	263
14	.00	76	1.05	315	1.46	526	.95	274
15	.01	77	1.01	298	1.35	462	.99	290
16	.09	87	.99	290	1.41	496	.99	290
17	.24	108	.98	286	1.57	596	.97	282
18	.26	110	.97	282	1.58	602	.97	282
19	.30	116	1.03	307	1.46	526	.98	286
20	.31	118	1.04	311	1.57	596	.96	278
21	.33	121	1.03	307	1.58	602	.93	267
22	.34	122	1.01	298	1.56	589	.92	263
23	.34	122	1.00	294	1.34	456	.90	256
24	.34	122	.99	290	1.28	423	.86	243
25	.35	124	1.21	387	1.20	382	.84	237
26	.39	130	1.58	602	1.17	368	.83	233
27	.43	137	1.54	576	1.23	397	.82	230
28	.47	144	1.35	462	1.22	392	.85	240
29	.56	162	1.26	412	1.22	392	.79	221
30	.57	165	1.15	358	1.22	392	.76	213
31	....	....	1.12	345	....	....	.73	204

Daily Gauge Height and Discharge of Elbow River at Calgary, for 1910.—*Continued.*

Day.	August.		September.		October.		November.		December.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	.72	202	.90	256	1.16	363	.82	230	1.24	161
2	.72	202	.86	243	1.13	349	.81	227	1.19	151
3	.71	199	.84	237	1.10	336	.80	224	1.21	154
4	.69	194	.89	253	1.12	345	.78	218	1.08	129
5	.79	221	.94	270	1.09	332	.76	213	1.06	126
6	.76	213	1.06	320	1.07	323	75	210	1.01	117
7	1.01	298	1.22	392	1.03	307	.74	207	1.13	136
8	1.16	363	1.18	372	1.04	311	.73	204	1.07	126
9	1.13	349	1.12	345	1.04	311	.72	202	1.11	132
10	1.15	358	1.06	320	1.06	320	.71	199	1.05	120
11	1.26	412	1.15	358	1.05	315	1.07	323	.99	112
12	1.24	402	1.20	382	1.05	315	.85	240	1.01	114
13	1.18	372	1.25	407	1.04	311	.79	221	.97	107
14	1.17	368	1.25	407	1.03	307	.86	243	1.12	130
15	1.19	377	1.33	451	1.01	298	.85	240	1.16	134
16	1.13	349	1.46	526	.99	290	.84	237	1.32	160
17	1.10	336	1.54	576	.97	282	.78	218	1.17	130
18	1.05	315	1.65	650	1.01	299	*.75	210	1.14	123
19	1.00	294	1.66	657	.97	282	.94	240	1.21	132
20	.98	286	1.58	602	.95	274	.94	212	1.23	132
21	.95	274	1.54	576	.94	270	1.12	238	1.225	128
22	.94	270	1.45	520	.92	263	1.15	212	.90	80
23	.93	267	1.43	508	.91	260	1.00	146	.84	72
24	.93	267	1.41	496	.89	253	.97	116	1.145	110
25	.92	263	1.36	467	.88	250	.79	90	1.195	114
26	.87	246	1.31	440	.90	256	1.06	130	1.18	108
27	.84	237	1.28	423	.88	250	1.22	157	1.235	115
28	.79	221	1.27	418	.87	246	1.26	166	1.095	90
29	.85	240	1.24	402	.86	243	1.41	204	1.06	84
30	.86	243	1.20	382	.85	240	1.35	188	1.04	80
31	.95	274	......	......	.84	237	......	......	*1.095	82

* Ice conditions from Nov. 18th to Dec. 31st.

Monthly Discharge of Elbow River at Calgary, for 1910.

Drainage area, 482 square miles.

Month.	Discharge in Second-Feet				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in Acre Feet.
April	165	76	101	0.209	0.233	6,009
May	602	156	308.5	0.640	0.738	18,970
June	650	336	466	0.967	1.08	27,727
July	387	204	282	0.585	0.675	17,340
August	412	194	287.5	0.596	0.687	17,678
September	657	237	421.9	0.875	0.976	25,103
October	363	237	291.6	0.605	0.698	17,930
November	323	90	205.5	0.426	0.475	12,228
December	161	72	119	0.247	0.285	7,317
The period						150,302

Jumpingpound Creek near Jumping Pound.

This station was established in 1906, by J. F. Hamilton. It is located at a traffic bridge on a road diversion on Sec. 30, Tp. 24, Rge. 4, W. 5th Mer., and about 300 yards from Jumping Pound, P.O.

The channel is straight for about 600 feet below the station. The current is sluggish at and above the station, but breaks into rapids about 150 feet below the station. The right bank is composed of gravel and boulders, covered with clay, and not liable to overflow. The left bank is similar, but not so high, and liable to overflow in excessive floods. The bed of the stream is composed of coarse gravel and boulders. It is rough and may shift in flood stages. The stream is divided into several channels during its higher stages by a pier and pile bents supporting the bridge.

At low water stage of the stream discharge measurements are made at wading sections, either above or below the bridge. During higher stages of the stream, discharge measurements are made from the down stream side of the bridge. The initial point for soundings is the West side of the right abutment. Distances are marked on the railing of the bridge, at every five feet from the initial point.

The gauge, which is a plain staff, graduated to feet and hundredths is attached vertically to the down-stream face of the first pile bent West of the main truss of the bridge. It is referred to a bench mark on the North end of the cap of the right pile bent; elevation 10.90 above the zero of the gauge.

The gauge was read during 1910 by John Bateman, the postmaster at Jumping Pound.

Discharge Measurements of Jumpingpound Creek at Sec. 30, Tp. 24, Rge. 4, W. 5th M., near Jumping Pound.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge
1910		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 23	J. C. Keith	54	32.50	1.11	2.08	36.19†
June 28	do	54	166.53	0.16	1.97	26.38†
July 21	do	68	148.54	0.05	1.78	7.42
Aug. 16	do	77.8	163.67	0.156	1.98	25.53†
Sept. 7	do	90	177.03	0.214	2.10	38.02†
Sept. 30	H. R. Carscallen	101	215.14	0.22	2.12	47.22

† At wading stations near regular station.

Daily Gauge Height and Discharge of Jumpingpound Creek near Jumping Pound, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			2.00	27	1.90	16
2			2.00	27	1.90	9
3			2.00	27	2.10	40
4			2.00	27	2.10	40
5			2.00	27	2.00	27
6			2.00	27	2.00	27
7			2.00	27	2.00	27
8			2.00	27	2.00	27
9	1.80	9	2.00	27	2.10	40
10	1.80	9	2.00	27	2.10	40
11	1.80	9	2.00	27	2.10	40
12	1.80	9	2.00	27	2.10	40
13	1.80	9	2.00	27	2.10	40
14	1.80	9	2.00	27	2.10	40
15	1.80	9	1.90	16	2.10	40
16	1.80	9	1.90	16	2.10	40
17	1.80	9	1.90	16	2.20	57
18	1.80	9	1.90	16	2.20	57
19	1.90	16	2.00	27	2.20	57
20	1.90	16	2.00	27	2.30	76
21	1.90	16	2.00	27	2.30	76
22	1.90	16	2.00	27	2.30	76
23	1.90	16	1.90	16	2.30	76
24	1.90	16	1.90	16	2.20	57
25	1.90	16	1.90	16	2.10	40
26	1.90	16	1.90	16	2.00	27
27	1.90	16	1.90	16	2.00	27
28	1.90	16	1.90	16	2.00	27
29	1.90	16	1.90	16	1.90	16
30	1.90	16	1.90	16	1.90	16
31			1.90	16		

DAILY GAUGE HEIGHT AND DISCHARGE of Jumpingpound Creek near Jumping Pound, for 1910. *Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.90	16	1.60	3.5	1.80	9	2.10	40
2	1.80	9	1.60	3.5	1.80	9	2.10	40
3	1.80	9	1.60	3.5	1.80	9	2.10	40
4	1.80	9	1.60	3.5	1.80	9	2.10	40
5	1.80	9	1.70	5	1.90	16	2.10	40
6	1.80	9	1.80	9	1.95	21	2.10	40
7	1.80	9	1.90	16	2.12	43	2.00	27
8	1.80	9	1.70	5	2.20	57	2.00	27
9	1.80	9	1.70	5	2.20	57	2.00	27
10	1.80	9	1.70	5	2.20	57	1.90	16
11	1.80	9	1.70	5	2.20	57	1.90	16
12	1.80	9	1.80	9	2.20	57	1.90	16
13	1.80	9	1.90	16	2.20	57	1.90	16
14	1.70	5	2.00	27	2.30	76	1.80	9
15	1.70	5	2.00	27	2.30	76	1.80	9
16	1.70	5	2.00	27	2.30	76	1.80	9
17	1.70	5	1.90	16	2.40	96	1.80	9
18	1.70	5	1.70	5	2.40	96	1.80	9
19	1.70	5	1.70	5	2.50	117	1.80	9
20	1.70	5	1.70	5	2.50	117	1.80	9
21	1.70	5	1.70	5	2.50	117	1.80	9
22	1.70	5	1.70	5	2.50	117	1.80	9
23	1.70	5	1.80	9	2.40	96	1.70	5
24	1.70	5	1.80	9	2.40	96	1.70	5
25	1.60	3.5	1.70	5	2.30	76	1.70	5
26	1.60	3.5	1.70	5	2.30	76	1.70	5
27	1.60	3.5	1.70	5	2.30	76	1.70	5
28	1.60	3.5	1.70	5	2.20	57	1.70	5
29	1.60	3.5	1.80	9	2.20	57	1.70	5
30	1.60	3.5	1.80	9	2.10	40	1.70	5
31	1.60	3.5	1.80	9	....	....	1.70	5

MONTHLY DISCHARGE of Jumpingpound Creek near Jumping Pound, for 1910.

Drainage area, 187 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (9-30)	16	9	12.8	.063	.052	560
May	27	16	22.4	.119	.137	1,377
June	76	9	40.6	.216	.241	2,416
July	16	3.5	6.56	.035	.040	403
August	27	3.5	8.9	.042	.048	547
September	117	9	64.0	.342	.382	3,808
October	40	5	16.5	.088	.101	1,014
The period						10,125

SPRAY RIVER NEAR BANFF.

This station was established July 15th, 1910, by J. C. Keith. It is located at a traffic bridge about one mile South-East of the Village of Banff, on the N.W. ¼ Sec. 25, Tp. 25, Rge. 12, W. 5th Mer., and about 100 yards above the junction with Bow River.

Discharge measurements are made from the down-stream side of the bridge. The initial point for soundings is the extreme West end of the bottom chord of the bridge.

The channel is straight for 50 feet above and 250 feet below the station. The right bank is low and may overflow at high stages of the stream. The left bank is steep and high. The bed is composed of coarse gravel and is not liable to shift. The current is swift but the surface is free from ripples at the station. A quantity of rock has been dumped into the channel at the left abutment of the bridge and affects the accuracy of the results.

The gauge is a plain staff, graduated to feet and hundredths, nailed to the down-stream end of the abutment. It is referred to bench marks as follows:—(1) Top of bolt near the West end of the guard rail on the North side of the bridge; elevation 13.27. (2) Top of bolt near the centre of the guard rail on the North side of the bridge; elevation 13.42.

The gauge is read by N. B. Sanson, Meteorological Observer, at Banff.

Discharge Measurements of Spray River near Banff, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
1910		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
July 15	J. C. Keith	108.5	233.82	6.22	1.95	1,452.45
Aug. 10	do	82.5	181.87	5.245	1.45	952.00
Aug. 31	do	77.5	127.23	3.85	.86	490.03
Sept. 22	do	74.5	134.52	4.14	.95	557.16
Oct. 19	H. R. Carscallen	73.0	120.69	3.77	.83	454.59
Nov. 5	do	72.5	100.10	3.12	.54	312.81
Dec. 2	do	57.0	178.35	1.960	.63	231.93
Dec. 24	do	52.0	91.35	2.43	.59	221.69

Daily Gauge Height and Discharge of Spray River, near Banff, for 1910.

Day.	July.		August.		September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			1.35	862	.85	480	.80	450				
2			1.30	820	.85	480	.80	450				
3			1.25	777	.80	450	.80	450				
4			1.35	862	.80	450	.80	450			1.92	3.50
5			1.35	862	.80	450	.75	422				
6			1.45	950	.90	510	.75	422			1.99	390
7			1.55	1,042	.90	510	.85	480			1.98	380
8			1.45	950	.85	480	.85	480			1.72	260
9			1.45	950	.85	480	.80	450			1.66	235
10			1.45	950	.85	480	.90	510			1.66	235
11			1.50	995	.80	450	.95	545			1.62	220
12			1.45	950	.80	450	.90	510			1.71	255
13			1.45	950	.80	450	.90	510			1.56	200
14			1.40	905	.80	450	.85	480			1.47	170
15	1.95	1,455	1.40	905	.80	450	.85	480			1.52	185
16	1.95	1,455	1.35	862	.85	480	.85	480			1.52	185
17	1.95	1,455	1.30	820	.85	480	.85	480			1.51	180
18	2.00	1,510	1.25	777	.90	510	.85	480			1.54	190
19	1.80	1,290	1.25	777	.90	510	.85	480			1.38	150
20	1.75	1,240	1.25	777	.95	545	.85	480			1.49	175
21	1.75	1,240	1.20	735	.95	545	.80	450			1.52	185
22	1.75	1,240	1.20	735	.95	545	.75	422			1.44	165
23	1.70	1,190	1.15	695	.95	545	.75	422			1.67	240
24	1.60	1,090	1.20	735	.95	545	.70	395			1.62	220
25	1.50	995	1.05	617	.95	545	.75	422			1.77	280
26	1.50	995	.95	545	.90	510	.70	395			1.75	275
27	1.45	950	.95	545	.85	480	.60	345			1.72	260
28	1.40	905	.90	510	.85	480	.60	345			1.80	290
29	1.35	862	.90	510	.85	480	.60	345			1.76	275
30	1.35	862	.85	480	.85	480	.60	345			1.58	210
31	1.35	862	.80	450			.60	345			1.64	230

No observations taken for November.
Ice conditions during December.
Auxiliary Gauge used during month of December.

MONTHLY DISCHARGE of Spray River, near Banff, for 1910.

Drainage area, 310 square miles.

Month.	Discharge in Second-Feet.			Run-Off.		
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
July (15-31)	1,510	862	1,153	3.72	2.35	38,876
August	1,042	450	784	2.53	2.92	48,198
September	545	450	490	1.58	1.76	29,157
October	545	345	443	1.43	1.65	27,213
November†						
December (4-31)	390	150	237	.764	.767	12,486
The period						155,930

† No observations taken for November.

DEVILS CREEK NEAR BANKHEAD.

This gauging station, located on the S.E. ¼ Sec. 28, Tp. 26, Rge. 11, W. 5th Mer., and within 300 yards of Lake Minnewanka Chalet, was established June 18th, 1910, by J. C. Keith. It is about 8 miles North and East of Banff.

The gauge is a plain staff, graduated to feet and hundredths, placed at the right bank. It is referred to two bench marks, (1) The top of a blazed tree stump five feet North of the gauge; elevation 4.76. (2) The top of a blazed tree stump 75 feet East of the gauge; elevation 5.27.

The channel is straight for about 100 feet above and 300 feet below the station. Both banks are low, swampy and covered with timber and brush. The stream bed is of soft mud and very uneven. Several hundred yards down-stream is an old dam which raises the water-level about three feet above normal. Consequently the water at the station is deep and sluggish, being apparently dead at ordinary stages of the creek. On this account all discharge measurements are made at the traffic bridge, close to the mouth of the creek on the trail from Banff. The creek here flows in a narrow channel over a rough rocky bed and between high rocky banks. The initial point for soundings is painted on the down-stream guard rail in line with the inner face of the left abutment.

The gauge was read daily by Commander Way, R.N., proprietor of the Lake Minnewanka Chalet.

DISCHARGE MEASUREMENTS of Devils Creek, near Bankhead, in 1910.

Date.		Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1910			*Feet.*	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June	4	J. C. Keith	23	35.25	3.65	....	128.65
"	18	do	25	44.10	4.25	1.96	187.23
July	18	do	24	33.26	3.43	1.73	113.96
Aug.	10	do	25	41.16	3.93	1.86	161.92
Sept.	1	do	24	29.30	2.77	1.58	84.89
Sept.	23	do	24	31.60	3.034	1.63	95.90
Oct.	18	H. R. Carscallen	24	30.75	2.78	1.52	85.54
Nov.	7	do	24	26.92	2.579	1.42	69.53
Dec.	3	do	24	25.80	2.403	1.34	61.99
"	28	do	24	27.12	2.179	1.16	59.10

DAILY GAUGE HEIGHT AND DISCHARGE of Devils Creek, near Bankhead, for 1910.

Day.	June.		July.		August.		September.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	......	......	1.90	163	1.57	87.3	1.58	88.7
2	......	......	1.89	160	1.57	87.3	1.56	85.9
3	......	......	1.84	143	1.57	87.3	1.56	85.9
4	......	......	1.85	146	1.56	85.9	1.56	85.9
5	......	......	1.85	146	1.65	99.5	1.59	90.1
6	......	......	1.80	131	1.81	134	1.60	91.5
7	......	......	1.78	126	1.86	149	1.60	91.5
8	......	......	1.78	126	1.86	149	1.62	94.7
9	......	......	1.78	126	1.87	153	1.60	91.5
10	......	......	1.78	126	1.86	149	1.58	88.7
11	......	......	1.76	121	1.85	146	1.59	90.1
12	......	......	1.76	121	1.84	143	1.58	88.7
13	......	......	1.75	118.5	1.81	134	1.58	88.7
14	......	......	1.74	116.4	1.81	134	1.57	87.3
15	......	......	1.72	112.2	1.80	131	1.57	87.3
16	......	......	1.72	112.2	1.81	134	1.56	85.9
17	......	......	1.72	112.2	1.81	134	1.56	85.9
18	......	......	1.70	108	1.76	121	1.59	90.1
19	1.95	183	1.69	106.3	1.73	114.3	1.62	94.7
20	2.00	204	1.69	106.3	1.71	110.1	1.64	97.9
21	2.02	213	1.68	104.6	1.69	106.3	1.64	97.9
22	2.00	204	1.65	99.5	1.66	101.2	1.64	97.9
23	1.97	191	1.64	97.9	1.68	104.6	1.64	97.9
24	1.96	187	1.62	94.7	1.65	99.5	1.64	97.9
25	1.96	187	1.59	90.1	1.64	97.9	1.62	94.7
26	1.94	179	1.59	90.1	1.62	94.7	1.60	91.5
27	1.95	183	1.59	90.1	1.60	91.5	1.60	91.5
28	1.95	183	1.59	90.1	1.58	88.7	1.63	96.3
29	1.94	179	1.59	90.1	1.58	88.7	1.58	88.7
30	1.92	171	1.59	90.1	1.60	91.5	1.55	84.5
31	......	......	1.59	90.1	1.60	91.5	......	......

DAILY GAUGE HEIGHT AND DISCHARGE of Devils Creek, near Bankhead, for 1910.—*Continued.*

Day.	October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.58	88.7	1.39	66.5	1.28	56.4
2	1.57	87.3	1.36	63.5	1.32	59.8
3	1.56	85.9	1.38	65.5	1.30	58
4	1.56	85.9	1.39	66.5	1.25	54
5	1.52	80.9	1.36	63.5	1.24	53
6	1.53	82.1	1.40	67.5	1.25	54
7	1.57	87.3	1.40	67.5	1.24	53
8	1.53	82.1	1.38	65.5	1.20	50
9	1.55	84.5	1.38	65.5	1.33	60.7
10	1.56	85.9	1.37	64.5	1.25	54
11	1.56	85.9	1.37	64.5	1.19	49
12	1.53	82.1	1.38	65.5	1.15	46
13	1.51	79.7	1.36	63.5	1.12	44
14	1.47	74.9	1.37	64.5	1.20	50
15	1.48	76.1	1.37	64.5	1.25	54
16	1.48	76.1	1.37	64.5	1.18	49
17	1.49	77.3	1.36	63.5	1.20	51
18	1.51	79.7	1.36	63.5	1.20	52
19	1.48	76.1	1.36	63.5	1.18	51
20	1.46	73.7	1.33	60.7	1.20	54
21	1.45	72.5	1.37	64.5	1.16	52
22	1.45	72.5	1.37	64.5	1.15	52
23	1.42	69.5	1.35	62.5	1.14	52
24	1.41	68.5	1.36	63.5	1.18	58
25	1.46	73.7	1.35	62.5	1.18	59
26	1.42	69.5	1.35	62.5	1.20	61
27	1.41	68.5	1.33	60.7	1.13	56
28	1.38	65.5	1.30	58.0	1.11	55
29	1.37	64.5	1.30	58.0	1.12	56
30	1.39	66.5	1.30	58.0	1.11	55
31	1.37	64.5			1.10	54

Ice conditions from Dec. 16th to Dec. 31st.

MONTHLY DISCHARGE OF Devils Creek, near Bankhead, for 1910.

Drainage area, 58 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
June (19-30)	213	171	.88.7	3.26	1.45	4,490
July	163	90.1	114.7	1.98	2.28	7,052
August	153	87.3	114.1	1.96	2.26	7,017
September	97.9	84.5	90.66	1.56	1.74	5,394
October	88.7	64.5	77.03	1.33	1.53	4,736
November	67.5	58.0	63.63	1.09	1.22	3,786
December	61	44.	53.64	.925	1.06	3,298
The period						35,773

FISH CREEK NEAR PRIDDIS.

This station was established May 13th, 1907, by P. M. Sauder. It is on the S. W. ¼ Sec. 26, Tp. 22, Rge. 3, W. 5th Mer., about one mile from Priddis, and near Mr. Percival's buildings.

A plain staff gauge, graduated to feet and hundredths, is placed vertically at the left bank, about 200 yards North of Mr. Percival's house. Bench Mark No. 1 is a block of wood fastened on the North-East corner of frame stable near the road; elevation 9.26. Bench Mark No. 2 is two spikes driven about two feet from the ground, in a telephone post 259 feet West of the gauge; elevation 8.65 above the zero of the gauge.

The channel is straight for 100 feet above and 200 feet below the station. The left bank is high, and will not overflow. The right bank is low, covered with brush and timber, and is liable to overflow at extreme high water. The bed is composed of gravel, but not liable to shift. The current is sluggish at extreme low stages of the stream.

Measurements are made by wading at or near the gauge, during low water stages of the stream, and high water stages are computed from slope measurements by the use of Kutter's formula. It is proposed to establish a cable station at this point for high water measurements.

The gauge was read by George Percival from May 1st to Sept. 22nd, and by Fred. Percival for the remainder of 1910.

DISCHARGE MEASUREMENTS of Fish Creek, near Priddis, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.	
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*	
April 27	J. S. Tempest					7.8	
May 14	J. C. Keith	12	7.55	1.68	0.99	12.66	†
June 6	do	12	8.32	1.67	1.05	13.92	†
July 4	do	25.5	14.25	0.114	0.54	1.64	†
Aug. 4	do					Nil.	†
Aug. 19	do	27.0	17.22	1.36	0.65	2.34	†
Sept. 12	do	37.5	41.58	0.747	1.37	30.99	
Oct. 7	H. R. Carscallen	31.5	27.86	0.306	0.91	8.52	†
Nov. 10	do	17.0	8.73	0.39	0.81	3.42	†

† These measurements were taken at wading stations, near the regular station.

DAILY GAUGE HEIGHT AND DISCHARGE of Fish Creek, near Priddis, for 1910.

Day.	May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	.8	5.5	.8	5.5	.6	1.9
2	.8	5.5	.9	8.2	.6	1.9
3	.8	5.5	1.0	11.5	.6	1.9
4	.8	5.5	1.1	15.5	.5	1.0
5	.9	8.2	1.1	15.5	.5	1.0
6	.9	8.2	1.1	15.5	.5	1.0
7	.9	8.2	1.0	11.5	.5	1.0
8	.9	8.2	.9	8.2	.5	1.0
9	.9	8.2	.9	8.2	.5	1.0
10	.9	8.2	.9	8.2	.5	1.0
11	1.0	11.5	.9	8.2	.4	.3
12	1.0	11.5	.9	8.2	.4	.3
13	1.0	11.5	.9	8.2	.4	.3
14	1.0	11.5	.8	5.5	.4	.3
15	.9	8.2	.7	3.4	.3	.0
16	.9	8.2	.7	3.4	.5	1.0
17	.9	8.2	.8	5.5	.3	.0
18	.9	8.2	.8	5.5		.0
19	.9	8.2	.8	5.5		.0
20	.9	8.2	.8	5.5		.0
21	.9	8.2	.9	8.2		.0
22	.9	8.2	.9	8.2		.0
23	.9	8.2	.9	8.2		.0
24	.9	8.2	.8	5.5		.0
25	.9	8.2	.8	5.5		.0
26	.85	6.8	.8	5.5		.0
27	.85	6.8	.7	3.4		.0
28	.8	5.5	.6	1.9		.0
29	.8	5.5	.6	1.9		.0
30	.8	5.5	.6	1.9		.0
31	.8	5.5				.0

DAILY GAUGE HEIGHT AND DISCHARGE of Fish Creek, near Priddis, for 1910.—*Continued.*

Day.	August.		September.		October.	
	Gauge Height	Dis-charge.	Gauge Height	Dis-charge.	Gauge Height	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1		.0	.9	8.2	.8	5.5
2		.0	.9	8.2	.8	5.5
3		.0	.9	8.2	.8	5.5
4		.0	.9	8.2	.8	5.5
5		.0	.8	5.5	.8	5.5
6		.0	.9	8.2	.8	5.5
7	.5	1.0	1.4	35.7	.91	8.5
8	.5	1.0	1.5	44.8	.91	8.5
9	.5	1.0	1.4	35.7	.97	10.5
10	.5	1.0	1.3	27.6	.88	7.6
11	.5	1.0	1.4	35.7	.88	7.6
12	.5	1.0	1.4	35.7	.86	7.1
13	.5	1.0	1.3	27.6	.86	7.1
14	.4	.3	1.2	20.8	.85	6.8
15	.7	3.4	1.2	20.8	.84	6.5
16	.7	3.4	1.2	20.8	.85	6.8
17	.7	3.4	1.1	15.5	.86	7.1
18 *	.7	3.4	1.1	15.5	.86	7.1
19	.7	3.4	1.0	11.5	.85	6.8
20	.6	1.9	.9	8.2	.86	7.1
21	.5	1.0	1.0	11.5	.86	7.1
22	.5	1.0	1.0	11.5	.86	7.1
23	.5	1.0	1.0	11.5	.86	7.1
24	.5	1.0	1.0	11.5	.86	7.1
25	.5	1.0	1.0	11.5	.86	7.1
26	.5	1.0	1.0	11.5	.83	6.3
27	.5	1.0	1.0	11.5	.83	6.3
28	.5	1.0	1.0	11.5	.83	6.3
29	.7	3.4	1.0	11.5	.83	6.3
30	.7	3.4	.8	5.5	.83	6.3
31	.8	5.5			.83	6.3

* Creek dry from July 18th to Aug. 6th.

MONTHLY DISCHARGE of Fish Creek, near Priddis, for 1910.
Drainage area, 109 square miles.

Month.	Discharge in Second Feet.			Run-Off.		
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches in Drainage area.	Total in acre-feet.
May	11.5	5.5	7.8	0.071	0.082	480
June	15.5	1.9	7.23	0.066	0.074	430
July	1.9	.0	.48	0.004	0.0046	30
August	5.5	.0	1.5	0.014	0.016	92
September	44.8	5.5	17.0	0.156	0.174	1,011
October	10.5	5.5	6.8	0.062	0.071	418
The period						2,461

NORTH BRANCH OF SHEEP RIVER AT MILLARVILLE.

This station was established May 22nd, 1908, by P. M. Sauder. The gauge which is a plain staff, graduated to feet and hundredths, is fastened to the East end of a crib work about 100 yards from Malcolm T. Millar's house on the S. W. ¼ Sec. 12, Tp. 21, Rge. 3, W. 5th Mer. It is referred to a bench mark on the South-West corner of Mr. Millar's house elevation 13.89 above the zero of the gauge. Discharge measurements are made at a wading section 50 yards down-stream from the gauge at low water. During high water and flood stages of the stream, discharge measurements are made from a steel highway bridge about one mile below the gauge, on the road allowance East of Section 12. The initial point for soundings is the outer edge of the bed plate on the down-stream side of the North end of the bridge. Distances from the initial point are marked at every five feet, on the bottom chord.

The stream is subject to sudden rises and at high stages the current is swift. During these periods the channel which is composed of gravel is liable to shift.

The gauge was read once each day by Malcolm T. Millar.

DISCHARGE MEASUREMENTS of North Branch of Sheep River at Millarville, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 16.........	J. C. Keith....................	21.5	18.51	1.46	1.9	26.96†
July 5.........	do	18	8.7	0.397	1.5	3.45†
Aug. 3.........	do	9	2.27	0.577	1.45	1.31
Aug. 20.........	do	9	1.99	0.66	1.49	1.32
Sept. 13.........	do	26.7	20.09	1.56	1.90	31.4 †
Oct. 7.........	H. R. Carscallen..............	27.3	21.17	1.085	1.84	22.98†
Nov. 10.........	do	20.0	11.98	0.388	1.55	4.65†

† These measurements taken at wading stations near regular station.

SOUTH BRANCH OF SHEEP RIVER NEAR BLACK DIAMOND.

This station was established May 23rd, 1908, by P. M. Sauder. It is located at the steel highway bridge on the road allowance between Secs. 8 and 17, Tp. 20, Rge. 2, W. 5th Mer. It is one-half mile from Black Diamond P.O.

The gauge which is of the standard chain type, is fastened to the floor of the bridge on the down-stream side, about midway between the west abutment and the centre pier. Bench mark No. 1, is two nail heads on the North face of the West abutment; elevation 9.37 above the zero of the gauge. Bench mark, No. 2, is a block of wood nailed to the North face of the centre pier; elevation 7.67. The chain used at first, was not satisfactory and was replaced by a chain of better quality on July 13th, 1909. Since then the results have been more satisfactory.

The channel is straight for about 300 feet above the station, then swings sharply to the left. It is straight for about 200 feet below the station, then turns gradually to the right. Both banks are composed of gravel. The right bank is low, partly covered with brush, and overflows in higher stages of the stream. The left bank is high and cannot overflow. The bed is composed of coarse gravel, is permanent at low water stage of the stream, but a gravel bar at the right bank, which is covered during high water stages is liable to shift. The river has considerable fall and the current is swift.

Discharge measurements are made from the down-stream side of the bridge. The initial point for soundings is the outer edge of the bed plate on the West end of the bridge. Distances from the initial point are marked every five feet, on the bottom chord of the bridge.

The gauge was read once each day by Herbert Arnold, merchant at Black Diamond.

DISCHARGE MEASUREMENTS of S. Branch Sheep River, near Black Diamond, in 1910.

Date.	Hydrographer	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1910		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 12.........	J. S. Tempest..................	....	....	....	....	163.329
May 16.........	J. C. Keith....................	76	94.45	1.78	0.84	167.11
June 7.........	do	77.5	125.45	2.685	1.31	336.94
July 5.........	do	75	89.85	1.85	0.88	166.54
Aug. 3.........	do	65	64.20	1.20	0.50	76.92
Aug. 20.........	do	74	85.84	1.65	0.80	141.87
Sept. 13.........	do	76.5	94.72	1.87	0.91	177.47
Oct. 8.........	H. R. Carscallen..............	74.0	93.58	1.62	0.83	151.88
Nov. 11.........	do	62.0	66.00	1.106	0.52	73.01

Daily Gauge Height and Discharge of S. Branch Sheep River, near Black Diamond, for 1910.

Day.	June.		July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge. Height	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.1	248	1.0	209	.5	72	.7	115	1.0	209
2	1.2	289	1.0	209	.5	72	.7	115	.9	174
3	1.1	248	.9	174	.5	72	.7	115	.9	174
4	1.0	209	.9	174	.5	72	.7	115	.9	174
5	1.1	248	.9	174	.6	91	.7	115	.8	142
6	1.2	289	.9	174	.7	115	1.0	209	.8	142
7	1.3	333	.9	174	.9	174	1.0	209	.8	142
8	1.2	289	.9	174	.8	142	.9	174	.83	152
9	1.2	289	.8	142	.8	142	.9	174	.9	174
10	1.2	289	.8	142	.8	142	1.0	209	.9	174
11	1.4	380	.8	142	.8	142	1.0	209	.88	168
12	1.5	428	.8	142	.7	115	1.0	209	.88	168
13	1.3	333	.8	142	.8	142	1.0	209	.83	152
14	1.2	289	.8	142	.9	174	1.0	209	.81	145
15	1.2	289	.8	142	.9	174	1.1	248	.80	142
16	1.2	289	.8	142	.9	174	1.2	289	.80	142
17	1.4	380	.9	174	.9	174	1.4	380	.80	142
18	1.3	333	.9	174	.9	174	1.5	428	.80	142
19	1.1	248	.8	142	.9	174	1.4	380	.85	158
20	1.2	289	.7	115	.9	174	1.2	289	.72	120
21	1.3	333	.7	115	.8	142	1.2	289	.72	120
22	1.1	248	.7	115	.7	115	1.2	289	.70	115
23	1.1	248	.7	115	.7	115	1.2	289	.68	110
24	1.1	248	.7	115	.7	115	1.2	289	.65	102
25	1.0	209	.6	91	.7	115	1.0	209	.70	115
26	1.0	209	.6	91	.7	115	1.1	248	.60	91
27	1.2	289	.6	91	.7	115	1.0	209	.50	72
28	1.1	248	.6	91	.6	91	1.0	209	.55	81
29	1.0	209	.6	91	.6	91	1.0	209	.60	91
30	1.0	209	.6	91	.6	91	1.0	209	.57	85
31	......	......	.6	91	.7	115	......	......	.55	81

Monthly Discharge of S. Branch Sheep River, near Black Diamond, for 1910.

Drainage area, 241 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
June	428	209	278	1.15	1.28	16,542
July	209	91	139	.576	.664	8,529
August	174	72	127	.526	.606	7,797
September	428	115	228	.947	1.057	13,585
October	209	72	136	.562	.648	8,330
The period	....	....	....	....	....	54,783

Sheep River near Okotoks.

This station was established by J. F. Hamilton in 1906. It is located at the Canadian Pacific Railway Bridge, about one mile from Okotoks, on the West boundary of Sec. 22, Tp. 20, Rge. 29, W. 4th Mer.

A plain staff graduated to feet and tenths, was at first attached to the North face of the North pier. Later, owing to the shifting of the main channel of the stream to the right, another gauge, graduated to feet and hundredths, was attached to the North face of the South pier. Both these gauges were referred to a bench mark on the top of the down-stream end of the North pier; elevation 11.48. The railway have rebuilt this bridge and when building the centre pier during the winter of 1910, imbedded a plain staff, graduated to feet and tenths, in the North face. The datum of the new gauge is 0.85 feet above that of the old gauge.

The new gauge was used during 1910, and was read by Miss Henderson, who lives about a quarter of a mile from the bridge.

The channel is straight for about 700 feet above and 300 feet below the station. The current is swift and the bed which is composed of coarse gravel, shifts considerably. Short piles, the remains of an old pier, a few feet upstream from the station, affect the accuracy of discharge measurements. The right bank is low and composed of gravel. It overflows at high stages and shifts. The left bank is low and composed of gravel and sand. It also overflows at high water and shifts.

Discharge Measurements were made from the downstream side of the bridge. The initial point for soundings is 155 feet from the north end of the trestle approach to the bridge. Distances from the initial point are marked at intervals of five feet along the downstream side of the bridge.

Sheep River falls rapidly. The banks and bed of the stream are composed of gravel and clay. The current is swift and during high water the channel shifts almost continuously. It is impossible to locate a suitable gauging station for high water stages and the daily discharges at these stages are approximate. During low water stage the channel seldom shifts and the results are fairly good. During the latter period, discharge measurements are made at a wading section about 200 yards downstream from the bridge.

DISCHARGE MEASUREMENTS of Sheep River near Okotoks, for 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 17	J. C. Keith	57.5	80.69	2.51	1.8	203.22
July 6	do	54.5	69.39	2.33	1.55	162.01
Aug. 2	do	50	48.90	1.58	1.07	77.41
Aug. 22	do	53	58.87	2.06	1.40	121.26
Sept. 14	do	56.5	76.40	2.66	1.80	203.09
Oct. 8	H. R. Carscallen	55.5	78.35	2.52	0.70	197.53*
Nov. 11	do	51.7	64.33	1.93	0.40	124.00

* This measurement was taken at wading station near regular station.

DAILY GAUGE HEIGHT AND DISCHARGE of Sheep River, near Okotoks, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Gauge	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.1	80	1.7	180	1.9	228
2	.9	59	1.7	180	1.9	228
3	.9	59	1.8	203	2.0	255
4	.9	59	1.9	228	2.0	255
5	1.0	69	2.0	255	1.8	203
6	1.0	69	2.0	255	2.0	255
7	1.1	80	2.1	284	2.1	284
8	1.1	80	2.3	345	2.0	255
9	1.1	80	2.1	284	2.0	255
10	1.2	93	2.0	255	2.0	255
11	1.2	93	1.9	228	2.1	284
12	1.2	93	1.8	203	2.3	345
13	1.2	93	1.8	203	2.1	284
14	1.2	93	1.8	203	2.0	255
15	1.2	93	1.8	203	1.9	228
16	1.2	93	1.8	203	2.0	255
17	1.3	107	1.8	203	2.1	284
18	1.3	107	1.85	215	2.2	314
19	1.5	140	2.0	255	2.2	314
20	1.6	159	2.0	255	2.2	314
21	1.5	140	1.9	228	2.1	284
22	1.4	123	1.9	228	2.0	255
23	1.3	107	2.1	284	1.9	228
24	1.3	107	2.2	314	1.9	228
25	1.5	140	2.3	345	1.7	180
26	1.7	180	2.5	408	1.7	180
27	1.8	203	2.3	345	1.8	203
28	1.8	203	2.1	284	1.8	203
29	1.7	180	2.0	255	1.8	203
30	1.7	180	1.9	228	1.8	203
31	....	....	1.9	228	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Sheep River, near Okotoks, for 1910.—*Continued.*

Day.	July		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.7	180	1.1	80	1.3	107	1.8	203
2	1.7	180	1.0	69	1.3	107	1.8	203
3	1.7	180	1.0	69	1.3	107	1.8	203
4	1.6	159	1.0	69	1.3	107	1.8	203
5	1.5	140	1.0	69	1.5	140	1.7	180
6	1.5	140	1.0	69	1.8	203	1.7	180
7	1.5	140	1.45	132	1.9	228	1.7	180
8	1.5	140	1.4	123	1.8	203	1.7	180
9	1.4	123	1.4	123	1.7	180	1.6	159
10	1.4	123	1.45	132	1.7	180	1.6	159
11	1.4	123	1.4	123	1.8	203	1.6	159
12	1.4	123	1.4	123	1.7	180	1.6	159
13	1.4	123	1.4	123	1.7	180	1.6	159
14	1.4	123	1.4	123	1.8	203	1.6	159
15	1.4	123	1.5	140	1.9	228	1.6	159
16	1.4	123	1.6	159	2.0	255	1.6	159
17	1.4	123	1.6	159	2.0	255	1.55	150
18	1.4	123	1.6	159	2.0	255	1.5	140
19	1.4	123	1.6	159	2.0	255	1.5	140
20	1.35	115	1.5	140	2.0	255	1.5	140
21	1.35	115	1.5	140	2.0	255	1.5	140
22	1.3	107	1.4	123	2.0	255	1.5	140
23	1.2	93	1.4	123	2.0	255	1.5	140
24	1.2	93	1.4	123	2.0	255	1.5	140
25	1.1	80	1.3	107	2.0	255	1.5	140
26	1.1	80	1.3	107	2.0	255	1.45	132
27	1.1	80	1.3	107	1.95	242	1.4	123
28	1.1	80	1.2	93	1.9	228	1.4	123
29	1.1	80	1.2	93	1.9	228	1.4	123
30	1.1	80	1.2	93	1.9	228	1.4	123
31	1.1	80	1.3	107	....	....	1.4	123

MONTHLY DISCHARGE of Sheep River near Okotoks, for 1910.

Draingage area, 624 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches in Drainage area.	Total in Acre-feet.
April	203	59	112	0.180	0.201	6,668
May	408	180	251	0.403	0.464	15,445
June	314	180	251	0.402	0.448	14,910
July	180	80	119	0.191	0.220	7,329
August	159	69	115	0.184	0.212	7,059
September	255	107	210	0.336	0.375	12,470
October	203	123	156	0.249	0.287	9,562
The period						73,443

Highwood River at High River.

This station was first established some years ago, by the Irrigation Surveys. It was re-established May 28, 1908, by P. M. Sauder. It is located at the highway bridge in the town of High River, on the N.W. ¼ Sec. 6, Tp. 19, Rge. 28, W. 4th Mer.

A plain staff gauge, graduated to feet and tenths, is fastened vertically to the downstream face of the centre pier. It is referred to bench marks as follows:—(1) top of crib pier to which the gauge height is fixed, elevation 10.41; (2) top of crib abutment on the left bank, elevation 10.40; (3) southwest corner of concrete pier supporting north end of C. P. R. bridge, elevation 8.38.

The channel is straight for about 300 feet above and below the station. The right bank is low and liable to overflow. It is composed of gravel and sand and covered with brush. The left bank is low but is protected from overflow by a crib work. The current is swift in high stages of the stream, but is sluggish in low water.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inside edge of the crib abutment, supporting the north end of the bridge. Distances are marked on the bottom chord of the bridge at every five feet from the initial point. There is an eddy about the centre pier and special care must be exercised by the hydrographer in making discharge measurements at this station. At extreme low water, a check measurement is made at a wading section about 300 yards below the bridge.

Little Bow Ditch diverts water from Highwood River at a point about half a mile above this station. For some time previous to 1910. the diverting dam was out of repair and water could only be diverted during high water periods. In the summer of 1910 this dam was repaired and water has since been diverted. A gauge was established on the canal and records of the flow are given below.

During the flood in 1908, Highwood River overflowed its left bank some distance above the traffic bridge and did considerable damage to property. To prevent a repetition of this occurrence, a highwater overflow channel has been constructed from the Lineham Mill Pond to the river. The water carried off through this spillway does not pass the gauging station. During 1910, there was no flood and there was only an occasional flow through the spillway when the Company raised the water in the pond to float logs. Miscellaneous discharge measurements of this flow were made on the same day that Highwood River was measured. The flow through the Little Bow Ditch and Lineham's Spillway should both be added to the flow at the traffic bridge to obtain . the total flow in Highwood River.

Daily observations of the gauge height at the regular station on Highwood River were made by W. E. M. Holmes during 1910.

Discharge Measurements of Highwood River at High River, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 12	H. C. Ritchie	136	441.72	1.77	3.05	780.04
May 18	J. C. Keith	133.7	432.42	1.61	2.99	696.61
June 9	do	141.2	453.97	2.105	3.225	955.92
July 7	do	89.4	365.43	1.35	2.68	492.94
July 30	do	79.4	328.61	0.67	2.15	219.85
Aug. 22	do	59.8	319.24	0.50	2.08	159.58
Sept. 14	do	80.4	325.39	0.77	2.27	251.59
Oct. 10	H. R. Carscallen	90.5	368.3	1.13	2.62	416.95
Nov. 12	do	100	103.5	1.75	2.14	180.77*

*Measurement taken at wading station near regular station.

DAILY GAUGE HEIGHT AND DISCHARGE of Highwood River, at High River, for 1910

Day.	April.		May.		June.	
	Gauge Height	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.ft.*
1	1.8	110	2.7	475	3.4	1,095
2	1.8	110	2.7	475	3.5	1,205
3	1.8	110	2.6	405	3.3	995
4	1.8	110	2.6	405	3.2	895
5	1.9	120	2.6	405	3.2	895
6	2.0	140	2.8	545	3.3	995
7	1.9	120	3.0	710	3.3	995
8	1.9	120	3.4	1,095	3.3	995
9	1.95	130	3.3	995	3.2	895
10	2.0	140	3.3	995	3.2	895
11	2.0	140	3.0	710	3.4	1,095
12	2.0	140	3.0	710	3.4	1,095
13	2.0	140	3.0	710	3.5	1,205
14	2.1	165	3.0	710	3.4	1,095
15	2.0	140	3.1	800	3.4	1,095
16	2.0	140	3.0	710	3.4	1,095
17	2.0	140	3.0	710	3.4	1,095
18	2.0	140	3.0	710	3.4	1,095
19	2.0	140	2.9	625	3.4	1,095
20	2.4	290	3.0	710	3.4	1,095
21	2.5	345	3.0	710	3.4	1,095
22	2.5	345	3.2	895	3.2	895
23	2.4	290	3.4	1,095	3.1	800
24	2.5	345	3.5	1,205	3.0	710
25	2.5	345	3.7	1,445	2.9	625
26	2.8	545	3.9	1,715	3.0	710
27	3.0	710	3.7	1,445	3.0	710
28	3.0	710	3.6	1,320	3.0	710
29	3.0	710	3.4	1,095	3.0	710
30	2.9	625	3.3	995	3.0	710
31	....	....	3.3	995	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Highwood River, at High River, for 1910.—*Con.*

Days.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.0	710	2.2	200	2.1	165	2.5	345
2	3.0	710	2.2	200	2.1	165	2.5	345
3	3.0	710	2.2	200	2.1	165	2.5	345
4	2.9	625	2.1	165	2.1	165	2.4	290
5	2.8	545	2.1	165	2.1	165	2.4	290
6	2.7	475	2.1	165	2.2	200	2.4	290
7	2.7	475	2.1	165	2.2	200	2.6	405
8	2.7	475	2.1	165	2.35	265	2.65	440
9	2.6	405	2.1	165	2.3	240	2.65	440
10	2.6	405	2.1	165	2.2	200	2.65	440
11	2.6	405	2.1	165	2.2	200	2.6	405
12	2.5	345	2.1	165	2.35	265	2.6	405
13	2.5	345	2.2	200	2.35	265	2.6	405
14	2.5	345	2.2	200	2.3	240	2.55	375
15	2.5	345	2.2	200	2.3	240	2.5	345
16	2.5	345	2.2	200	2.7	475	2.5	345
17	2.5	345	2.2	200	2.7	475	2.5	345
18	2.5	345	2.2	200	2.7	475	2.55	375
19	2.5	345	2.1	165	2.7	475	2.55	375
20	2.4	290	2.1	165	2.7	475	2.3	240
21	2.4	290	2.1	165	2.7	475	2.35	265
22	2.4	290	2.1	165	2.6	405	2.25	220
23	2.4	290	2.1	165	2.6	405	2.2	200
24	2.3	240	2.1	165	2.6	405	2.25	220
25	2.3	240	2.1	165	2.5	345	2.25	220
26	2.2	200	2.0	140	2.5	345	2.3	240
27	2.2	200	2.0	140	2.5	345	2.2	200
28	2.2	200	2.0	140	2.5	345	2.2	200
.9	2.2	200	2.0	140	2.5	345	2.1	165
30	2.2	200	2.1	165	2.5	345	2.1	165
31	2.2	200	2.1	165	....	....	2.1	165

MONTHLY DISCHARGE of Highwood River at High River for 1910.

Drainage area, 760 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	710	110	258.5	0.34	0.379	15,381
May	1,715	405	855.6	1.13	1.3	52,612
June	1,205	625	953.2	1.25	1.4	56,717
July*	400	226	398.4	0.524	0.604	24,497
August*	226	155	191.2	0.252	0.290	11,756
September*	540	178	351.3	0.462	0.515	20,904
October*	490	185	341.1	0.449	0.518	20,973
The period	....	....	....	....	....	202,840

* Includes Little Bow Ditch.

LITTLE BOW DITCH AT HIGH RIVER.

This canal, about 2,000 feet in length, was built by the Alberta Government to divert water from Highwood River into Little Bow River. This latter stream has a small flow and in the dry season does not supply sufficient water for domestic and stock watering purposes. Some time after its construction the diverting dam was damaged and the ditch was not used till the summer of 1910 when the dam was repaired. The gauging station near High River, Alta, on the Highwood River is below the intake to the ditch so the discharge of the latter must be added to that obtained for the former to get the total discharge of the main stream.

This gauging station, located on Sec. 6, Tp. 19, Rge. 28, W. 4th Mer., at the traffic bridge and 100 feet from the power house of the town of High River, was established August 1st, 1910, by J. C. Keith.

The gauge is a plain staff, graduated to feet and hundredths, spiked to the cribbing on the left bank. It is referred to a bench mark at the northeast corner of the power house foundation: elevation 12.18.

The channel is straight for several hundred feet above and below the station. Both banks are high, clean and steep, cribbed for 20 feet above and below the bridge, and will not overflow.

Discharge measurements are made from the bridge. The initial point for soundings is on a line with the cribbing on the left bank.

The gauge was read daily by Mr. Phil. Weinard.

Discharge Measurements of Little Bow Ditch at High River, in 1910

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 12	H. C. Ritchie	3.0	0.71	1.21	....	0.86
May 18	J. C. Keith					0.35†
June 9	do					Nil
July 6	do					Nil
Aug. 1	do	10.6	18.48	1.38	2.49	25.53*
Aug. 22	do	10.6	16.41	0.95	2.22	15.52
Sept. 14	do	10.6	22.06	1.72	2.72	37.99
Oct. 12	H. R. Carscallen	10.5	23.83	1.78	2.84	42.62
Nov. 12	do	10.5	17.43	1.178	2.22	20.54

* No Gauge Height was established before Aug. 1st, 1910.
† Discharge estimated.

Daily Gauge Height and Discharge of Little Bow Ditch at High River, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			2.5	26.5	2.2	14.5	2.82	41.5
2			2.5	26.5	2.17	13.0	2.82	41.5
3			2.42	23.5	2.3	18.5	2.8	40.5
4			2.32	19.5	2.4	22.5	2.8	40.5
5			2.32	19.5	2.5	26.5	2.75	38.0
6			2.32	19.5	2.7	35.5	2.72	36.5
7			2.4	22.5	3.02	51.5	2.72	36.5
8			2.5	26.5	2.8	40.5	3.0	50.5
9			2.35	20.5	2.7	35.5	2.95	48.0
10			2.32	19.5	2.7	35.5	2.9	45.5
11			2.32	19.5	2.8	40.5	2.9	45.5
12	3.1*	55.5	2.3	18.5	2.8	40.5	2.82	41.5
13	3.1	55.5	2.3	18.5	2.7	35.5	2.8	40.5
14	3.1	55.5	2.35	20.5	2.7	35.5	2.76	38.5
15	3.0	50.5	2.4	22.5	3.0	50.5	2.74	37.5
16	3.0	50.5	2.35	20.5	3.2	60.5	2.7	35.5
17	3.0	50.5	2.35	20.5	3.2	60.5	2.7	35.5
18	3.0	50.5	2.35	20.5	3.3	65.5	2.71	36.0
19	2.9	45.5	2.3	18.5	3.2	60.5	2.69	35.0
20	2.9	45.5	2.3	18.5	3.1	55.5	2.63	32.0
21	2.8	40.5	2.25	16.5	3.02	51.5	2.61	31.5
22	2.8	40.5	2.25	16.5	3.0	50.5	2.56	29.0
23	2.7	35.5	2.25	16.5	2.9	45.5	2.55	28.5
24	2.7	35.5	2.27	17.5	3.0	50.5	2.51	27.0
25	2.7	35.5	2.25	16.5	2.95	48.0	2.51	27.0
26	2.6	31.0	2.22	15.5	2.9	45.5	2.55	28.5
27	2.6	31.0	2.22	15.5	2.87	44.0	2.29	18.0
28	2.6	31.0	2.22	15.5	2.87	44.0	2.28	17.5
29	2.6	31.0	2.25	16.5	2.85	43.0	2.41	23.0
30	2.5	26.5	2.2	14.5	2.85	43.0	2.41	23.0
31	2.5	26.5	2.2	14.5			2.35	20.5

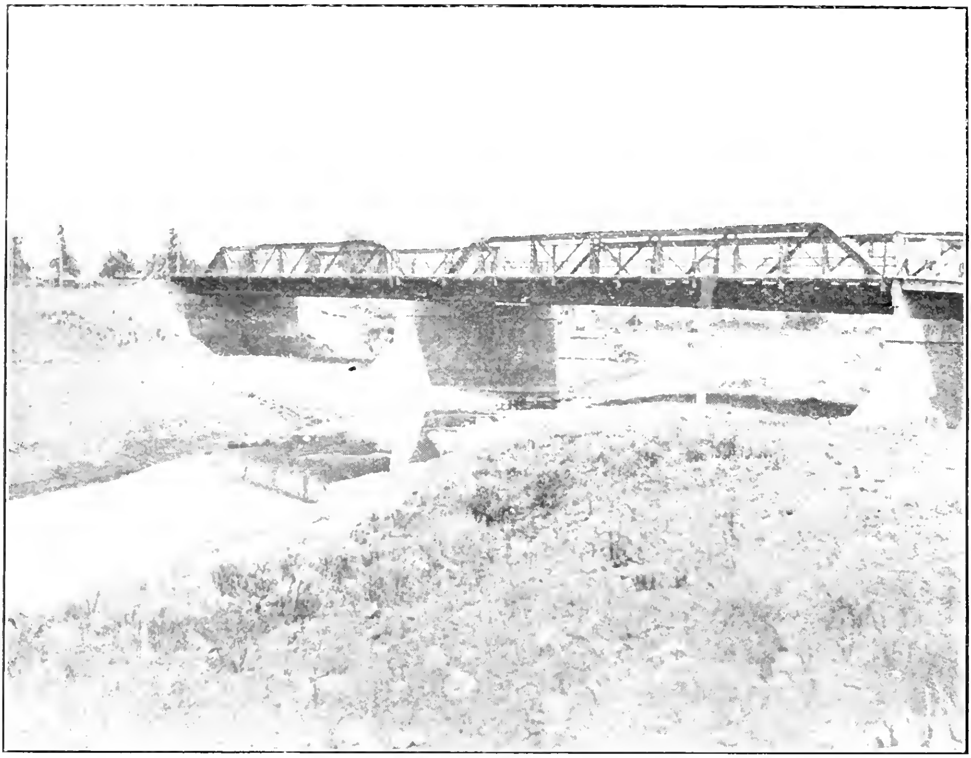
* Gauge height established on Aug. 1st, 1910, July 12th to 31st filled in by interpolation.

Miscellaneous Discharge Measurements of Bow River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Dis-charge.
				Feet.	*Sq.-Ft.*	*Sec.-ft.*
Aug. 1	Brown's Ditch	2-17-3-5	J. C. Keith			Nil.
May 24	Bighill Creek	10-26-4-5	"	10.4	4.68	6.76
June 29	"	"	"	10.5	4.85	4.85
July 22	"	"	"	10	4.74	4.53
Aug. 17	"	"	"	10.6	5.56	7.48
Sept. 8	"	"	"	11.8	9.83	17.63
" 30	"	"	H. R. Carscallen	10.8	5.64	4.93
May 24	Beaupre Creek	15-26-5-5	J. C. Keith			Nil.
June 29	"	"	"			Nil.
July 22	"	"	"			Nil.
Aug. 17	"	"	"			Nil.
Sept. 8	"	"	"	4.9	73	0.39
Oct. 1	"	"	H. R. Carscallen			Nil.
Sept. 5	Calgary Waterworks	N.W. 10-24-3-5	J. C. Keith	†4	7.91	10.65
" 5	"	"	"	*4	7.91	11.81
" 29	"	"	H. R. Carscallen	3.8	9.62	9.44
June 4	Cascade River	S.E. 7-26-11-5	J. C. Keith	78.5	147.87	714.45
Sept. 1	"	"	"	45	95	267.66
Oct. 18	"	"	H. R. Carscallen	50.8	134.23	275.49
Nov. 7	"	"	"	46.5	113.7	190.72
Aug. 1	Eckford's Ditch	10-19-29-4	J. C. Keith	3.3	0.84	0.66
April 24	Elbow River	25-23-2-5	J. S. Tempest			134.46
Dec. 20	" "	S.E. 10-24-3-5	H. R. Carscallen	37.5	65.3	179.48
" 3	Fisher's Ditch	8-20-2-5	J. C. Keith	2.8	0.43	0.23
" 4	Ford's Ditch	26-22-3-5	"			Nil.
" 4	Fish Creek So. Branch	26-22-3-5	"			Nil.
Aug. 4	FishCreek No. Branch	21-22-3-5	"			Nil.
Oct. 7	" "	"	H. R. Carscallen	11.2	9.9	2.23
June 4	Fortymile Creek	35-25 12-5	J. C. Keith	78.5	229.97	161.22
" 17	"	"	"	79	354.9	246.61
May 24	Grand Valley Creek	24-26-5-5	"	7.5	1.32	1.01
June 29	"	"	"	6	0.49	0.18
July 22	"	"	"			Nil.
Aug. 17	"	"	"	7	3.26	2.23
Sept. 8	"	"	"	9	7.3	8.12
Oct. 1	"	"	H. R. Carscallen	8	3.3	0.78
May 24	Ghost River	13-26-6-5	J. C. Keith	40.5	133.05	163.89
June 29	"	"	"	61	67.3	152.61
July 22	"	"	"	41	130.4	215.42
Aug. 17	"	"	"	69	142.85	325.78
Sept. 8	"	"	"	70	156.25	352.47
Oct. 1	"	"	H. R. Carscallen	67.5	148.08	264.67
July 30	Highwood River	17-18-2-5	J. C. Keith	63.5	66.47	224.54
Oct. 12	" "	"	H. R. Carscallen	131.5	197.02	419.78
Aug. 2	" "	N.E. 18-20-28-4	J. C. Keith	88	117.3	183.98
Oct. 10	" "	"	H. R. Carscallen	144	215.42	386.64
May 24	Horse Creek	8-26-4-5	J. C. Keith			Nil.
June 29	"	"	"			Nil.
July 22	"	"	"			Nil.
Aug. 17	"	"	"			Nil.
Sept. 8	"	"	"	7.5	2.59	2.14
Oct. 1	"	"	H. R. Carscallen			Nil.
Aug. 4	Jamieson's Ditch	21-22-3-5	J. C. Keith			Nil.
May 24	Jacob Creek	Stoney Indian Reserve	"			Nil.
Aug. 1	McLaughlin's Ditch	35-18-29-4	"	6	2.95	1.5
June 2	Meinsinger Creek	N.E. 14-17-4-5	J. S. Tempest	¶‡		0.06
May 11	Nose Creek	13-24-1-5	J. C. Keith	17.5	8.45	9.4
Aug. 27	"	"	"	9.8	2.3	2.51
Sept. 10	"	"	"	18.5	9	14.36
May 26	Pekisko Creek	N.W. 8-17-2-5	J. S. Tempest			26.94
June 4	"	N.E. 1-17-3-5	"			18.18
July 29	"	N.W. 8-17-2-5	J. C. Keith	10	2.81	1.51
Sept. 15	"	"	"	64.5	75.3	48.07
Oct. 11	"	"	H. R. Carscallen	61	62.53	24.57
May 19	Sullivan Creek	S.W. 20-18-3-5	J. S. Tempest			19.7
July 29	Stimson Creek	S.E. 14-17-2-5	J. C. Keith			Nil.
Sept. 15	"	"	"			Nil.
May 12	Spillway, on High-					
May 18	wood River	6-19-28-4	H. C. Ritchie			Nil.
June 9	"	"	J. C. Keith			Nil.
July 6	"	"	"			Nil.
Aug. 1	"	"	"	6.2	4.67	4.97
Aug. 22	"	"	"	6	4.59	3.77
Sept. 14	"	"	"	6.5	5.07	6.36
Oct. 10	"	"	"	6.3	5.11	4.1
	"	"	H. R. Carscallen	6.8	6.08	5.87

† One point method used.
* Two point method used.
¶ Creek was dry on this date, 1,000 feet downstream.
‡ Weir measurement

PLATE NO. 9.



Traffic Bridge over Lee Creek at Cardston, Alta

PLATE NO. 10.

Sharp-crested, Rectangular, Wooden Weir.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Bow River Drainage Basin, in 1910.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		*Sec.-ft.*
May 4......	Sheep River, N. Br..	N.E. 22-20-4-5....	J. S. Tempest.....	....	....	25.57
May 24......	Spencer Creek......	17-26-5-5.........	J. C. Keith.......	4.7	0.79	0.66
June 29......	"	"	"	4.5	0.65	0.48
July 22......	"	"	"	4.3	1.4	1.1
Aug. 17......	"	"	"	4.5	1.07	0.96
Sept. 8......	"	"	"	5	1.49	1.29
Oct. 1......	"	"	H. R. Carscallen...	6	2.02	0.89
May 20......	Trap Creek.........	N.W. 36-17-4-5....	J. S. Tempest.....	....	....	56.65
June 8......	Tongueflag Creek....	S.W. 19-19-28-4...	J. C. Keith.......	8.5	3.21	1.86
July 6......	"	"	"	....	....	Nil.
Aug. 2......	"	"	"	....	....	Nil.
Aug. 22......	"	"	"	....	....	Nil.
Sept. 14......	"	"	"	8	2.49	1.48
Oct. 10......	"	"	H. R. Carscallen...	6.3	1 68	0.27
June 8......	Wallace's Ditch.....	7-19-28-4.........	J. C. Keith.......	7	6.15	5.97
July 6......	"	"	"	12	8.4	17.96

LITTLE BOW RIVER DRAINAGE BASIN.

General Description.

The source of the Little Bow River is a spring near the Town of High River in Sec. 6, Tp. 19, Rge. 28, W. 4th Mer. From here it flows in a South-easterly direction for about 100 miles and empties into Belly River. In the first few miles, the flow is augmented by a number of springs, and later by Mosquito Creek.

There is a comparatively large flow in this stream during the spring freshets but during summer it would under natural conditions dry up. There are a large number of ranchers and settlers on this stream and it is very important that there should be a good flow for domestic and stock watering purposes. For this reason, the Provincial Government has constructed a canal and diverts water from Highwood River into Little Bow River whenever desired.

MOSQUITO CREEK, NEAR NANTON,

This station was established August 1, 1908, by H. C. Ritchie. It is located at a traffic bridge, about four miles from Nanton, on the road from Nanton to Cayley. The bridge is on a road diversion on Sec. 30, Tp. 16, Rge. 28, W. 4th Mer.

A plain staff gauge, graduated to feet and hundredths, was at first placed about twenty feet upstream from the bridge, in the bed of the stream at the right bank and stayed to posts driven in the bank. This location was not altogether suitable, being on the opposite side of the stream from the observer and the hole about the gauge was continually filling in with sand and mud. During the winter the gauge was disturbed by frost. On July 7, 1909, Mr. Ritchie re-established the gauge on the opposite bank of the stream and built a plank crib about it and the difficulties above mentioned have been overcome. The elevation of the gauge is referred to the top of two spike heads in the south side of the bridge pier at the right bank of the stream; elevation 11.47.

The channel is straight for about 175 feet below the station, then curves to the left. Above the station the channel curves slightly to the left for about 500 feet, then it turns sharply to the left. The right bank is low at water's edge but high a few feet from it. Sand and mud accumulates on this bank at high water. The left bank is high and is of solid clay with a few boulders. There is only one channel at low water. The bridge piers divide the stream into three channels at flood stage.

Discharge measurements are made from the bridge at high water and flood stages. The initial point for soundings is the north end of the bridge. The current is very sluggish at the bridge at low water, and during this stage, discharge measurements should be made at a wading section, a distance above or below the bridge.

The gauge was read daily by A. J. Clever, who lives about 1,200 feet north of the bridge.

DISCHARGE MEASUREMENTS of Mosquito Creek, near Nanton, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 14	H. C. Ritchie	17.5	8.99	0.79	2.53	7.16
June 9	J. C. Keith	6.0	1.93	1.62	2.36	3.02*
June 22	H. C. Ritchie	13.0	2.73	0.58	2.35	1.58
July 7	J. C. Keith				2.00	Nil.
Sept. 29	H. C. Ritchie	5.5	1.55	0.632	2.29	0.98
Oct. 24	do	6.5	1.90	0.89	2.37	1.69

* Measurement taken at Clever's farm.

DAILY GAUGE HEIGHT AND DISCHARGE of Mosquito Creek, near Nanton, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.95	46.5	2.64	11.78	2.39	2.34
2	2.9	38.5	2.64	11.78	2.41	2.7
3	2.9	38.5	2.55	6.7	2.43	3.1
4	2.88	35.7	2.53	5.98	2.48	4.34
5	2.9	38.5	2.51	5.26	2.43	3.1
6	2.86	32.9	2.51	5.26	2.4	2.5
7	2.86	32.9	2.5	4.9	2.38	2.18
8	2.81	26.7	2.59	8.78	2.38	2.18
9	2.80	25.5	2.49	4.62	2.37	2.02
10	2.76	21.5	2.55	6.7	2.37	2.02
11	2.77	22.5	2.61	9.92	2.36	1.86
12	2.75	20.5	2.6	9.3	2.29	1.03
13	2.72	17.8	2.55	6.7	2.28	.95
14	2 73	18.7	2.53	5.98	2.26	.78
15	2.7	16.0	2.51	5.26	2.25	.7
16	2.67	13.84	2.54	6.34	2.23	.58
17	2.62	10.54	2.5	4.9	2.23	.58
18	2.61	9.92	2.5	4.9	2.21	.46
19	2.6	9.3	2.5	4.9	2.19	.36
20	2.6	9.3	2.5	4.9	2.25	.7
21	2.6	9.3	2.5	4.9	2.26	.78
22	2.59	8.78	2.48	4.34	2.3	1.1
23	2.59	8.78	2.45	3.5	2.3	1.1
24	2.53	5.98	2.43	3.1	2.28	.95
25	2.51	5.26	2.42	2.9	2.2	.4
26	2.51	5.26	2.4	2.5	2.19	.36
27	2.51	5.26	2.39	2.34	2.14	.17
28	2.52	5.62	2.39	2.34	2.13	.14
29	2.54	6.34	2.38	2.18	2.12	.11
30	2.62	10.54	2.36	1.86	2.11	.08
31			2.36	1.86		

DAILY GAUGE HEIGHT AND DISCHARGE of Mosquito Creek, near Nanton, for 1910.—*Con.*

DAY.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.1	0.05	1.64	0.0	2.3	1.1	2.33	1.46
2	2.09	0.04	1.63	0.0	2.33	1.46	2.31	1.22
3	2.08	0.03	1.63	0.0	2.32	1.34	2.31	1.22
4	2.08	0.03	1.62	0.0	2.31	1.22	2.32	1.34
5	2.04	0.0	1.62	0.0	2.33	1.46	2.31	1.22
6	2.0	0.0	1.62	0.0	2.42	2.9	2.30	1.11
7	2.0	0.0	1.62	0.0	2.52	5.62	2.31	1.22
8	2.0	0.0	1.61	0.0	2.42	2.9	2.29	1.02
9	1.99	0.0	1.61	0.0	2.42	2.9	2.31	1.22
10	1.95	0.0	1.60	0.0	2.42	2.9	2.31	1.22
11	1.94	0.0	1.59	0.0	2.42	2.9	2.31	1.22
12	1.92	0.0	1.59	0.0	2.38	2.18	2.31	1.22
13	1.89	0.0	1.59	0.0	2.35	1.7	2.32	1.34
14	1.88	0.0	1.58	0.0	2.32	1.34	2.32	1.34
15	1.87	0.0	1.61	0.0	2.32	1.34	2.32	1.34
16	1.82	0.0	1.61	0.0	2.32	1.34	2.32	1.34
17	1.80	0.0	1.6	0.0	2.32	1.34	2.32	1.34
18	1.79	0.0	1.59	0.0	2.31	1.22	2.36	1.86
19	1.78	0.0	1.58	9.0	2.26	.78	2.39	2.34
20	1.77	0.0	1.57	0.0	2.25	.7	2.39	2.34
21	1.76	0.0	1.54	0.0	2.24	.64	2.38	2.18
22	1.73	0.0	1.52	0.0	2.23	.58	2.38	2.18
23	1.71	0.0	1.66	0.0	2.26	.78	2.38	2.18
24	1.71	0.0	1.66	0.0	2.39	2.34	2.37	2.02
25	1.7	0.0	1.65	0.0	2.41	2.7	2.37	2.02
26	1.69	0.0	1.65	0.0	2.35	1.7	2.37	2.02
27	1.68	0.0	1.65	0.0	2.37	2.02	2.4	2.5
28	1.67	0.0	1.64	0.0	2.31	1.22	2.4	2.5
29	1.66	0.0	1.63	0.0	2.3	1.1	2.4	2.5
30	1.65	0.0	1.62	0.0	2.31	1.22	2.4	2.5
31	1.64	0.0	1.62	0.0	....	....	2.41	2.7

July 5 to August 31 inclusive, no flow.

MONTHLY DISCHARGE of Mosquito Creek, near Nanton, for 1910.

Drainage area, 183 square miles.

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on area.	Total in acre-feet.
April	46.5	5.26	18.56	0.102	0.114	1,104
May	11.78	1.86	5.38	0.029	0.034	331
June	4.34	0.08	1.32	0.007	0.008	79
July	0.05	0.0	0.005	0.0	0.0	0
August	0.0	0.0	0.0	0.0	0.0	0
September	5.62	0.58	1.76	0.009	0.01	105
October	2.7	1.02	1.72	0.009	0.01	107
The period						1,726

Nanton Creek, near Nanton.

This station was established August 3, 1908, by P. M. Sauder. It is located at George Topper's Farm, near Nanton. It is on Sec. 20, Tp. 16, Rge. 28, W. 4th Mer., and almost directly west of Mr. Topper's stable.

The gauge, which is a plain staff, graduated to feet and hundredths, is driven vertically into the bed of the stream, at the left bank. It is attached by braces to posts in the bank. The bench mark is the top of a hub (wood stake with iron cap) on the right bank, about 75 feet south-east from the gauge; elevation 17.82 above the zero of the gauge.

This stream follows a very crooked course, but the channel is nearly straight for about 125 feet above the gauge and for about 75 feet below. The banks are well defined but not high and may overflow in excessive floods. The banks are composed of clay and covered with tough sod. The bed of the stream is composed of gravel, not liable to shift and free from vegetation.

Discharge measurements are made by wading at or near the gauge. At flood stage discharge measurements may be made at Mr. Topper's bridge, about 1,000 feet downstream from the gauge.

The gauge was read once each day by Mr. George Topper.

Discharge Measurements of Nanton Creek, near Nanton, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge. height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 13	M. C. Ritchie		2.92	.78	5.3	2.27
June 9	J. C. Keith		0.53		4.93	Nil.
June 22	H. C. Ritchie					Nil.
July 7	J. C. Keith					Nil.
*Sept. 29	P. M.Sauder		0.92	.377	5.03	.347
*Sept. 30	do		0 92	.377	5.03	.339
*Oct. 24	H. C. Ritchie		0.63	.238	4.96	.15

* Discharge determined by using 15 inch weir.
All areas calculated from cross section of May 13th.

Daily Gauge Height and Discharge of Nanton Creek, near Nanton, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	5 4	3.3	5.4	3.3	5.15	1.0
2	5.35	2.7	5.4	3.3	5.15	1.0
3	5 3	2.25	5.35	2.7	5.15	1.0
4	5.3	2.25	5.35	2.7	5.1	.7
5	5.25	1.75	5.35	2.7	5.0	.25
6	5.25	1.75	5.3	2.25	5.0	.25
7	5.2	1.35	5.25	1.75	5.0	.25
8	5.2	1.35	5.25	1.75	5.0	.25
9	5.2	1.35	5.25	1.75	5.0	.25
10	5.3	2.25	5.25	1.75	5.0	.25
11	5.35	2.7	5.3	2.25	5.0	.25
12	5.35	2.7	5.4	3.3	5.0	.25
13	5.35	2.7	5.3	2.25	0.0	0.0
14	5.35	2.7	5.3	2.25	0.0	0.0
15	5.35	2.7	5.3	2.25	0.0	0.0
16	5.35	2.7	5.3	2.25	0.0	0.0
17	5.35	2.7	5.3	2.25	0.0	0.0
18	5.35	2.7	5.25	1.75	0.0	0.0
19	5.35	2.7	5.35	2.7	0.0	0.0
20	5.35	2.7	5.3	2.25	0.0	0.0
21	5.35	2.7	5.3	2.25	0.0	0.0
22	5.35	2.7	5.3	2.25	0.0	0.0
23	5.35	2.7	5.3	2.25	0.0	0.0
24	5.35	2.7	5.3	2.25	0.0	0.0
25	5.35	2.7	5.25	1.75	0.0	0.0
26	5.35	2.7	5.2	1.35	0.0	0.0
27	5.3	2.25	5.2	1.35	0.0	0.0
28	5.3	2.25	5.2	1.35	0.0	0.0
29	5.35	2.7	5.2	1.35	0.0	0.0
30	5.35	2.7	5.2	1.35	0.0	0.0
31			5.2	1.35		

DAILY GAUGE HEIGHT AND DISCHARGE of Nanton Creek, near Nanton, for 1910.—*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.0	0.0	0.0	0.0	0.0	0.0	5.05	.45
2	0.0	0.0	0.0	0.0	0.0	0.0	5.05	.45
3	0.0	0.0	0.0	0.0	0.0	0.0	5.05	.45
4	0.0	0.0	0.0	0.0	0.0	0.0	5.05	.45
5	0.0	0.0	0.0	0.0	5.2	1.35	5.05	.45
6	0.0	0.0	0.0	0.0	5.6	6.3	4.95	.1
7	0.0	0.0	0.0	0.0	5.8	11.0	4.95	.1
8	0.0	0.0	0.0	0.0	5.8	11.0	4.95	.1
9	0.0	0.0	0.0	0.0	5.3	2.25	4.95	.1
10	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
11	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
12	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
13	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
14	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
15	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
16	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
17	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
18	0.0	0.0	0.0	0.0	5.05	.45	5.0	.25
19	0.0	0.0	0.0	0.0	5.05	.45	5.0	.25
20	0.0	0.0	0.0	0.0	5.05	.45	5.0	.25
21	0.0	0.0	0.0	0.0	5.05	.45	5.0	.25
22	0.0	0.0	0.0	0.0	5.05	.45	5.0	.25
23	0.0	0.0	0.0	0.0	5.05	.45	5.0	.25
24	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
25	0.0	0.0	0.0	0.0	5.1	.7	4.95	.1
26	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
27	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
28	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
29	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
30	0.0	0.0	0.0	0.0	5.05	.45	4.95	.1
31	0.0	0.0	0.0	0.0	......	......	4.95	.1

MONTHLY DISCHARGE of Nanton Creek, near Nanton, for 1910.

Drainage area, 44 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
April	3.3	1.35	2.45	.0557	.0621	146
May	3.3	1.35	2.14	.0486	.0560	131
*June	1.0	0.25	0.19	.0043	.0045	11
*July	......	......	......	......	......	......
*August	......	......	......	......	......	......
*September 5-30	11.0	0.45	1.66	.0377	.0364	86
October	0.45	0.1	0.185	.0042	.0048	11
The period	......	......	......	......	......	385

* Creek dry from June 13th to Sept. 5th.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Little Bow River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
Nov. 3....	Greig's Ditch.......	S.E. 11-16-29-4....	J. S. Tempest.....	....	....	0.06
June 17....	Nanton Creek.......	N.E. 22-15-29-4...	"	¶.......	....	0.138
" 20....	"	N.W. 31-15-28-4...	"	....	....	0.18
Sept. 30....	Spring A...........	N.W. 3-16-29-4....	P. M. Sauder.....	†.......	....	0.27
" 30....	"	"	"	†.......	....	0.04
Nov. 3....	"	S.W. 3-16-29-4....	J. S. Tempest.....	....	....	0.166
" 3....	"	N.W. 3-16-29-4....	"	....	....	0.034
June 20....	Spring Creek........	S.W. 12-16-29-4...	"	....	....	0.203
June 16....	Springhill Creek.....	"	"	*.......	....	0.118
" 20....	"	Sec. 3-16-29-4.....	"	....	....	0.404
Oct. 1....	"	S.W. 12-16-29-4...	P.M. Sauder......	....	....	0.41
Nov. 3....	"	S.E. 11-16-29-4....	J. S. Tempest.....	....	....	0.15
" 3....	Springhill Ck. Br. of	"	"	....	....	0.03
" 3....	Springhill Creek.....	"	"	‡.......	....	0.18
" 3....	"	N.E. 12-16-29-4...	"	....	....	0.02

‡ Below junction with Branch.
* Same Creek 1,000 ft. down-stream was dry on this date.
† These two springs combined form Springhill Creek, the 2nd is the one furthest West.
¶ Same Creek dry, one mile down-stream on this date, but at N.E. 25-15-29-4 had about 0.1 sec.-ft. discharge.

OLDMAN RIVER DRAINAGE BASIN.

General Description.

Oldman River, one of the principal tributaries of the South Saskatchewan River, is formed in the Livingstone Range of the Rocky Mountains by the junction of four small rivers, viz., Livingstone, Northwest Branch, West Branch and Racehorse Creek; and flows in a south and easterly direction to near Cowley where it is joined by the Crowsnest and Southfork Rivers. Between Cowley and Kipp, where it empties into the Belly River, the Oldman River is augmented by numerous small rivers and creeks, its course being easterly and northerly. It drains the area bounded on the north by the parallel of latitude through 59° 20′, on the south by a parallel through 49° 20′, and on the west by the Great Divide, this area being estimated to contain about 2,235 square miles, with topography varying from mountainous to rolling prairie.

The bed of the river is of rock and gravel and has a sharp fall with consequent swift water interspersed with falls and rapids, but it changes to quicksand and mud after reaching the prairie region where the current is more sluggish.

The flow of this river, draining as it does mountain ranges with peaks extending above the snow line, is subject to great changes, caused by melting snow and heavy summer rains in the mountains. Floods occur regularly in both May and June, the one in June generally rising higher and lasting longer. From this time on however the flow is normally steady but gradually decreases until the minimum is reached during January and February.

The precipitation throughout the basin is quite large, consequently, though almost entirely under cultivation where practicable there is little need of irrigation. Indeed, owing to the depth of the valley and its steep rocky banks, irrigation from this river would be expensive if not impossible, but there are many excellent power sites at its falls and rapids. Up to the present, however, no power has been developed on this river, but investigations with that end in view are being planned for the coming summer.

TROUT CREEK AT STEVENSON'S FARM.

This gauging station, located at the traffic bridge on the road allowance east of the S.E. ¼ Sec. 12, Tp. 12, Rge. 28, W. 4th Mer., and about 7 miles southwest of Claresholm, was established May 14th, 1909, by H. C. Ritchie.

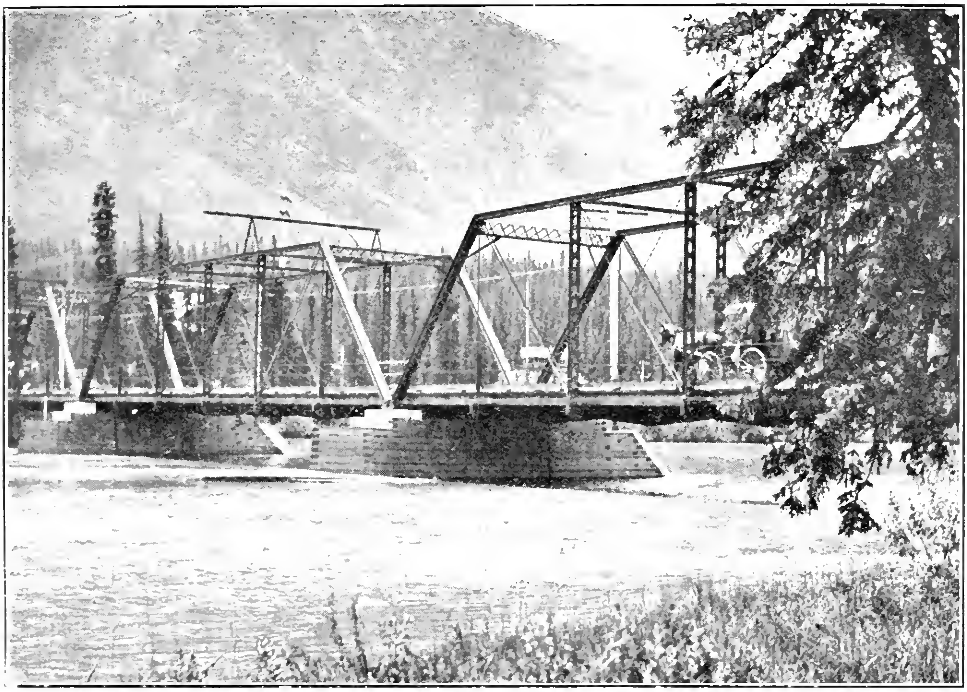
The gauge is a plain staff, graduated to feet and hundredths, fastened to the left abutment of the bridge. It is referred to a bench mark on top of the outer, downstream pile of the same abutment; elevation 7.99.

The channel is straight for 60 feet above and 50 feet below the station. Both banks are low wooded and liable to overflow during high water. The bed of the stream is sand and gravel. The current is fairly swift.

Discharge measurements are taken from the bridge during high water stages, the initial point for soundings being in line with the inner face of the left abutment. In low water the stream is waded at the same section.

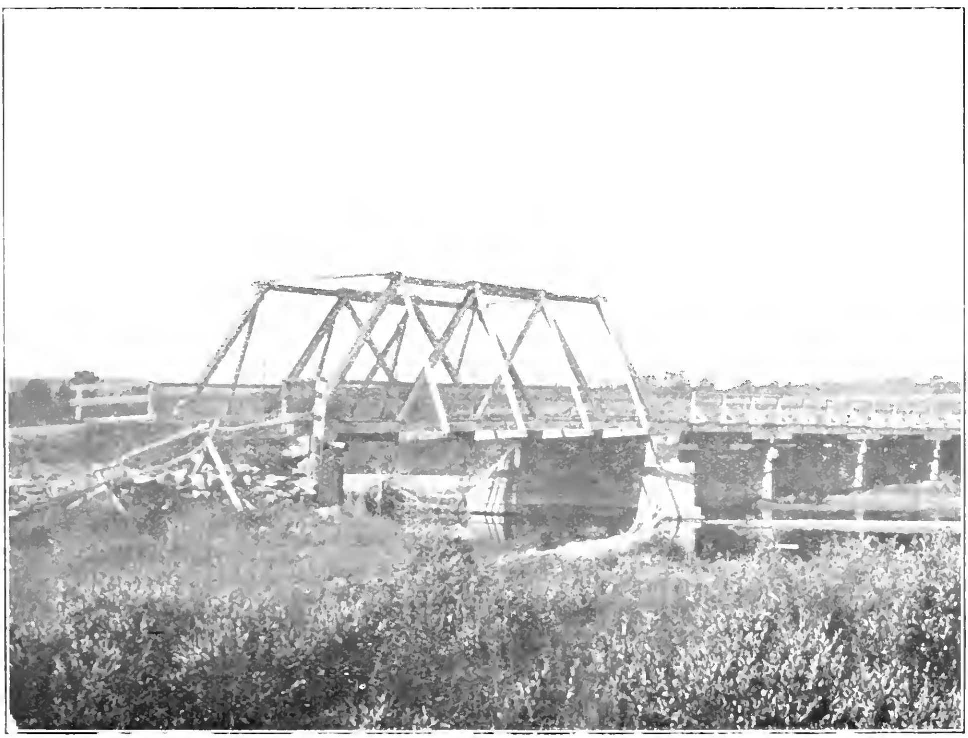
The gauge was read daily by Mr. John Stevenson.

Plate No. 11.



Traffic Bridge over the Bow River at Banff, Alta.

Plate No. 12.



Traffic Bridge over Jumpingpound Creek, near Jumping Pound, P. O., Alta

DISCHARGE MEASUREMENTS of Trout Creek, near Claresholm, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq. ft.*	*Ft per sec.*	*Feet.*	*Sec.-ft.*
May 17	H. C. Ritchie	28.0	13.52	0.44	0.75	5.92
June 10	J. C. Keith	9.0	2.31	1.24	0.65	2.86 *
June 21	H. C. Ritchie	2.2	0.49	0.51	0.43	0.25 *
July 11	"	2.4	0.31	0.547	0.40	0.17 *
Aug. 29	"	2.0	0.18	0.11	0.39	0.20 *
Sept. 26	"	27.8	9.65	0.33	0.65	3.14
Oct. 21	"				0.43	0.323†

* Measurements taken at wading stations near regular station.
† Discharge determined by using 15-inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Trout Creek, near Claresholm, for 1910.

DAY.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge. Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1						
2			.8	6.9	.6	2.1
3					.6	2.1
4					.6	2.1
5	.9	10.5	.8	6.9		
6					.6	2.1
7	.9	10.5	.8	6.9	.6	2.1
8					.6	2.1
9						
10			.8	6.9	.6	2.1
11					.6	2.1
12			.9	10.5		
13	.9	10.5			.5	.9
14			.9	10.5	.5	.9
15					.4	.2
16	.8	6.9				
17			.8	6.9	.4	.2
18	.8	6.9				
19			.9	10.5		
20					.4	.2
21			.8	6.9	.4	.2
22						
23	.8	6.9			.4	.2
24					.4	.2
25			.6	2.1	.4	.2
26			.6	2.1		
27	.8	6.9				
28			.6	2.1	.4	.2
29						
30	.8	6.9	.6	2.1	.4	.2
31						

Daily Gauge Height and Discharge of Trout Creek, near Claresholm, for 1910.—*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			.4	.2	.4	.2		
2	.4	.2						
3					.4	.2	.6	2.1
4								
5	.4	.2	.4	.2				
6			.4	.2	.4	.2	.6	2.1
7					.7	4.1		
8	.4	.2			.7	4.1	.6	2.1
9			.4	.2	.7	4.1		
10					.7	4.1		
11	.4	.2					.6	2.1
12	.4	.2			.7	4.1		
13			.4	.2	.7	4.1		
14	.4	.2			.7	4.1		
15					.7	4.1	.6	2.1
16	.4	.2	.4	.2	.7	4.1		
17			.4	.2	.7	4.1		
18							.6	2.1
19	.4	.2			.6	2.1		
20			.4	.2	.6	2.1		
21	.4	.2					.4	.2
22								
23	.4	.2	.4	.2	.6	2.1		
24								
25			.4	.2			.4	.2
26	.4	.2			.6	2.1		
27			.4	.2			.4	.2
28					.6	2.1		
29	.4	.2					.4	.2
30					.6	2.1		
21			.4	.2			.4	.2

Monthly Discharge of Trout Creek, near Claresholm, for 1910.

Dranage area, 168 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
April (8 days)	10.5	6.9	8.25	0.049	0.015	131
May (13 days)	10.5	2.1	6.25	0.037	0.018	161
June (19 days)	2.1	0.2	1.07	0.0063	0.0044	40
July (12 days)	0.2	0.2	0.2	0.0012	0.0005	5
August (12 days)	0.2	0.2	0.2	0.0012	0.0005	5
September (19 days)	4.1	0.2	2.85	0.017	0.012	107
October (11 days)	2.1	0.2	1.24	0.0073	0.003	27
The period						476

MUDDYPOUND CREEK, AT HART'S RANCHE.

This gauging station, located on the S.W. ¼ Sec. 27, Tp. 11, Rge. 28, W. 4th Mer., at the foot-bridge on L. O. Hart's ranche, was established July 27th, 1908, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed at the left bank 15 feet upstream, from the bridge. It is referred to a bench mark on an iron pin near a post 35 feet northeast of the gauge; elevation 8.94.

The channel is straight for 30 feet above and 110 feet below the station. Both banks are high, clayey, and liable to overflow in extreme floods. The bed is of clean gravel. The current is fairly swift.

Discharge measurements are taken from the bridge in high water, the initial point for soundings being marked at the left end of the bridge. At low stages the creek is waded about 100 feet upstream.

The gauge was read daily by Mrs. M. E. Hart.

DISCHARGE MEASUREMENTS of Muddypound Creek, Hart's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 17	H. C. Ritchie	13.5	11.95	0.14	2.05	1.71
May 17	"	8.0	2.23	0.85	2.05	1.89
June 10	J. C. Keith	6.0	1.35	0.79	2.04	1.07*
June 21	H. C. Ritchie					Dry*
July 11	"					Dry
Aug. 29	"					Dry
Sept. 26	"	5.5	1.02	0.78	2.03	0.8
Oct. 21	"				2.04	0.67†

*Measurement taken at wading station near regular station.
† Discharge determined by using 15 inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Muddypound Creek, at Hart's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.25	5.6	2.1	2.5	2.0	1.2
2	2.25	5.6	2.1	2.5	2.0	1.2
3	2.25	5.6	2.1	2.5	2.0	1.2
4	2.25	5.6	2.1	2.5	2.0	1.2
5	2.25	5.6	2.1	2.5	2.0	1.2
6	2.25	5.6	2.1	2.5	2.0	1.2
7	2.25	5.6	2.1	2.5	2.0	1.2
8	2.25	5.6	2.1	2.5	2.0	1.2
9	2.2	4.4	2.1	2.5	2.1	2.5
10	2.2	4.4	2.3	7.0	2.0	1.2
11	2.2	4.4	2.25	5.6	2.0	1.2
12	2.2	4.4	2.25	5.6	1.9	0.5
13	2.2	4.4	2.2	4.4	1.9	0.5
14	2.1	2.5	2.2	4.4	1.9	0.5
15	2.1	2.5	2.1	2.5	1.8	0.1
16	2.1	2.5	2.1	2.5	1.8	0.1
17	2.1	2.5	2.05	1.8	1.8	0.1
18	2.1	2.5	2.05	1.8	1.8	0.1
19	2.1	2.5	2.05	1.8	0	0
20	2.1	2.5	2.05	1.8	0	0
21	2.1	2.5	2.05	1.8	0	0
22	2.1	2.5	2.03	1.6	0	0
23	2.1	2.5	2.03	1.6	0	0
24	2.1	2.5	2.01	1.3	0	0
25	2.1	2.5	2.01	1.3	0	0
26	2.1	2.5	2.0	1.2	0	0
27	2.1	2.5	2.0	1.2	0	0
28	2.1	2.5	2.0	1.2	0	0
29	2.1	2.5	2.0	1.2	0	0
30	2.1	2.5	2.0	1.2	0	0
31			2.0	1.2		

DAILY GAUGE HEIGHT AND DISCHARGE of Muddypound Creek, at Hart's Ranche, for 1910—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0	0	0	0	0	0	2.0	1.2
2	0	0	0	0	0	0	2.0	1.2
3	0	0	0	0	0	0	2.0	1.2
4	0	0	0	0	0	0	2.0	1.2
5	0	0	0	0	0	0	2.0	1.2
6	0	0	0	0	0	0	2.0	1.2
7	0	0	0	0	1.0	......	2.0	1.2
8	0	0	0	0	1.1	....	2.0	1.2
9	0	0	0	0	1.2	....	2.0	1.2
10	0	0	0	0	1.3	....	2.0	1.2
11	0	0	0	0	1.4	....	2.0	1.2
12	0	0	0	0	1.5	....	2.0	1.2
13	0	0	0	0	1.6	....	2.0	1.2
14	0	0	0	0	1.7	....	2.0	1.2
15	0	0	0	0	1.7	....	2.0	1.2
16	0	0	0	0	1.7	....	2.0	1.2
17	0	0	0	0	1.7	....	2.0	1.2
18	0	0	0	0	1.7	....	2.05	1.8
19	0	0	0	0	1.8	0.1	2.05	1.8
20	0	0	0	0	1.8	0.1	2.04	1.7
21	0	0	0	0	1.8	0.1	2.04	1.7
22	0	0	0	0	1.8	0.1	2.04	1.7
23	0	0	0	0	1.8	0.1	2.04	1.7
24	0	0	0	0	2.0	1.2	2.04	1.7
25	0	0	0	0	2.0	1.2	2.03	1.6
26	0	0	0	0	2.0	1.2	3.03	1.6
27	0	0	0	0	2.0	1.2	2.03	1.6
28	0	0	0	0	2.0	1.2	2.03	1.6
29	0	0		0	2.0	1.2	2.03	1.6
30	0	0	0	0	2.0	1.2	2.03	1.6
31	0	0	0	0	.0	....	2.03	1.6
				0				

Creek dry from June 19th to Sept. 18th.

MONTHLY DISCHARGE of Muddypound Creek at Hart's Ranche, for 1910.

[Drainage area, 43 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
April	5.6	2.5	3.64	0.85	0.95	217
May	7.0	1.2	2.47	0.57	0.66	152
*June	2.5	0	0.547	0.013	0.15	33
*July	....	....	....	....	....	....
*August	....	....	....	....	....	....
*September	1.2	0	0.296	0.007	0.008	18
October	1.8	1.2	1.41	0.33	0.38	87
The period						507

* Creek dry from June 19th to Sept. 18th.

WILLOW CREEK, NEAR MACLEOD.

This gauging station, located at the traffic bridge on the S.W.¼ Sec. 25, Tp. 9, Rge.26,W. 4th Mer., was established July 1st, 1909, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed in a stilling box about 300 yards upstream from the bridge and near Mr. McLean's stable. It is referred to a bench mark on a post 150 feet north of the gauge; elevation 8.41.

The channel is straight for about 600 feet above and below the station. The right bank is high and wooded. The left bank is low, wooded and liable to overflow in high water stages. The bed of the stream is of clean gravel. The slope is uniform and the current swift.

Discharge measurements are taken from the bridge during high stages, initial point for soundings being marked on the downstream handrail on a line with a face of the north abutment. During low stages the river is waded at the same section and at the gauge rod when near zero flow.

The gauge was read daily by Jas. R. McLean.

DISCHARGE MEASUREMENTS of Willow Creek, near Macleod, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 19	H. C. Ritchie	55	74.70	0.766	1.81	57.26
June 23	"	26	15.93	1.27	1.41	20.13*
July 12	"	21	9.51	0.59	1.13	5.59*
Aug. 8	"	10.2	3.73	0.504	1.02	1.88*
Aug. 30	"	13.6	5.29	0.82	1.11	4.35*
Sept. 22	"	60	81.80	0.90	1.95	73 93
Oct. 27	"	47.5	56.55	0.41	1.49	23.36

* Measurements taken at wading stations near regular station.

DAILY GAUGE HEIGHT AND DISCHARGE of Willow Creek, near Macleod, in 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.7	45	1.7	45	1.6	35
2	1.7	45	1.8	56	1.6	35
3	1.7	45	1.8	56	1.6	35
4	1.7	45	1.8	56	1.6	35
5	1.7	45	1.8	56	1.6	35
6	1.7	45	1.7	45	1.6	35
7	1.7	45	1.7	45	1.6	35
8	1.7	45	1.7	45	1.6	35
9	1.7	45	1.7	45	1.6	35
10	1.7	45	1.7	45	1.6	35
11	1.7	45	1.8	56	1.6	35
12	1.7	45	1.8	56	1.5	25.5
13	1.7	45	1.9	68	1.5	25 5
14	1.7	45	1.9	68	1.5	25.5
15	1.7	45	1.8	56	1.5	25.5
16	1.7	45	1.8	56	1.4	18
17	1.7	45	1.8	56	1.4	18
18	1.6	35	1.8	56	1.4	18
19	1.6	35	1.8	56	1.4	18
20	1.6	35	1.8	56	1.4	18
21	1.6	35	1.8	56	1.3	12
22	1.6	35	1.8	56	1.3	12
23	1.6	35	1.8	56	1.3	12
24	1.6	35	1.8	56	1.3	12
25	1.6	35	1.8	56	1.4	18
26	1.6	35	1.8	56	1.4	18
27	1.6	35	1.8	56	1.3	12
28	1.6	35	1.7	45	1.3	12
29	1.6	35	1.7	45	1.3	12
30	1.6	35	1.6	35	1.2	7.5
31			1.6	35		

DAILY GAUGE HEIGHT AND DISCHARGE of Willow Creek, near Macleod, for 1910. —*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.2	7.5	.95	1.0	1.14	5.2	1.9	68
2	1.2	7.5	.95	1.0	1.17	6.3	1.89	67
3	1.2	7.5	.95	1.0	1.21	7.9	1.89	67
4	1.2	7.5	.94	.9	1.21	7.9	1.92	70
5	1.2	7.5	.94	.9	1.23	8.7	1.9	68
6	1.1	4.0	.94	.9	1.27	10.5	1.88	66
7	1.1	4.0	.96	1.1	1.48	23.9	1.85	62
8	1.1	4.0	1.02	1.9	1.52	27.3	1.81	57
9	1.1	4.0	1.03	2.1	1.57	32	1.79	55
10	1.1	4.0	1.08	3.4	1.62	37	1.76	51
11	1.1	4.0	1.06	2.8	1.68	43	1.8	56
12	1.1	4.0	1.03	2.1	1.58	33	1.72	47
13	1.11	4.3	1.02	1.9	1.6	35	1.71	46
14	1.08	3.4	1.04	2.3	1.66	41	1.7	45
15	1.06	2.8	1.08	3.4	1.78	54	1.69	44
16	1.04	2.3	1.05	2.5	1.8	56	1.68	43
17	1.03	2.1	1.05	2.5	1.83	60	1.67	42
18	1.02	1.9	1.06	2.8	1.86	63	1.68	43
19	1.01	1.7	1.07	3.1	1.88	66	1.68	43
20	1.0	1.5	1.07	3.1	1.96	75	1.67	42
21	.99	1.4	1.08	3.4	2.02	82	1.66	41
22	.99	1.4	1.08	3.4	1.95	74	1.64	39
23	.98	1.3	1.09	3.7	1.91	69	1.63	38
24	.98	1.3	1.1	4.0	1.93	72	1.63	38
25	.97	1.2	1.11	4.3	1.9	68	1.62	37
26	.97	1.2	1.11	4.3	1.92	70	1.6	35
27	.97	1.2	1.1	4.0	1.94	73	1.49	24.7
28	.97	1.2	1.1	4.0	1.84	61	1.48	23.9
29	.96	1.1	1.1	4.0	1.89	67	1.73	48
30	.96	1.1	1.11	4.3	1.91	69	1.62	37
31	.96	1.1	1.11	4.3	....	....	1.58	33

MONTHLY DISCHARGE of Willow Creek, near Macleod, for 1910.
[Drainage area, 750 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
April	45	35	40.67	0.054	0.06	2,420
May	68	35	52.58	0.07	0.081	3,233
June	35	7.5	23.48	0.031	0.035	1,397
July	7.5	1.1	3.2	0.0043	0.005	196
August	4.3	.9	2.72	0.0036	0.0041	167
September	82	5.2	46.59	0.062	0.069	772
October	70	23.9	47.63	0.064	0.073	2,928
The period						11,113

OLDMAN RIVER, NEAR MACLEOD.

A gauging station was established on this river in 1906 by Mr. J. F. Hamilton. During the floods in June, 1908, this cross-section was so altered that it was abandoned. On July 12th, 1910, a station was established at the traffic bridge on the N.W.¼ Sec. 10, Tp. 9, Rge. 26, W. 4th Mer., by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, fastened to a crib protecting the pier near the right bank. It is referred to a bench mark on spikes in a wooden bent, 93 feet east of the gauge; elevation 11.96.

The channel is straight for 400 feet above and 1,000 feet below the station. The right bank is low, wooded, and liable to overflow at extreme high water. The left bank is low, wooded and liable to overflow during high water. The bed is of clean gravel, and shifts during high water stages. The current is swift, especially during high water.

Discharge measurements are taken from the bridge, the initial point for soundings being at the left end of the handrail on the downstream side.

The gauge was read daily by Mrs. Walter Jackson.

Discharge Measurements of Oldman River, near Macleod, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
June 24	H. C. Ritchie	91	393.5	4.63	4.6	1,823.3
July 13	"	95	304.82	3.19	3.85	974.05
Aug. 8	"	81	248.63	2.13	3.15	529.64
Sept. 1	"	29.5	216.45	1.7	2.85	368.13
Sept. 22	"	84	288.5	3.01	3.72	868.8
Oct. 1	"	83	284.8	2.89	3.69	824.79†
Oct. 1	"	83	284.8	2.95	3.69	839.5 *
Oct. 1	"	83	284.8	2.92	3.69	830.61¶
Oct. 25	"	83	267.15	2.92	3.56	779.46
Nov. 15	"	85	293.45	3.32	3.85	975.37

† One point method used.
* Two point method used.
¶ Three point method used.

Daily Gauge Height and Discharge of Oldman River, near Macleod, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			3.3	555	2.85	370	3.67	816
2			3.3	555	2.85	370	3.85	975
3			3.2	505	2.84	367	3.92	1,040
4			3.2	505	2.83	364	3.95	1,070
5			3.2	505	2.83	364	3.97	1,090
6			3.2	505	2.82	361	3.97	1,090
7			3.16	487	3.18	496	3.98	1,100
8			3.15	482	3.2	505	3.99	1,110
9			3.14	478	3.17	492	3.99	1,110
10			3.14	478	3.12	469	4.22	1,354
11			3.13	474	3.15	482	4.24	1,378
12	3.85	975	3.12	469	3.13	474	4.24	1,378
13	3.8	930	3.11	465	3.11	465	4.23	1,366
14	3.8	930	3.1	460	3.11	465	4.22	1,354
15	3.8	930	3.09	456	3.15	482	4.21	1,342
16	3.8	930	3.1	460	3.2	505	4.2	1,330
17	3.7	840	3.1	460	3.4	615	3.99	1,110
18	3.7	840	3.09	456	3.6	760	3.91	1,030
19	3.7	840	3.08	452	3.75	885	3.85	975
20	3.7	840	3.07	448	3.8	930	3.83	957
21	3.6	760	3.08	452	3.85	975	3.78	912
22	3.6	760	3.07	448	3.72	858	3.7	840
23	3.5	685	3.05	440	3.72	858	3.65	800
24	3.5	685	3.04	436	3.7	840	3.6	760
25	3.4	615	3.02	428	3.68	824	3.56	730
26	3.4	615	3.01	424	3.66	808	3.65	800
27	3.4	615	2.9	385	3.68	824	3.74	876
28	3.4	615	2.97	410	3.7	840	3.82	948
29	3.4	615	2.96	406	3.7	840	3.89	1,011
30	3.3	555	2.94	399	3.68	824	3.97	1,090
31	3.3	555	2.93	396			3.89	1,011

Monthly Discharge of Oldman River, near Macleod, for 1910.

[Drainage area, 2,235 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
July (12 tc 31)	975	555	756.5	0.338	0.251	30,002
August	555	385	460.6	0.206	0.237	28,321
September	975	361	623.7	0.279	0.311	37,113
October	1,378	730	1,056.6	0.473	0.545	64,969
The period						160,405

Oldman River, near Cowley.

This gauging station, located at a ford on the N.W.¼ Sec. 34, Tp. 7, Rge. 1, W. 5th Mer., and approximately four miles north-east of Cowley, was established by H. C. Ritchie on September 15th, 1908.

The gauge is a plain staff, graduated to feet and hundredths. It is securely fastened to a post on the right bank and is connected with the channel by a ditch. It is referenced by two bench marks. (1) On a tree 20 feet upstream; elevation 9.63. (2) On a stone, 15 feet downstream; elevation 3.32. During the summer months the gauge reader, Mr. Hugh W. Pettit, moves upstream about one mile. In order that the readings should not be interrupted, a new rod was placed on the right of the river, within 50 yards of his temporary dwelling. On the periodic trips of the hydrographer both rods are read rating curves being plotted for each section.

The discharge measurements are taken at the lower rod, where a cable station has been erected for use during high water stages. At low water the river is waded at the same section. The points for soundings are permanently marked by a tagged wire, stretched, directly above the cable.

The channel is straight for about 900 feet above and 250 feet below the section. The bed is of rock and gravel and is free from vegetation. The current has considerable velocity but flows smoothly till about 150 feet below the section where it breaks into small rapids.

Both banks are high and wooded, neither being liable to overflow.

Discharge Measurements of Oldman River, near Cowley, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 24	H. C. Ritchie	194	365.4	3.72	2.78	1,359.47
June 7	"	193	310.35	3.20	2.56	993.89
July 4	"	178	200.12	2.265	2.98	453.4
July 25	"	146	130.4	1.75	1.66	228.76
Aug. 24	"	136	117.1	1.57	1.53	184.4
Sept. 16	"	172	147.64	1.91	1.76	282.35
Oct. 13	"	178	182.25	1.93	1.84	352.28
Nov. 12	"	172	152.85	1.71	1.73	262.08
Dec. 7	W. H. Greene	190	236.75	0.94	2.59	222.19
Dec. 29	"	168	120.0	0.94	2.23	112.82

DAILY GAUGE HEIGHT AND DISCHARGE of Oldman River, near Cowley, for 1910.

Day.	May.		June.		July.		August.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			2.48	938	2.08	548	1.58	199
2			2.58	1,052	2.08	548	1.58	199
3			2.58	1,044	2.08	548	1.58	199
4			2.48	920	*1.98	453	1.58	199
5			2.48	912	1.98	454	1.58	199
6			2.48	908	1.98	454	1.58	199
7			2.56	994	1.88	368	1.58	199
8			2.58	1,024	1.88	368	1.58	199
9			2.48	912	1.88	368	1.58	199
10			2.48	916	1.88	368	1.58	199
11			2.48	920	1.88	368	1.58	199
12			2.48	924	1.78	296	1.58	199
13			2.48	928	1.78	296	1.58	199
14			2.58	1,052	1.78	296	1.58	199
15			2.58	1,058	1.78	296	1.58	199
16			2.48	940	1.78	296	1.58	199
17			2.48	944	1.78	296	1.58	199
18	2.58	1,101	2.48	948	1.78	296	1.58	199
19	2.58	1,101	2.48	952	1.78	296	1.58	199
20	2.48	980	2.38	842	1.78	296	1.58	199
21	2.48	980	2.38	844	1.78	296	1.58	199
22	2.58	1,101	2.28	740	1.68	238	1.48	174
23	2.68	1,228	2.28	744	1.68	238	1.48	174
24	*2.78	1,359	2.28	746	1.68	238	1.48	174
25	2.88	1,488	2.28	748	1.68	238	1.48	174
26	3.08	1,760	2.18	640	1.68	238	1.48	174
27	2.98	1,612	2.18	644	1.68	238	1.48	174
28	2.78	1,336	2.08	546	1.58	199	1.48	174
29	2.68	1,200	2.08	547	1.58	199	1.48	174
30	2.68	1,195	2.08	548	1.58	199	1.48	174
31	2.58	1,064			1.58	199	1.48	174

* Changing conditions from May 24th to July 4th. Bolster method used.

DAILY GAUGE HEIGHT AND DISCHARGE of Oldman River, near Cowley, for 1910.—*Continued.*

Day.	September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.48	174	1.68	238	1.73	264	......	......
2	1.48	174	1.68	238	1.71	253	......	......
3	1.48	174	1.68	238	1.71	253	2.35†	......
4	1.48	174	1.68	238	1.72	259	2.18	......
5	1.48	174	1.68	238	1.72	259	2.09	......
6	1.48	174	1.68	238	1.72	259	2.53	......
7	1.68	238	2.28	756	1.71	253	2.55	......
8	1.58	199	2.08	549	1.71	253	2.55	......
9	1.68	238	1.98	454	1.7	247	2.52	......
10	1.68	238	1.88	368	1.7	247	2.44	......
11	1.68	238	1.88	368	1.69	242	2.38	......
12	1.68	238	1.88	368	1.7	247	2.43	......
13	1.68	238	1.88	368	1.7	247	2.43	......
14	1.78	296	1.82	323	1.7	247	2.43	......
15	1.78	296	1.8	309	1.7	247	2.36	......
16	1.78	296	1.8	309	1.7	247	2.34	......
17	1.78	296	1.8	309	1.72	259	2.32	......
18	1.78	296	1.8	309	1.72	259	2.28	......
19	1.78	296	1.78	296	1.74	260	2.25	......
20	1.78	296	1.78	296	1.76	283	2.23	......
21	1.78	296	1.77	289	1.78	296	2.19	......
22	1.68	238	1.76	283	1.8	309	2.18	......
23	1.68	238	1.75	276	1.8	309	2.05	......
24	1.68	238	1.73	264	1.81	316	2.16	......
25	1.68	238	1.84	338	1.82	323	2.18	......
26	1.68	238	1.83	331	1.85	345	1.9	......
27	1.68	238	1.74	260	1.86	341	2.18	......
28	1.68	238	1.78	296	1.86	341	2.2	......
29	1.68	238	1.82	323	*	......	2.22	......
30	1.68	238	1.79	303	......	......	2.21	......
31	......	......	1.76	283	......	......	2.18	......

* No observations from Nov. 28 to Dec. 2.
† Ice conditions during December.

MONTHLY DISCHARGE of Oldman River, near Cowley, for 1910.

[Drainage area, 820 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
May (18-31)	1,760	980	1,250.36	1.52	0.791	34,712
June	1,058	546	826.5	1.01	1.13	49,177
July	548	199	323.52	0.395	0.455	19,893
August	199	174	190.94	0.233	0.269	11,741
September	296	174	212.7	0.259	0.289	12,656
October	756	238	324.4	0.396	0.457	19,947
November (1-28)	345	242	273.71	0.334	0.348	15,202
The period						163,328

Crowsnest River, near Lundbrek.

This gauging station, located on the N.W.¼ Sec. 26, Tp. 7, Rge. 2, W. 5th Mer., at the traffic bridge just north of Lundbrek, was established September 7th, 1907, by P. M. Sauder.

The gauge is a plain staff, graduated to feet and hundredths, placed 20 feet downstream from the bridge and about 6 feet from the water's edge. It is connected with the channel by a ditch which is kept open by the hydrographer on his periodic trips. It is referred to a bench mark on a notch in a tree about 20 yards north of the gauge; elevation 9.74.

The channel is straight for 250 feet above and 1,500 feet below the station. The right bank is high, wooded and will not overflow. The left bank is low, wooded, and liable to overflow in extreme high water. The bed of the stream is of rock, giving a stable cross-section. The current is swift and tumultuous.

Discharge measurements are taken from the bridge, the initial point for soundings being marked, on the lower downstream chord on a line with the face of the left abutment.

There was at first some difficulty in securing a satisfactory observer. On Sept. 16th, 1908, Mr. J. G. Short, mine manager, was appointed to read the gauge and since then the records have been satisfactory. He left Lundbrek at the end of May, 1910, and the gauge has since been read by Mr. C. C. Moore.

Discharge Measurements of Crowsnest River, near Lundbrek, in 1907-1908-1909-1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1907		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
Sept. 7	I. J. Wamsley	55	106.0	2.43	2.5	257.1
1908						
July 11	H. C. Ritchie	64	131.35	4.03	2.717	532.02
Aug. 14	"	53.5	78.9	2.25	1.8	177.3
Aug. 18	"	59	103.9	2.99	2.285	310.82
Sept. 10	"	52	76.42	1.97	1.7	150.5
Sept. 16	"	52	73.87	1.97	1.7	146.04
1909						
Nov. 10	A. W. Pae	54	71.33	1.92	1.69	137.29
1910						
May 23	H. C. Ritchie	65	129.6	4.09	2.73	528.62
June 8	"	65.5	133.71	4.12	2.73	549.82
June 15	"	65	121.05	3.864	2.63	467.69
July 2	"	61.5	101.11	3.067	2.24	310.13
July 23	"	58	81.45	2.6	1.94	211.62
Aug. 22	"	54	65.15	1.747	1.60	113.82†
Aug. 22	"	54	65.15	1.78	1.60	116.16•
Aug. 22	"	54	65.15	1.71	1.60	111.44*
Sept. 14	"	55	68.1	1.69	1.61	114.95
Oct. 11	"	60.8	96.6	2.46	2.15	237.74
Nov. 8	"	58	84.42	2.11	1.89	178.19
Dec. 9	W. H. Greene	55	95.7	1.487	2.60	142.33
Dec. 31	"	60	72.65	0.806	2.34	58.55

† One point method.
• Two point method.
* Three point method.

Daily Gauge Height and Discharge of Crowsnest River, near Lundbrek, for 1908.

Day.	September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	....	....	1.7	142
2	....	....	1.7	142
3	....	....	1.7	142
4	....	....	1.7	142
5	....	....	1.7	142
6	....	....	1.7	142
7	....	....	1.7	142
8	....	....	1.8	167
9	....	....	1.7	142
10	....	....	1.7	142
11	....	....	1.7	142
12	....	....	1.7	142
13	....	....	1.8	167
14	....	....	1.8	167
15	....	....	1.8	167
16	1.7	142	1.8	167
17	1.7	142	1.8	167
18	1.8	167	1.8	167
19	1.7	142	1.7	142
20	1.7	142	1.7	142
21	1.7	142	1.7	142
22	1.8	167	1.7	142
23	1.8	167	1.7	142
24	1.8	167	1.7	142
25	1.8	167	1.7	142
26	1.8	167	1.7	142
27	1.7	142	1.7	142
28	1.7	142	1.7	142
29	1.7	142	1.7	142
30	1.7	142	1.8	167
31	....	....	1.8	167

DAILY GAUGE HEIGHT AND DISCHARGE of Crowsnest River, near Lundbrek, for 1909.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			1.4	82	4.2	1,545
2			1.6	119	4.8	2,035
3			2.1	260	5.3	2,395
4			3.2	820	5.0	2,215
5			2.8	575	4.6	1,860
6			2.6	473	4.8	2,035
7			2.8	575	4.9	2,125
8			3.0	690	4.6	1,860
9			2.7	523	4.2	1,545
10			2.7	523	3.8	1,245
11			2.9	630	3.8	1,245
12			2.8	575	4.2	1,545
13			2.7	523	4.0	1,395
14			2.5	425	4.2	1,545
15	1.4	82	2.8	575	3.8	1,245
16	1.4	82	2.6	473	3.9	1,320
17	1.6	119	2.6	473	3.8	1,245
18	2.0	226	2.7	523	3.9	1,320
19	2.0	226	2.2	297	3.8	1,245
20	2.2	297	2.9	630	3.8	1,245
21	2.3	337	3.0	690	3.9	1,320
22	2.4	380	3.2	820	3.8	1,245
23	2.4	380	3.5	1,025	3.9	1,320
24	2.5	425	4.0	1,395	3.8	1,245
25	2.3	337	4.4	1,700	3.7	1,170
26	2.2	297	4.7	1,945	3.5	1,025
27	2.0	226	4.6	1,860	3.4	955
28	1.7	142	4.5	1,780	3.2	820
29	1.6	119	4.7	1,945	3.0	690
30	1.4	82	4.6	1,860	3.1	755
31			4.1	1,470		

DAILY GAUGE HEIGHT AND DISCHARGE of Crowsnest River, near Lundbrek, for 1909.—*Con.*

Day.	July.		August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-chairge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.0	690	3.7	1,170	2.0	226	1.8	167	1.6	119
2	2.9	630	2.8	1,245	2.0	226	1.8	167	1.7	142
3	2.5	425	2.8	1,245	2.0	226	1.8	167	1.8	167
4	2.7	523	2.7	523	2.0	226	1.8	167	1.9	195
5	3.0	690	2.7	523	2.0	226	1.8	167	1.9	195
6	3.5	1,025	2.7	523	2.0	226	1.8	167	1.9	195
7	3.4	955	2.7	523	1.9	195	1.7	142	1.8	167
8	3.1	755	2.6	473	1.9	195	1.7	142	1.7	142
9	3.0	690	2.6	473	1.9	195	1.7	142	1.7	142
10	2.9	630	2.5	425	1.9	195	1.7	142	1.7	142
11	2.9	630	2.5	425	1.9	195	1.7	142	1.7	142
12	2.8	575	2.4	380	1.9	195	1.7	142	1.8	167
13	2.8	575	2.4	380	1.9	195	1.7	142	1.8	167
14	2.7	523	2.8	575	1.9	195	1.7	142	1.8	167
15	2.6	473	2.4	380	1.9	195	1.7	142	1.8	167
16	2.6	473	2.3	337	1.8	167	1.7	142	1.8	167
17	2.6	473	2.2	297	1.8	167	1.7	142	2.0	226
18	2.6	473	2.2	297	1.8	167	1.7	142	1.9	195
19	2.5	425	2.2	297	1.8	167	1.7	142	1.8	167
20	2.5	425	2.2	297	1.8	167	1.7	142	1.8	167
21	2.5	425	2.1	260	1.8	167	1.7	142	1.8	167
22	2.4	380	2.1	260	1.8	167	1.7	142	1.8	167
23	2.4	380	2.1	260	1.8	167	1.7	142	1.8	167
24	2.4	380	2.1	260	1.8	167	1.7	142	1.8	167
25	2.5	425	2.1	260	1.8	167	1.8	167	1.9	195
26	3.9	1,320	2.1	260	1.8	167	1.9	119	1.9	195
27	4.7	1,945	2.1	260	1.8	167	1.6	119	1.8	167
28	5.5	2,665	2.1	260	1.8	167	1.6	119	1.8	167
29	4.6	1,860	2.1	260	1.8	167	1.6	119	2.0	226
30	4.0	1,395	2.0	226	1.8	167	1.6	119	2.2	297
31	3.6	1,095	2.0	226	......	......	1.6	119	......	......

DAILY GAUGE HEIGHT AND DISCHARGE of Crowsnest River, near Lundbrek, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height	Discharge.	Gauge Height.	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	1.83	175	2.83	591	2.73	539	2.33	350
2	1.83	175	2.73	539	2.73	539	2.33	350
3	1.83	175	2.53	439	2.63	488	2.23	309
4	1.83	175	2.53	439	2.63	488	2.23	309
5	1.83	175	2.53	439	2.53	439	2.23	309
6	2.13	271	2.73	539	2.53	439	2.23	309
7	2.23	309	2.73	539	2.73	539	2.23	309
8	2.13	271	3.03	709	2.73	539	2.23	309
9	2.23	309	3.03	709	2.63	488	2.13	271
10	2.23	309	3.03	709	2.63	488	2.13	271
11	2.23	309	2.93	648	2.63	488	2.13	271
12	2.43	393	2.83	591	2.73	539	2.13	271
13	2.53	439	2.73	539	2.73	539	2.13	271
14	2.33	350	2.73	539	2.63	488	2.13	271
15	2.33	350	2.83	591	2.63	488	2.03	236
16	2.33	350	2.73	539	2.63	488	2.03	236
17	2.33	350	2.63	488	2.63	488	2.03	236
18	2.33	350	2.73	539	2.53	439	2.03	236
19	2.63	488	2.83	591	2.53	439	2.03	236
20	2.83	591	2.83	591	2.53	439	2.03	236
21	2.83	591	2.83	591	2.53	439	1.93	204
22	2.83	591	2.83	591	2.43	393	1.93	204
23	2.73	539	2.73	539	2.43	393	1.93	204
24	2.83	591	2.83	591	2.33	350	1.83	175
25	2.93	648	2.83	591	2.33	350	1.83	175
26	3.13	774	3.03	709	2.33	350	1.83	175
27	3.23	839	3.03	709	2.33	350	1.83	175
28	3.23	839	3.03	709	2.33	350	1.83	175
29	3.23	839	2.93	648	2.33	350	1.83	175
30	3.13	774	2.73	539	2.33	350	1.83	175
31	......	......	2.73	539	......	......	1.83	175

DAILY GAUGE HEIGHT AND DISCHARGE of Crowsnest River, near Lundbrek, for 1910.—*Con.*

Day.	August.		September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.83	175	1.63	129	1.73	149	1.91	198	....	....
2	1.83	175	1.63	129	1.75	154	1.86	184	....	....
3	1.83	175	1.53	105	1.75	154	1.87	187	*	....
4	1.73	149	1.53	105	1.96	214	1.85	181	2.63	....
5	1.73	149	1.53	105	1.94	207	1.83	175	2.66	....
6	1.73	149	1.63	126	1.93	204	1.81	170	2.73	....
7	1.73	149	1.63	126	1.93	204	1.81	170	2.74	....
8	1.73	149	1.63	126	2.15	278	1.87	187	2.68	....
9	1.73	149	1.63	126	2.14	275	1.89	192	2.61	....
10	1.73	149	1.63	126	2.25	317	1.86	184	2.62	....
11	1.73	149	1.63	126	2.15	278	1.93	204	2.57	....
12	1.73	149	1.63	126	2.13	271	2.23	309	2.58	....
13	1.73	149	1.63	126	2.03	236	1.98	220	2.53	....
14	1.73	149	1.63	126	2.03	236	1.93	204	2.43	....
15	1.73	149	1.63	126	2.03	236	1.93	204	2.38	....
16	1.73	149	1.63	126	1.93	204	1.91	198	2.36	....
17	1.73	149	1.63	126	1.93	204	1.88	189	2.36	....
18	1.63	126	1.73	149	1.93	204	1.98	220	2.36	....
19	1.63	126	1.73	149	1.93	204	1.78	162	2.36	....
20	1.63	126	1.73	149	1.83	175	1.78	162	2.02	....
21	1.63	126	1.73	149	1.83	175	1.78	162	1.95	....
22	1.63	126	1.73	149	1.83	175	1.78	162	1.97	....
23	1.63	126	1.73	149	1.83	175	1.78	162	1.98	....
24	1.63	126	1.73	149	1.83	175	1.78	162	2.92	....
25	1.63	126	1.73	149	2.13	271	1.81	170	2.53	....
26	1.63	126	1.73	149	2.13	271	1.81	170	2.58	....
27	1.53	105	1.73	149	2.13	271	†	....	2.50	....
28	1.53	105	1.73	149	2.13	271	....	....	2.48	....
29	1.53	105	1.73	149	1.93	204	....	....	2.61	....
30	1.53	105	1.73	149	1.91	198	....	....	2.59	....
31	1.53	105	....	....	1.91	198	....	....	2.38	....

* Ice conditions during December.
† No observations from Nov. 27 to Dec. 3.

MONTHLY DISCHARGE of Crowsnest River, near Lundbrek, for 1908-1909-1910.

[Drainage area, 263 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
1908						
September (16-30)	167	142	152	0.578	0.322	4,522
October	167	142	149	0.568	0.654	9,178
The period						13,700
1909						
April (15-30)	425	82	235	0.893	0.531	7,453
May	1,945	82	847	3.22	3.71	52,074
June	2,395	690	1,425	5.42	6.05	84,803
July	2,665	380	785	2.98	3.44	48,316
August	1,245	226	439	1.67	1.92	26,936
September	226	167	187	0.712	0.794	11,139
October	167	119	143	0.544	0.627	8,805
November	297	142	175	0.666	0.743	10,419
The period						249,945
1910						
April	839	175	445	1.69	1.89	26,457
May	709	439	583	2.22	2.55	35,829
June	539	350	450	1.71	1.91	26,767
July	350	175	245	0.933	1.07	15,090
August	175	105	138	0.523	0.603	8,469
September	149	105	134	0.510	0.569	7,978
October	278	149	219	0.833	0.96	13,463
November (1-26)	309	162	188	0.715	0.69	9,697
The period						143,750

CROWSNEST RIVER, NEAR FRANK.

This gauging station, located at the traffic bridge on Sec. 36, Tp. 7, Rge. 4, W.5th Mer., was established on July 28th, 1910, by H. C. Ritchie.

The gauge consists of a plain staff, graduated to feet, tenths and hundredths, placed at the left bank about 20 feet down stream from the bridge. It is referenced by a bench mark, on spikes driven into a tree stump within three feet of gauge; elevation 9.43.

The channel is straight for about 200 feet above the station and for 500 feet below, both banks being high, wooded and not liable to overflow. The bed of the stream is clean gravel.

The discharge measurements are taken from the bridge during high water stages, the points for soundings being marked on the lower chord. In low stages the river is waded at the same section.

The gauge was read daily during the season of 1910 by Chas. Richardson.

DISCHARGE MEASUREMENTS of Crowsnest River, near Frank, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 13	H. C. Ritchie	69	116.77	3.8		444.15
July 20	"	61.8	70.87	2.447		173.45
July 29	"	60	62.4	2.126	4.28	132.69
Aug. 16	"	59	59.35	1.82	4.19	107.88
Sept. 10	"	54	49.75	1.57	4.1	78.31
Oct. 17	"	62	68.3	2.36	4.39	161.37
Nov. 4	"	60	60.89	1.97	4.27	119.74
Dec. 10	"	54	51.07	1.62	4.07	82.76

Daily Gauge Height and Discharge of Crowsnest River, near Frank, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	....	....	4.3	134	4.2	105	4.4	164
2	....	....	4.3	134	4.2	105	4.4	164
3	....	....	4.3	134	4.2	105	4.5	196
4	....	....	4.3	134	4.1	78	4.5	196
5	....	....	4.2	105	4.1	78	4.6	230
6	....	....	4.2	105	4.1	78	4.6	230
7	....	....	4.2	105	4.1	78	4.7	265
8	....	....	4.2	105	4.1	78	4.7	265
9	....	....	4.2	105	4.1	78	4.7	265
10	....	....	4.2	105	4.1	78	4.7	265
11	....	....	4.2	105	4.1	78	4.7	265
12	....	....	4.2	105	4.2	105	4.6	230
13	....	....	4.2	105	4.2	105	4.6	230
14	....	....	4.2	105	4.2	105	4.6	230
15	....	....	4.2	105	4.2	105	4.5	196
16	....	....	4.2	105	4.2	105	4.5	196
17	....	....	4.2	105	4.3	134	4.4	164
18	....	....	4.2	105	4.3	134	4.4	164
19	....	....	4.2	105	4.3	134	4.4	164
20	....	....	4.2	105	4.3	134	4.4	164
21	....	....	4.2	105	4.3	134	4.4	164
22	....	....	4.2	105	4.3	134	4.4	164
23	....	....	4.2	105	4.3	134	4.4	164
24	....	....	4.2	105	4.3	134	4.4	164
25	....	....	4.2	105	4.3	134	4.6	230
26	....	....	4.2	105	4.3	134	4.7	265
27	....	....	4.2	105	4.3	134	4.68	258
28	....	....	4.2	105	4.3	134	4.67	254
29	4.3	134	4.2	105	4.3	134	4.62	237
30	4.3	134	4.2	105	4.4	164	4.53	206
31	4.3	134	4.2	105	....	....	4.42	170

Monthly Discharge of Crowsnest River, near Frank, for 1910.

[Drainage area, 170 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
July (29-31)	134	134	134	0.790	0.088	797
August	134	105	108.7	0.639	0.737	6,684
September	164	78	112.3	0.661	0.738	6,682
October	265	164	210.3	1.24	1.43	12,931
The period						27,094

Crowsnest River, near Coleman.

This gauging station, located on the S.W.¼ Sec. 12, Tp. 8, Rge. 5, W. 5th Mer., at a private bridge about 2½ miles west of Coleman, was established July 28th. 1910, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed at the left bank about 150 feet upstream from the bridge. It is referred to a bench mark on top of a post 30 feet west of the gauge; elevation 10.16.

The channel is straight for 30 feet above and 300 feet below the station. Both banks are high, wooded, and will not overflow. The bed of the stream is of sand and gravel. The current is fairly swift.

Discharge measurements are made from the bridge during high water stages, the initial point for soundings being on line with the face of the left abutment. In low stages the stream is waded ¾ mile downstream from the bridge.

The gauge was read daily by Prudent LeGal, whose house is about 40 feet away.

DISCHARGE MEASUREMENTS of Crowsnest River, near Coleman, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 13	H. C. Ritchie	31.5	94.15	3.59	....	338.35
July 28	"	34	69.7	1.84	4.7	128.38
Aug. 17	"	35	67.7	1.4	4.44	94.67
Sept. 12	"	29	61.95	1.2	4.3	74.34
Oct. 19	"	31	67.15	1.63	4.74	109.17
Nov. 4	"	30	63.15	1.18	4.45	74.75

DAILY GAUGE HEIGHT AND DISCHARGE of Crowsnest River, near Coleman, for 1910.

DAY.	July.		August.		September.		October.		November.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			4.70	128	4.30	74	4.50	98	4.52	82
2			4.60	112	4.30	74	4.70	128	4.61	92
3			4.60	112	4.30	74	4.90	164	4.52	82
4			4.60	112	4.30	74	4.80	142	4.51	81
5			4.60	112	4.30	74	4.80	141	4.53	83
6			4.60	112	4.30	74	4.70	122		
7			4.60	112	4.30	74	4.70	120		
8			4.60	112	4.30	74	4.90	154		
9			4.60	112	4.30	74	4.90	152		
10			4.50	98	4.30	74	5.10	192		
11			4.50	98	4.30	74	4.90	148		
12			4.50	98	4.30	74	5.00	166		
13			4.50	98	4.30	74	4.90	144		
14			4.50	98	4.30	74	4.90	142		
15			4.50	98	4.30	74	4.80	123		
16			4.50	98	4.30	74	4.80	122		
17			4.50	98	4.60	112	4.80	120		
18			4.50	98	4.70	128	4.70	103		
19			4.50	98	4.80	146	4.74	109		
20			4.40	85	4.70	128	4.72	106		
21			4.40	85	4.70	128	4.63	95		
22			4.40	85	4.70	128	4.56	87		
23			4.40	85	4.60	112	4.50	80		
24			4.40	85	4.60	112	4.46	76		
25			4.40	85	4.60	112	4.54	84		
26			4.40	85	4.50	98	4.62	93		
27			4.40	85	4.50	98	4.72	106		
28	4.70	128	4.30	74	4.50	98	4.64	96		
29	4.70	128	4.30	74	4.40	85	4.62	93		
30	4.70	128	4.30	74	4.50	98	4.50	80		
31	4.70	128	4.30	74			4.46	76		

Changing conditions from Oct. 2nd to Oct. 18th. Bolster method applied.

MONTHLY DISCHARGE of Crowsnest River, near Coleman, for 1910.

[Drainage area, 68 square miles.]

MONTH.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
July (28-31)	128	128	128	1.88	0.279	1,015
August	128	74	96.1	1.41	1.63	5,909
September	146	74	92.2	1.36	1.52	5,486
October	192	76	118.1	1.74	2.00	7,262
November (1-5)	92	81	84	1.23	0.229	833
The period						20,505

Todd Creek at Elton's Ranche.

This station was established by H. C. Ritchie, August 3rd, 1909. It is located 7 miles northwest of Cowley, at a private footbridge about 20 feet from Cecil Elton's house on the S.W.¼ Sec. 19, Tp. 8, Rge. 1, W. 5th Mer.

The gauge is a plain staff, graduated to feet and hundredths, driven into the bed of the stream and securely braced to the left bank. It is referred to the top of a stake about 10 feet east; elevation 6.70 above the zero mark of the gauge. It is read by Cecil Elton.

The channel is straight for about 55 feet above and 60 feet below the gauge. The right bank is high and wooded and liable to overflow in extreme high water. The left bank is wooded and liable to overflow for about 5 feet from edge, when it rises abruptly to about 6 feet. The bed lies in one channel and is composed of clean sand and gravel. The current is inclined to be swift at high stages, but quite sluggish at low.

Cecil Elton and Capt. Cardwell have irrigation ditches which divert water at points above this gauging station. Mr. Elton irrigates about 35 acres, and Capt. Cardwell about 90.

Discharge Measurements of Todd Creek at Elton's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 25	H. C. Ritchie	20.5	32.68	0.78	2.75	25.54
June 9	"	21	32.19	0.77	3.02	24.81
July 5	"	11	4.56	1.8	2.66	8.23†
July 5	"	21	25.54	0.25	2.66	6.38
July 26	"	4.6	1.452	0.97	2.45	1.41†
Aug. 20	"	4.6	1.08	0.76	2.4	0.82†
Sept. 15	"	4.9	1.86	1.51	2.55	2.81†
Sept. 15	"	20.8	21.11	0.13	2.55	2.74
Oct. 12	"	4.9	2.18	1.5	2.55	3.27†

† Measurements taken at wading stations near regular station.

Daily Gauge Height and Discharge of Todd Creek at Elton's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.75	7.9	2.91	15.0	2.97	18.4
2	2.75	7.9	2.9	14.5	2.98	19.0
3	2.79	9.4	2.89	14.0	2.97	18.4
4	2.84	11.6	2.88	13.5	2.97	17.4
5	2.8	9.8	2.88	13.5	2.95	17.2
6	2.82	10.7	2.85	12.0	2.93	16.1
7	2.85	12.0	2.87	13.0	2.92	15.6
8	2.81	10.2	2.86	12.5	2.94	16.7
9	2.78	9.0	2.87	13.0	2.99	19.6
10	2.78	9.0	2.93	16.1	2.94	16.7
11	2.8	9.8	3.0	20.2	2.89	14.0
12	2.81	10.2	3.1	27.0	2.88	13.5
13	2.81	10.2	3.09	26.3	2.86	12.5
14	2.8	9.8	3.1	27.0	2.85	12.0
15	2.8	9.8	3.07	24.9	2.85	12.0
16	2.79	9.4	3.07	24.9	2.73	7.3
17	2.79	9.4	3.01	20.9	2.73	7.3
18	2.79	9.4	3.0	20.2	2.72	7.0
19	2.79	9.4	3.15	30.5	2.71	6.7
20	2.79	9.4	3.06	24.2	2.71	6.7
21	2.78	9.0	3.02	21.5	2.7	6.4
22	2.78	9.0	3.01	20.9	2.71	6.7
23	2.78	9.0	3.0	20.2	2.71	6.7
24	2.78	9.0	3.01	20.9	2.64	4.9
25	2.79	9.4	3.05	23.5	2.62	4.4
26	2.8	9.8	3.0	20.2	2.61	4.2
27	2.81	10.2	2.8	9.8	2.61	4.2
28	2.81	10.2	2.98	19.0	2.6	4.0
29	2.84	11.6	2.96	17.8	2.66	5.3
30	2.89	14.0	2.97	18.4	2.66	5.3
31	....	....	2.97	18.4	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Todd Creek at Elton's Ranche, for 1910.—*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.67	5.6	2.52	2.5	2.57	3.4	2.53	2.6
2	2.67	5.6	2.48	1.8	2.56	3.2	2.54	2.8
3	2.68	5.9	2.45	1.4	2.55	3.0	2.53	2.6
4	2.67	5.6	2.45	1.4	2.55	3.0	2.54	2.8
5	2.68	5.9	2.46	1.5	2.53	2.6	2.57	3.4
6	2.64	4.9	2.51	2.3	2.54	2.8	2.57	3.4
7	2.61	4.2	2.55	3.0	2.57	3.4	2.56	3.2
8	2.6	4.0	2.54	2.8	2.63	4.7	2.63	4.7
9	2.63	4.7	2.48	1.8	2.61	4.2	2.58	3.6
10	2.63	4.7	2.5	2.1	2.61	4.2	2.58	3.6
11	2.67	5.6	2.51	2.3	2.58	3.6	2.57	3.4
12	2.65	5.1	2.48	1.8	2.57	3.4	2.55	3.0
13	2.64	4.9	2.47	1.7	2.55	3.0	2.54	2.8
14	2.6	4.0	2.48	1.8	2.56	3.2	2.54	2.8
15	2.58	3.6	2.52	2.5	2.55	3.0	2.54	2.8
16	2.59	3.8	2.56	3.2	2.55	3.0	2.54	2.8
17	2.59	3.8	2.57	3.4	2.54	2.8	2.54	2.8
18	2.56	3.2	2.54	2.8	2.53	2.6	2.55	3.0
19	2.57	3.4	2.43	1.1	2.52	2.5	2.56	3.2
20	2.54	2.8	2.4	0.8	2.53	2.6	2.56	3.2
21	2.53	2.6	2.39	0.7	2.54	2.8	2.55	3.0
22	2.53	2.6	2.42	1.0	2.55	3.0	2.54	2.8
23	2.5	2.1	2.47	1.7	2.56	3.2	2.55	3.0
24	2.48	1.8	2.54	2.8	2.58	3.6	2.55	3.0
25	2.47	1.7	2.52	2.5	2.57	3.4	2.58	3.6
26	2.46	1.5	2.52	2.5	2.54	2.8	2.64	4.9
27	2.47	1.7	2.51	2.3	2.55	3.0	2.56	3.2
28	2.47	1.7	2.5	2.1	2.54	2.8	2.57	3.4
29	2.49	2.0	2.52	2.5	2.55	3.0	2.65	5.1
30	2.53	2.6	2.52	2.5	2.54	2.8	2.63	4.7
31	2.52	2.5	2.53	2.6	....	....	2.61	4.2

MONTHLY DISCHARGE of Todd Creek at Elton's Ranche, for 1910.

[Drainage area, 62 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
April	14.0	7.9	9.85	0.159	0.177	586
May	30.5	9.8	19.15	0.309	0.356	1,178
June	19.6	4.0	10.91	0.176	0.196	649
July	5.9	1.5	3.7	0.06	0.069	228
August	3.4	0.7	2.1	0.034	0.039	129
September	4.7	2.5	3.15	0.051	0.057	187
October	5.1	2.6	3.34	0.054	0.062	205
The period						3,162

Cow Creek at Ross' Ranche.

A gauging station, located on Sec. 12, Tp. 8, Rge. 2, W. 5th Mer., on Abel Brux's farm, was established August 2nd, 1909, by H. C. Ritchie. In the spring of 1910, Mr Brux moved away and, as no other observer was available, Mr. Ritchie established a new station at John Ross' ranche on the N.E.¼ Sec. 14, Tp. 8, Rge. 2, W. 5th Mer., on May 26th, 1910.

The gauge is a plain staff, graduated to feet and hundredths, placed at the right bank. It is referred to a bench mark on the east side of the step at the door on the south side of John Ross' stable; elevation 13.71.

The channel is straight for 25 feet above and 40 feet below the station. Both banks are high, wooded, and not liable to overflow. The bed is of clean sand and gravel.

Discharge measurements are taken from a private bridge during high water stages, the initial point for soundings being on the left bank. In low water the creek is waded.

The gauge was read daily by Mr. John Ross.

Discharge Measurements of Cow Creek at Ross' Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 26	H. C. Ritchie	9.5	8.28	0.727	2.00	6.02
June 9	"	10	8.57	0.75	1.98	6.43
July 5	"	9	4.92	0.29	1.71	1.43
July 26	"	2.6	0.64	0.87	1.55	0.56*
Aug. 20	"	1.8	0.23	0.62	1.43	0.14*
Sept. 15	"	....	....	....	1.59	0.72†
Sept. 15	"	2.6	0.6	1.27	1.59	0.76*
Oct. 12	"	2.7	0.71	1.34	1.63	0.95*

* Measurements taken at wading stations near regular station.
† Discharge determined by using 15-inch weir.

Daily Gauge Height and Discharge of Cow Creek at Ross' Ranche, for 1910.

Day.	May.		June.		July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	......	......	2.0	6.2	1.7	1.35	1.55	0.55	1.52	0.43	1.63	0.95
2	......	......	2.0	6.2	1.7	1.35	1.55	0.55	1.52	0.43	1.64	1.0
3	......	......	2.0	6.2	1.7	1.35	1.55	0.55	1.5	0.35	1.64	1.0
4	......	......	2.0	6.2	1.7	1.35	1.55	0.55	1.5	0.35	1.65	1.05
5	......	......	1.9	4.1	1.7	1.35	1.57	0.65	1.47	0.26	1.65	1.05
6	......	......	1.9	4.1	1.7	1.35	1.57	0.65	1.45	0.2	1.65	1.05
7	......	......	1.9	4.1	1.7	1.35	1.57	0.65	1.45	0.2	1.65	1.05
8	......	......	2.0	6.2	1.7	1.35	1.57	0.65	1.55	0.55	1.65	1.05
9	......	......	2.0	6.2	1.7	1.35	1.57	0.65	1.6	0.8	1.65	1.05
10	......	......	2.0	6.2	1.7	1.35	1.57	0.65	1.62	0.9	1.65	1.05
11	......	......	1.9	4.1	1.7	1.35	1.55	0.55	1.62	0.9	1.63	0.95
12	......	......	1.9	4.1	1.7	1.35	1.52	0.43	1.6	0.8	1.60	0.8
13	......	......	1.9	4.1	1.6	0.8	1.5	0.35	1.6	0.8	1.60	0.8
14	......	......	1.9	4.1	1.6	0.8	1.47	0.26	1.6	0.8	1.63	0.95
15	......	......	1.9	4.1	1.6	0.8	1.45	0.2	1.6	0.8	1.63	0.95
16	......	......	1.8	2.45	1.6	0.8	1.45	0.2	1.58	0.7	1.63	0.95
17	......	......	1.8	2.45	1.6	0.8	1.45	0.2	1.58	0.7	1.63	0.95
18	......	......	1.8	2.45	1.6	0.8	1.43	0.16	1.57	0.65	1.63	0.95
19	......	......	1.8	2.45	1.6	0.8	1.4	0.1	1.55	0.55	1.65	1.05
20	......	......	1.8	2.45	1.6	0.8	1.4	0.1	1.55	0.55	1.65	1.05
21	......	......	1.8	2.45	1.6	0.8	1.4	0.1	1.55	0.55	1.65	1.05
22	......	......	1.8	2.45	1.6	0.8	1.4	0.1	1.55	0.55	1.65	1.05
23	......	......	1.8	2.45	1.6	0.8	1.4	0.1	1.57	0.65	1.65	1.05
24	......	......	1.8	2.45	1.6	0.8	1.45	0.2	1.6	0.8	1.65	1.05
25	......	......	1.8	2.45	1.55	0.55	1.47	0.26	1.63	0.95	1.65	1.05
26	2.0	6.2	1.8	2.45	1.55	0.55	1.47	0.26	1.63	0.95	1.65	1.05
27	2.0	6.2	1.8	2.45	1.55	0.55	1.47	0.26	1.63	0.95	1.65	1.05
28	2.0	6.2	1.8	2.45	1.55	0.55	1.47	0.26	1.63	0.95	1.65	1.05
29	2.1	8.6	1.8	2.45	1.55	0.55	1.47	0.26	1.63	0.95	1.65	1.05
30	2.0	6.2	1.7	1.35	1.55	0.55	1.47	0.26	1.63	0.95	1.65	1.05
31	2.0	6.2	......	......	1.55	0.55	1.5	0.35	......	......	1.65	1.05

MONTHLY DISCHARGE of Cow Creek at Ross' Ranche, for 1910.

[Drainage area, 28 square miles.]

Month.	Discharge in Second-Feet.			Run-Off.		
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
May (26-31)	8.60	6.20	6.60	0.236	0.056	78
June	6.20	1.35	3.73	0.133	0.148	222
July	1.35	0.55	0.956	0.034	0.039	58
August	0.65	0.1	0.357	0.013	0.015	22
September	0.95	0.2	0.665	0.024	0.027	39
October	1.05	0.8	1.01	0.036	0.041	62
The period						481

CONNELY CREEK NEAR LUNDBREK.

This station was established July 31st, 1909, by H. C. Ritchie. It is located at a footbridge on the trail in S.E.¼ Sec. 36, Tp. 7, Rge. 2, W. 5th Mer., and about 100 feet from the mouth of the creek.

This stream has a very crooked channel, it being very difficult to find a suitable place for gauging. For about 20 feet below and above the gauge, the channel is practically straight. The right bank is low and liable to overflow at high stages of the stream; the left bank is comparatively high. Both banks are thickly wooded near the water's edge. The bed is composed of sand and gravel, and is free from vegetation.

During high stages, discharge measurements are made from the foot bridge; the initial point for soundings being a stake on the right bank. During low stages, the current at this point is too sluggish for accurate results and a wading section about 200 feet upstream, is used.

As Mr. N. V. Holway, who read the gauge in 1909, was not available, the gauge was not read during 1910.

DISCHARGE MEASUREMENTS of Connely Creek, near Lundbrek, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 23	H. C. Ritchie	12.3	6.88	0.38	2.46	2.63
June 8	"	12.5	7.27	0.41	2.45	2.97
July 2	"	3.7	0.52	0.807	2.33	0.42
July 23	"					Dry*
Oct. 12	"				2.36	0.27†

* Creek dry.
† Discharge determined by using 15-inch weir.

SOUTHFORK RIVER, NEAR COWLEY.

This gauging station, located at the traffic bridge between Cowley and Pincher on the S.E.¼ Sec. 2, Tp. 7, Rge. 1, W. 5th Mer., was established by H. C. Ritchie on August 5th, 1909.

The gauge is a plain staff, graduated to feet and hundredths. It was first fastened to the second pier of the bridge from the left bank, but, owing to this section changing during floods, was moved to a point about half a mile downstream and securely fastened by braces to supports on the bank. In its present position it is about five minutes walk from Mr. G. W. Buchanan's house, who reads it daily. It is referenced by a bench mark on a tree within 20 feet; elevation 8.33.

Above the bridge an island divides the river into two channels, this island being submerged during high water stages. These two channels join about fifty feet upstream from the section, but the stream is again divided into three by the piers of the bridge. Owing to the protection of the piers gravel bars are formed downstream from the section.

The bed of the river is quite rough requiring extreme care in determining the area of the section. The current is swift except through the east channel during low stages when it becomes dead.

Discharge measurements are taken from the downstream side of the bridge at both high and low water, the initial point for sounding being marked on the superstructure in line with the face of the abutment on the left bank.

DISCHARGE MEASUREMENTS of Southfork River, near Cowley, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 27	H. C. Ritchie	228	514.53	4.425	4.25	2,277.1
June 10	"	208	377.75	3.697	3.6	1,396.56
June 18	"	207.5	358.0	3.6	3.53	1,289.02
July 8	"	110.5	241.29	2.45	2.84	591.11
July 25	"	97	185.0	1.607	2.46	298 25
Aug. 19	"	65	76.07	2.32	2.18	176.48
Sept. 13	"	95	166.87	1.54	2.34	256.66
Sept. 20	"	108	225.69	2.29	2.8	516.98
Oct. 10	"	199	312.8	3.1	3.33	969.64
Nov. 7	"	102	209.24	2.0	2.65	418.01
Dec. 30	W. H. Greene	80.5	64.4	1.62	2.815	104.33*

* Ice conditions.

DAILY GAUGE HEIGHT AND DISCHARGE of Southfork River, near Cowley, for 1910.

Day.	April.		May.		June.		July.		August.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.5	345	3.9	1,760	4.2	2,250	3.2	880	2.3	240
2	2.5	345	3.7	1,470	4.2	2,250	3.1	785	2.3	240
3	2.5	345	3.6	1,340	4.1	2,080	3.1	785	2.3	240
4	2.5	345	3.5	1,215	3.9	1,760	3.1	785	2.3	240
5	2.5	345	3.5	1,215	3.7	1,470	3.0	695	2.3	240
6	2.6	400	3.6	1,340	3.7	1,470	3.0	695	2.3	240
7	2.7	465	3.9	1,760	3.8	1,610	2.9	610	2.3	240
8	2.7	465	4.4	2,605	3.8	1,610	2.8	530	2.3	240
9	2.9	610	4.4	2,605	3.8	1,610	2.8	530	2.3	240
10	2.9	610	4.2	2,250	3.6	1,340	2.8	530	2.3	240
11	2.9	610	4.0	1,915	3.8	1,610	2.8	530	2.2	195
12	3.0	695	4.0	1,915	4.0	1,915	2.8	530	2.2	195
13	3.1	785	3.9	1,760	4.0	1,915	2.8	530	2.2	195
14	3.1	785	3.9	1,760	3.9	1,760	2.8	530	2.2	195
15	3.1	785	3.9	1,760	3.8	1,610	2.7	465	2.2	195
16	3.1	785	3.8	1,610	3.7	1,470	2.7	465	2.2	195
17	3.2	880	3.8	1,610	3.6	1,340	2.7	465	2.2	195
18	3.3	985	3.8	1,610	3.6	1,340	2.7	465	2.2	195
19	3.4	1,095	4.0	1,915	3.6	1,340	2.7	465	2.2	195
20	3.8	1,610	3.9	1,760	3.5	1,215	2.7	465	2.2	195
21	3.8	1,610	3.9	1,760	3.4	1,095	2.6	400	2.2	195
22	3.8	1,610	3.9	1,760	3.3	985	2.6	400	2.2	195
23	3.7	1,470	4.1	2,080	3.3	985	2.6	400	2.2	195
24	3.8	1,610	4.2	2,250	3.3	985	2.5	345	2.2	195
25	4.0	1,915	4.3	2,425	3.2	880	2.5	345	2.2	195
26	4.4	2,605	4.5	2,790	3.3	985	2.5	345	2.2	195
27	4.3	2,425	4.3	2,425	3.3	985	2.5	345	2.2	195
28	4.3	2,425	4.2	2,250	3.3	985	2.4	290	2.1	155
29	4.3	2,425	4.1	2,080	3.2	880	2.4	290	2.1	155
30	4.1	2,080	4.1	2,080	3.2	880	2.4	290	2.1	155
31	....	....	4.1	2,080	....	....	2.3	240	2.1	155

DAILY GAUGE HEIGHT AND DISCHARGE of Southfork River, near Cowley, for 1910.—*Continued.*

DAY	September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.1	155	2.8	530	†	......	......	......
2	2.1	155	3.0	695	......	......	......	......
3	2.1	155	3.1	785	......	......	......	......
4	2.1	155	3.2	880	......	......	......	......
5	2.1	155	3.1	785	......	......	......	......
6	2.2	195	3.1	785	......	......	......	......
7	2.3	240	3.2	880	......	......	......	......
8	2.3	240	3.4	1,095	......	......	* †	......
9	2.3	240	3.44	1,145	......	......	3.38	......
10	2.3	240	3.33	1,018	......	......	3.36	......
11	2.4	290	3.27	953	......	......	3.3	......
12	2.3	240	3.2	880	......	......	3.34	......
13	2.3	240	3.2	880	......	......	3.27	......
14	2.3	240	3.02	713	......	......	3.05	......
15	2.4	290	3.08	767	......	......	3.05	......
16	2.6	400	3.03	733	......	......	3.05	......
17	2.9	610	2.9	610	......	......	2.97	......
18	3.0	695	3.0	695	......	......	2.8	......
19	3.0	695	2.9	610	......	......	2.65	......
20	2.8	530	2.79	523	......	......	2.85	......
21	2.7	465	2.75	498	......	......	2.65	......
22	2.8	530	2.71	471	......	......	2.8	......
23	2.8	530	2.7	465	......	......	2.85	......
24	2.8	530	2.8	530	......	......	3.05	......
25	2.8	530	2.88	594	......	......	2.7	......
26	2.7	465	2.98	678	......	......	2.8	......
27	2.7	465	3.0	695	......	......	2.8	......
28	2.7	465	2.92	627	......	......	2.95	......
29	2.7	465	2.95	652	......	......	2.8	......
30	2.8	530	2.92	627	......	......	2.65	......
31	......	......	2.91	619	......	......	2.4	......

† No gauge height observations from Nov. 1st to Dec. 8th.
* Ice conditions.

MONTHLY DISCHARGE of Southfork River, near Cowley, for 1910.

[Drainage area, 374 square miles.]

MONTH.	DISCHARGE IN SECOND-FEET.				RUN-OFF.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
April	2,605	345	1,115.5	2.98	3.321	66,377
May	2,790	1,215	1,908.2	5.15	5.937	117,332
June	2,250	880	1,420.3	3.8	4.24	84,516
July	880	240	497.6	1.33	1.533	30,595
August	240	155	204.4	0.547	0.631	12,565
September	695	155	371.2	0.993	1.108	22,086
October	1,145	465	722.8	1.93	2.225	44,444
The period						377,915

Canyon Creek, near Mountain Mill.

This gauging station, located on the N.E.¼ Sec. 14, Tp. 6, Rge. 2, W. 5th Mer., near G. Biron's ranche, was established July 6th, 1910, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed at the left bank within 75 feet of Mr. Biron's corral. It is referred to a bench mark on a spike in a tree within 15 feet, elevation 14.49.

The channel is straight for 150 feet above and 30 feet below the station. Both banks are high, wooded, and will not overflow. The bed of the stream is of clean gravel and rock. The current is very swift and turbulent. On this account, discharge measurements are made about ½ mile upstream at the traffic bridge on the road allowance to the Beaver Coal Mines.

Discharge measurements are taken from the bridge during high water stages, the initial point for soundings being on a line with the face of the left abutment. At ordinary stages the stream is waded about 100 yards downstream, the initial point for soundings being marked by a hub on the left bank.

The gauge was read by Mr. G. Biron.

Discharge Measurements of Canyon Creek, near Mountain Mill, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
June 17	H. C. Ritchie	13.6	8.22	0.846	....	6.96*
July 6	"	11	4.52	0.51	4.1	2.3
July 27	"	13.5	5.55	0.317	3.96	1.76
Aug. 25	"	13.6	5.12	0.31	3.95	1.58
Sept. 19	"	13.5	6.32	0.29	4.0	1.81

* Measurement taken at wading station near regular station.

Mill Creek, near Mountain Mill.

This gauging station, located on the S.W. ¼ Sec. 18, Tp. 6, Rge. 1, W. 5th Mer., at the abandoned site of the old Government Mill, 9½ miles west off Pincher Creek, P.O., was established July 7th, 1910, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed on the left bank. It is referred to a bench mark on a spike at the northeast corner of the mill; elevation 10.97.

The channel is straight for 200 feet above and 300 feet below the station. Both banks are high, clean, rocky and will not overflow. The bed of the stream is of gravel giving a staple cross-section. The current is swift.

Discharge measurements in flood stages are taken from the bridge. In normal and low water stages the creek is waded 50 feet upstream from the gauge, the initial point for soundings being a stake on the left bank.

The gauge was read daily by Mr. J. McIlquham.

Discharge Measurements of Mill Creek, near Mountain Mill, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
June 17	H. C. Ritchie	45.4	69.97	1.72	....	120.48*
July 7	"	41	37.83	1.31	2.1	49.66*
July 27	"	39.6	29.8	0.89	1.95	26.67
Aug. 25	"	18.4	27.01	0.7	1.88	18.9
Sept. 19	"	43.4	52.92	2.22	2.45	118.63
Oct. 14	"	43	48.64	2.0	2.34	97.3

* Measurement taken at wading station, near regular station.

Daily Gauge Height and Discharge in Mill Creek, near Mountain Mill, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	feet	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			1.85	15	1.86	16	2.5	132
2			1.86	16	1.87	17	2.51	135
3			1.88	19	1.87	17	2.51	135
4			1.89	20	1.89	20	2.5	132
5			1.89	20	1.92	23	2.5	132
6			1.89	20	2.2	67	2.5	132
7	2.1	49	1.89	20	2.8	217	2.5	132
8	2.1	49	1.89	20	2.8	217	2.49	130
9	2.1	49	1.88	19	2.7	187	2.49	130
10	2.1	49	1.87	17	2.8	217	2.48	127
11	2.1	49	1.87	17	2.1	49	2.47	125
12	2.1	49	1.87	17	2.1	49	2.43	115
13	2.1	49	1.86	16	2.11	51	2.42	113
14	2.1	49	1.87	17	2.11	51	2.34	95
15	2.1	49	1.87	17	2.28	82	2.33	93
16	2.1	49	1.86	16	2.6	159	2.33	93
17	2.1	49	1.86	16	2.57	151	2.33	93
18	2.0	34	1.86	16	2.5	132	2.3	86
19	2.0	34	1.86	16	2.45	120	2.29	84
20	2.0	34	1.85	15	2.39	106	2.28	82
21	2.0	34	1.85	15	2.39	106	2.25	76
22	2.0	34	1.86	16	2.51	135	2.22	71
23	2.0	34	1.86	16	2.52	137	2.20	67
24	2.0	34	1.86	16	2.52	137	2.19	65
25	2.0	34	1.86	16	2.51	135	2.19	65
26	2.0	34	1.86	16	2.51	135	2.21	69
27	2.0	34	1.86	16	2.52	137	2.25	76
28	2.0	34	1.86	16	2.52	137	2.24	74
29	1.89	20	1.86	16	2.51	135	2.2	67
30	1.89	20	1.86	16	2.5	132	2.18	63
31	1.86	16	1.86	16			2.18	63

Monthly Discharge of Mill Creek, near Mountain Mill, for 1910.

[Drainage area, 64 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in Inches on Drainage area.	Total in acre-feet.
July (7-31)	49	16	38.8	0.606	0.563	1,923
August	20	15	16.9	0.264	0.304	1,039
September	217	16	109.1	1.7	1.9	6,494
October	135	63	98.5	1.54	1.77	6,056
The period						15,512

Pincher Creek, at Pincher Creek.

Under the direction of Arthur O. Wheeler, a regular gauging station was established on Pincher Creek, at Pincher Creek, in the spring of 1898. On August 13, 1906, J. F. Hamilton replaced the old gauge by a new one. Owing to local improvements the gauge has since been changed, but the station remains practically in the same place as established by Mr. Wheeler.

The gauge is a plain staff, graduated to feet and hundredths, securely fastened to the break-water on the right bank, about 20 feet below the traffic bridge. It is referred to bench marks on the north abutment and a low pile underneath the north end of the bridge; elevations 7.55 and 3.40 feet, respectively, above the zero of the gauge. It is read by P. Bertles, who lives on the north side of the creek.

During high water, discharge measurements are made from the downstream side of the bridge. At low stages, the creek is waded 450 yards upstream.

The channel is straight for about 200 yards above and 300 yards below the bridge. Both banks are high, the right being well cribbed; neither is liable to overflow. The bed is rock and free from vegetation. At the wading section, the channel is straight for about 500 yards; above and 70 yards below. Both banks are high, clean, and not liable to overflow. The bed is gravel, mixed with heavy gumbo clay.

The town of Pincher Creek has a gravity waterworks system which diverts water from the creek at a point about 3¼ miles above the bridge and the records at this station do not include the water used by the town.

DISCHARGE MEASUREMENTS of Pincher Creek, at Pincher Creek, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 21	H. C. Ritchie	71.0	42.15	2.82	2.05	118.77*
June 6	"	34.5	20.84	2.06	1.8	42.95†
June 16	"	34.4	20.97	1.922	1.79	40.56†
July 1	"	10.2	6.97	2.75	1.57	19.19¶
July 1	"	10.2	6.42	2.61	1.57	16.75¶
July 8	"	10.0	5.32	2.21	1.48	11.8 ¶
July 19	"	9.3	3.2	1.29	1.28	4.13¶
Aug. 18	"	9.0	2.42	0.925	1.19	2.24¶
Aug. 26	"	9.0	2.67	1.0	1.2	2.68¶
Sept. 9	"	10.0	5.57	2.2	1.5	12.25¶
Sept. 17	"	35.6	30.97	3.2	2.1	99.15†
Oct. 10	"	35.0	21.66	2.15	1.86	46.5 †
Nov. 3	"	11.5	6.22	2.22	1.56	13.9 ¶

* At Pincher Creek Bridge.
† Waded near mouth of Canal.
¶ Waded centre of Canal.

DAILY GAUGE HEIGHT AND DISCHARGE of Pincher Creek, at Pincher Creek, for 1910.

DAY.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.3	5	1.9	55.5	2.0	75
2	1.3	5	1.9	55.5	2.1	99
3	1.3	5	1.8	40	2.1	99
4	1.4	8.1	1.8	40	2.0	75
5	1.4	8.1	1.7	27.7	1.9	55.5
6	1.3	5	1.8	40	1.9	55.5
7	1.3	5	1.8	40	2.0	75
8	1.4	8.1	1.9	55.5	2.0	75
9	1.4	8.1	1.9	55.5	1.9	55.5
10	1.4	8.1	1.7	27.7	1.9	55.5
11	1.4	8.1	1.9	55.5	1.9	55.5
12	1.3	5	1.8	40	1.9	55.5
13	1.4	8.1	1.7	27.7	1.8	40
14	1.6	18.8	2.0	75	1.8	40
15	1.5	12.5	2.0	75	1.8	40
16	1.5	12.5	2.0	75	1.8	40
17	1.5	12.5	2.0	75	1.8	40
18	1.5	12.5	1.9	55.5	1.8	40
19	1.5	12.5	2.0	75 5	1.8	40
20	1.9	55.5	2.1	99	1.8	40
21	1.8	40	2.0	75.5	1.7	27.7
22	1.8	40	2.0	75.5	1.7	27.7
23	1.7	27.7	2.0	75.5	1.7	27.7
24	1.7	27.7	1.9	55.5	1.7	27.7
25	1.7	27.7	2.0	75.5	1.7	27.7
26	1.8	40	2.0	75.5	1.7	27.7
27	2.0	75	2.0	75.5	1.7	27.7
28	1.8	40	2.0	75.5	1.6	18.8
29	1.9	55.5	2.0	75.5	1.6	18.8
30	1.9	55.5	2.0	75.5	1.5	12.5
31	....	....	2.0	75.5	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Pincher Creek, at Pincher Creek, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.5	12.5	1.19	2.4	1.28	4.5	2.02	79.8
2	1.5	12.5	1.19	2.4	1.3	5	2.0	75
3	1.5	12.5	1.18	2.2	1.32	5.6	2.0	75
4	1.5	12.5	1.18	2.2	1.36	6.7	1.97	69
5	1.5	12.5	1.18	2.2	1.39	7.8	1.96	67
6	1.5	12.5	1.17	2	1.4	8.1	1.95	65
7	1.5	12.5	1.17	2	1.5	12.5	1.99	73
8	1.6	18.8	1.16	1.9	1.51	13.1	2.0	75
9	1.6	18.8	1.16	1.9	1.5	12.5	2.1	99
10	1.5	12.5	1.16	1.9	1.51	13.1	2.1	99
11	1.5	12.5	1.15	1.75	1.51	13.1	2.0	75
12	1.5	12.5	1.15	1.75	1.53	14.2	1.9	55.5
13	1.5	12.5	1.15	1.75	1.57	16.8	1.9	55.5
14	1.4	8.1	1.15	1.75	1.62	20.4	1.87	50.7
15	1.4	8.1	1.15	1.75	2.02	79.8	1.85	47.5
16	1.4	8.1	1.14	1.65	2.01	77.4	1.84	46
17	1.28	4.5	1.14	1.65	1.95	65	1.84	46
18	1.28	4.5	1.14	1.65	1.92	59.3	1.88	52.3
19	1.28	4.5	1.13	1.55	1.9	55.5	1.85	47.5
20	1.28	4.5	1.13	1.55	1.83	44.5	1.80	40
21	1.27	4.2	1.12	1.45	1.79	38.7	1.76	34.8
22	1.27	4.2	1.12	1.45	2.01	77.4	1.76	34.8
23	1.27	4.2	1.12	1.45	2.04	84.6	1.74	32.3
24	1.26	4	1.26	4	2.1	99	1.74	32.3
25	1.24	3.5	1.2	2.5	2.1	99	1.7	27.7
26	1.21	2.7	1.16	1.9	1.79	38.7	1.73	31.2
27	1.21	2.7	1.14	1.65	1.84	46	1.74	32.3
28	1.21	2.7	1.16	1.9	1.9	55.5	1.73	31.2
29	1.21	2.7	1.13	1.55	1.91	57.4	1.7	27.7
30	1.2	2.5	1.14	1.65	2.0	75	1.68	25.7
31	1.19	2.4	1.16	1.9	....	....	1.68	25.7

MONTHLY DISCHARGE of Pincher Creek, at Pincher Creek, for 1910.

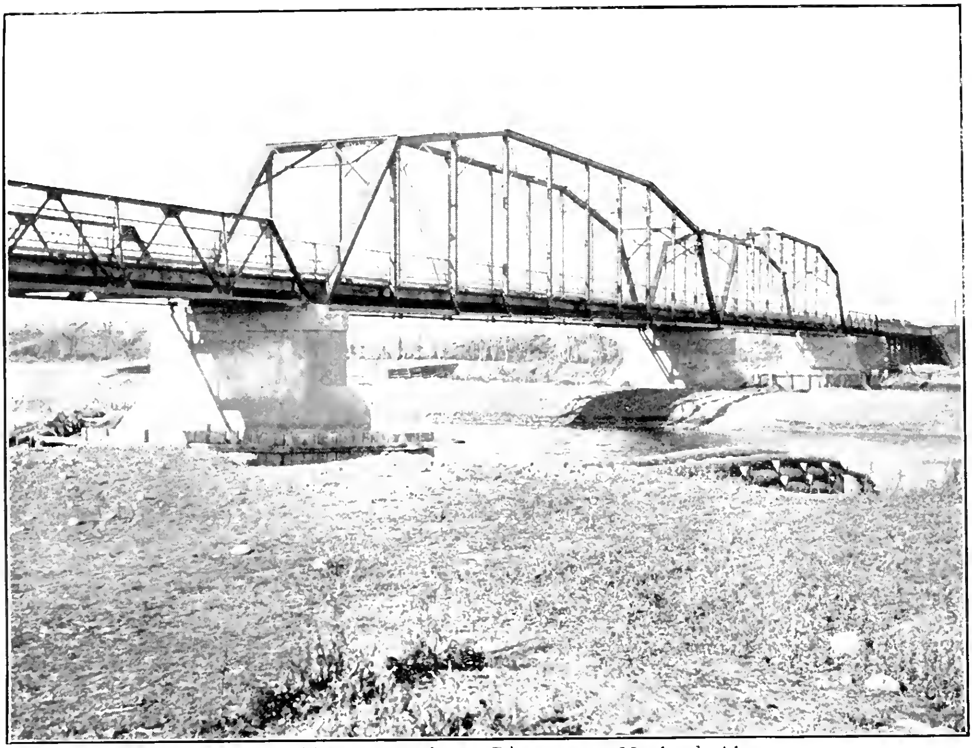
Drainage area, 52 square miles.

Month	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	75.0	5.0	21.75	0.418	0.466	1,294
May	99.0	27.7	61.31	1.179	1.358	3,770
June	99.0	12.5	46.5	0.894	0.997	2,767
July	18.8	2.4	81.7	1.571	1.811	502
August	4.0	1.45	1.92	0.037	0.043	118
September	99	4.5	40.2	0.773	0.862	2,392
October	99	25.7	52.53	1.01	1.164	3,233
The period	....	....	....	....	....	14,076

MISCELLANEOUS DISCHARGE MEASUREMENTS of Oldman River Drainage Basin, in 1910.

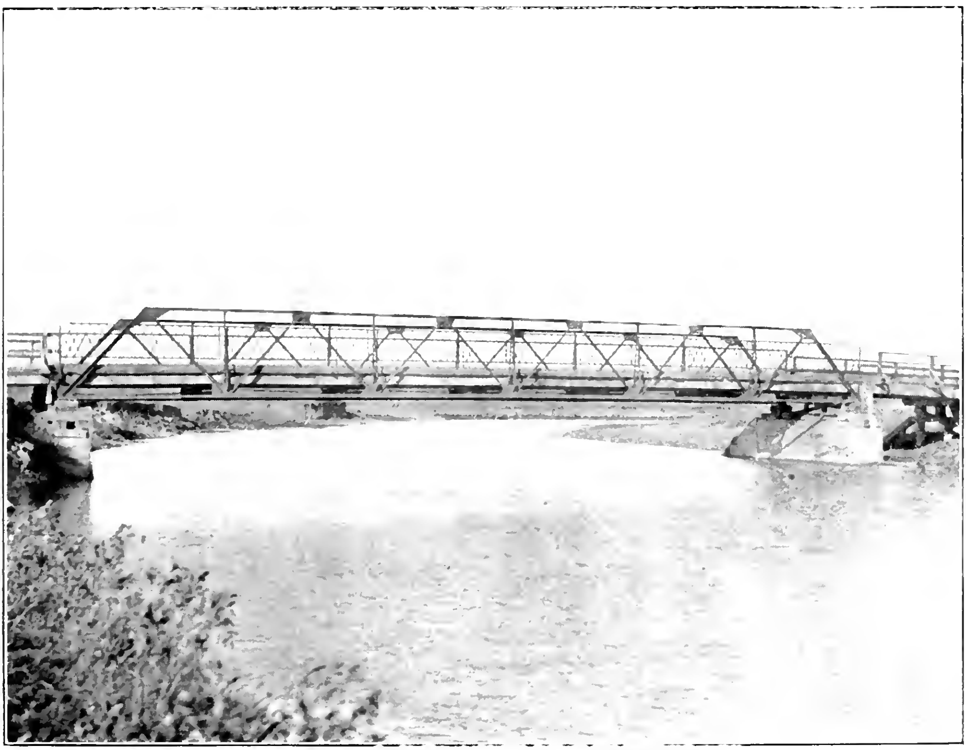
Date	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		Sec.-ft.
June 14	Blairmore Creek	10-8-4-5	H. C. Ritchie	7.9	5.12	7.73
July 20	"	"	"	4.5	2.07	1.88
Aug. 16	"	"	"	6.0	2.36	2.36
Sept. 10	"	"	"	7.5	3.84	5.35
Oct. 18	"	"	"	10.0	5.13	7.47
Nov. 5	"	"	"	9.8	4.43	4.78
May 23	Crowsnest River	N.E./29-7-1-5	"	108.0	231.00	551.91
June 15	"	"	"	108.0	213.35	167.08
July 2	"	"	"	105.5	185.32	313.72
" 23	"	"	"	105.5	155.77	188.60
Aug. 23	"	"	"	102.0	128.40	113.98
Sept. 14	"	"	"	103.0	124.02	115.66
Oct. 11	"	"	"	107.0	177.06	262.86
Aug. 4	"	S.E. 28-7-2-5	J. S. Tempest			138.87
July 20	Calium Creek	N.W. 36-11-2-5	"			Dry
June 13	Creek (small)	12-8-5-5	H. C. Ritchie	5.2	1.21	2.41
" 29	"	S.W. 34-13-29-4	J. S. Tempest	*		0.035
Aug. 11	"	S.E. 36-7-4-5	"	*		0.064
July 4	Creek (spring)	N.E. 13-14-30-4	"	*		0.049
" 4	"	S.E. "	"	*		0.006
" 5	"	S.E. 35-13-30-4	"	*		Dry
" 5	"	aN.E. 27-13-1-5	"	*		0.012
" 5	"	aN.W. 35-13-1-5	"	*		0.012
" 5	"	a "	"	*		0.023
" 26	"	S.E. 7-12-1-5	"	*		0.138
" 20	"	S.E. 6-12-1-5	"	*		0.07
" 29	"	N.W. 26-10-3-5	"	*		0.023
" 5	Cecil Eiton's Ditch	S.W. 19-8-1-5	H. C. Ritchie	4.0	1.34	0.43
" 26	"	"	"	3.7	1.54	0.71
Aug. 5	"	"	J. S. Tempest			0 758
Aug. 20	"	"	H. C. Ritchie	*		0.49
July 29	Ernest Creek	N.W. 26-10-3-5	J. S. Tempest	*		0.52
Aug. 18	Gold Creek	near Frank, Alta	H. C. Ritchie	19.7	9.88	10.57
Oct. 19	"	"	"	21.2	11.47	13.63
Nov. 5	"	"	"	20.7	10.67	13.90
July 4	Kuntz Creek	N.W. 18-14-29-4	J. S. Tempest	* 1.0		0.07
June 13	Lyon Creek	26-7-4-5	H. C. Ritchie	7.0	4.34	6.99
July 20	"	"	"			Dry
Oct. 18	"	"	"	6.0	2.05	2.41
Nov. 4	"	"	"	7.2	3.13	2.33
July 9	Langford Creek	S.E. 28-13-2-5	J. S. Tempest	*		0.90
" 11	"	"	"	*		0.79
" 18	"	S.E. 30-13-2-5	"	*		0.28
" 18	"	S.E. 28-13-2-5	"	*		0.10
June 13	McGillivary Creek, W. Branch	near Coleman, Alta	H. C. Ritchie	7.6	4.94	4.77
" 13	" E. Branch	"	"	16.5	16.55	26.60
July 21	McGillivary Creek	N.E. 7-8-4-5	"	14.8	10.79	6.20
Aug. 10	"	"	"	*		2.37
" 17	"	"	J. S. Tempest	14.6	10.05	3.37
Sept. 12	"	18-8-4-5	"	7.5	2.71	3.06
Oct. 19	"	7-8-4-5	H. C. Ritchie	1.5	11.27	7.26
Nov. 4	"	7-8-4-5	"	15.2	11.56	6.39
July 21	Nez-perce River	17-8-4-5	"	2.5	0.69	1.10
" 21	"	"	"	11.8		0.12
Aug. 17	"	"	"	3.5	0.84	1.04
" 10	"	"	"	*		0.53
" 10	"	"	"	*		0.02
Sept. 12	"	"	"	4.0	1.19	1.78
Oct. 19	"	"	"	11.8		0.62
" 19	"	"	"	4.0	1.41	2.13
Nov. 4	"	"	"	4.9	2.00	3.40
July 1	Oldman River	S.E. 35-7-1-5	"	78.7	148.14	786.44
" 22	"	N.E. 1-10-2-5	J. S. Tempest			265.27
" 20	Playle Creek	S.W. 32-11-1-5	"	*		0.8
" 19	Pincher Creek	N.W. 16-6-30-4	H. C. Ritchie	12.7	7.20	5.71
Aug. 16	"	N.E. 17-6-30-4	J. S. Tempest			4.25
" 26	"	N.W. 16-6-30-4	H. C. Ricthie	7.0	2.64	2.81
July 19	Pincher Creek Waterworks	At. Intake, Pincher Creek, Alta	"	2.5	0 52	0.67
Aug. 12	Southfork River	N.W. 35-6-1-5	J. S. Tempest			192.35
July 11	Stevenson's Ditch	N.E. 12-12-28-4	H. C. Ritchie			Nil
Oct. 20	"	"	"	4.0	1.99	2.10
July 2	Sorrel Horse Creek	S.E. 26-13-30-4	J1 S. Tempest	*		0.012
" 11	Trout Creek	11-12-28-4	H. C. Ritchie	3.0	0.44	0.40
Oct. 21	"	N.E. 2-12-28-4	"	4.3	1.98	2.17
July 25	Todd Creek	N.W. 36-8-2-5	J. S. Tempest	x		3.625
" 28	"	S.E. 11-9-2-5	"	b		4.987
" 28	"	"	"	c		4.182
" 28	"	S.W. 1-9-2-5	"	b		6.13
" 28	"	"	"	c		4.681
" 29	"	N.W. 36-8-2-5	"	d		3.283
" 30	"	"	"	e		4.131

PLATE No. 13.



Traffic Bridge over Oldman River, near Macleod, Alta.

PLATE No. 14.



Traffic Bridge over Belly River, near Stand Off, Alta.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Oldman River Drainage Basin, in 1910.—*Con.*

Date	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		*Sec. ft.*
Aug. 5	Todd Creek	N.W. 19-18-1-5	J. S. Tempest	*A*		2.962
" 5	"	S.W. 18-8-1-5	"	*B*		1.819
July 14	Westrup Creek	S.W. 16-13-2-5	"	*x*		0.56
June 21	Willow Creek	S.W. 36-12-28-4	H. C. Ritchie	20.0	18.79	26.63
" 27	"	S.E. 31-13-28-4	J. S. Tempest			19.85
July 5	"	N.E. 1-14-1-5	"			12.92
" 21	"	S.W. 36-12-28-4	H. C. Ritchie	19.0	7.36	6.69
Aug. 29	"	"	"	14.0	4.88	5.57
Sept. 26	"	"	"	23.0	30.75	64.94
Oct. 20	"	"	"	22.0	24.80	35.26
Nov. 16	"	N.W. 30-14-2-5	J. S. Tempest	7.0	2.80	1.73
June 14	York Creek	34-7-4-5	H. C. Ritchie	21.5	24.10	62.36
July 20	"	"	"	19.5	12.29	13.54
Aug. 16	"	"	"	17.5	8.72	5.83
Sept. 10	"	"	"	17.2	8.07	5.68
Oct. 18	"	"	"	18.8	12.66	15.14
Nov. 5	"	"	"	18.9	12.07	11.90

* Weir Measurements.
a Three separate creeks emptying into Willow Creek.
x Hot day.
b Cloudy.
c Warm and clear.
d After very hot day.
e Cool morning.
A. Above Cecil Eldon's Ditch.
B. Below " "

WATERTON RIVER DRAINAGE BASIN.

General Description.

Waterton River rises in the Northwestern portion of the state of Montana, in the Eastern slope of the Rocky Mountains. It flows in a northerly direction and passing through a chain of lakes near the International Boundary, known as Waterton Lakes, it continues in a north and easterly direction and finally empties into Belly River, near Stand Off, Alta.

The topography of the basin is of a varied character, ranging from the mountainous regions of Montana to the rolling prairie of Southern Alberta. The tributaries are mostly in the upper portion of the basin, near the International Boundary and from the west side.

There is a large snow-fall in the upper portion of the basin, and the melting of this, combined with heavy rains, often causes big floods on this river in the early summer. Thereafter the river steadily decreases in volume, until the minimum is reached about mid-winter.

Waterton Lakes offer a very favourable site for a storage reservoir, approximately 14 miles long and 1 mile wide. The steep rock banks of the narrows are an ideal site for the construction of a dam. The flow could be more than doubled during the summer months and used for irrigation purposes, or a power project could easily be developed.

WATERTON RIVER, AT WATERTON MILLS.

This gauging station, located on the N.E. ¼ Sec. 8, Tp. 2, Rge. 29, W. 4th Mer., about 250 feet below the river's outlet from the lake, was established August 26th, 1908, by P. M. Sauder.

The gauge is a plain staff, graduated to feet and hundredths, placed in a box cribbing, at the right bank. It is referred to a bench mark on a tree stump within 6 feet of the gauge; elevation 9.69.

The channel is wide and straight for 300 feet above and 400 feet below the station. Both banks are high, wooded, and will not overflow. The bed of the stream is rough and rocky with a stable cross-section. The current is rather sluggish but there is a good flow at all stages.

Discharge measurements are made from a cable car during high stages. In low water the stream can be waded almost across, the deep channel in the centre being taken from the cable car. The heavy winds which blow frequently affect the measurements. The points for soundings are marked by a tagged wire stretched above the cable.

The gauge was read daily by Mr. H. H. Hanson.

DISCHARGE MEASUREMENTS of Waterton River at Waterton Mills, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 2	H. C. Ritchie	297	673.25	3.896	4.45	2623.29
June 28	"	293	479.8	2.778	3.81	1332.95
July 16	"	289	355.65	2.05	3.37	729.66
Aug. 12	"	230	207.88	1.56	2.79	325.22
Oct. 7	"	292.5	425.67	2.67	3.74	1136.8
Oct. 31	"	287	397.25	2.12	3.44	842.89

DAILY GAUGE HEIGHT AND DISCHARGE of Waterton River, at Waterton Mills, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.1	520	4.2	2,100	4.5	2,925	3.7	1165
2	3.1	520	4.2	2,100	4.4	2,650	3.7	1165
3	3.1	520	4.0	1,670	4.4	2,650	3.7	1165
4	3.1	520	3.9	1,485	4.2	2,100	3.7	1165
5	3.1	520	3.9	1,485	4.2	2,100	3.7	1165
6	3.1	520	4.0	1,670	4.1	1,870	3.7	1165
7	3.1	520	4.1	1,870	4.1	1,870	3.6	1030
8	3.1	520	4.2	2,100	4.0	1,670	3.6	1030
9	3.1	520	4.4	2,650	4.1	1,870	3.7	1165
10	3.1	520	4.4	2,650	4.1	1,870	3.6	1030
11	3.2	600	4.3	2,375	4.2	2,100	3.5	910
12	3.2	600	4.3	2,375	4.2	2,100	3.5	910
13	3.2	600	4.3	2,375	4.1	1,870	3.4	795
14	3.3	695	4.2	2,100	4.1	1,870	3.4	795
15	3.4	795	4.2	2,100	4.1	1,870	3.4	795
16	3.4	795	4.2	2,100	4.0	1,670	3.4	795
17	3.4	795	4.1	1,870	4.1	1,870	3.4	795
18	3.4	795	4.1	1,870	4.0	1,670	3.4	795
19	3.5	910	4.0	1,670	4.0	1,670	3.4	795
20	3.7	1,165	4.0	1,670	4.1	1,870	3.4	795
21	3.8	1,315	4.0	1,670	4.1	1,870	3.3	695
22	3.9	1,485	4.0	1,670	4.0	1,670	3.3	695
23	3.8	1,315	4.0	1,670	4.0	1,670	3.3	695
24	3.8	1,315	4.4	2,650	3.9	1,485	3.2	600
25	4.2	2,100	4.4	2,650	3.8	1,315	3.2	600
26	4.3	2,375	4.4	2,650	3.8	1,315	3.2	600
27	4.4	2,650	4.4	2,650	3.8	1,315	3.1	520
28	4.4	2,650	4.4	2,650	3.8	1,315	3.1	520
29	4.4	2,650	4.4	2,650	3.8	1,315	3.1	520
30	4.3	2,375	4.4	2,650	3.7	1,165	3.0	450
31			4.4	2,650			3.0	450

DAILY GAUGE HEIGHT AND DISCHARGE of Waterton River, at Waterton Mills, for 1910.—*Con.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-Ft*	*Feet.*	*Sec.-ft.*
1	3.0	450	2.6	248	3.6	1030	3.4	795
2	3.0	450	2.6	248	3.6	1030	3.35	745
3	3.0	450	2.6	248	3.7	1165	3.35	745
4	3.0	450	2.7	285	3.7	1165	3.3	695
5	3.0	450	2.8	332	3.7	1165	3.25	647
6	2.9	387	2.8	332	3.7	1165	3.2	600
7	2.9	387	2.7	285	3.75	1240	3.2	600
8	2.9	387	2.7	285	4.05	1770	3.2	600
9	2.9	387	2.8	332	4.0	1670	3.2	600
10	2.9	387	2.8	332	4.0	1670	3.3	695
11	2.9	387	2.9	387	3.98	1633	3.35	745
12	2.9	387	3.0	450	3.95	1578	3.4	795
13	2.9	387	3.1	520	3.9	1485	3.45	852
14	2.9	387	3.4	795	3.8	1315	3.45	852
15	2.8	332	3.4	795	3.7	1165	3.5	910
16	2.8	332	3.4	795	3.65	1097	3.55	970
17	2.8	332	3.4	795	3.6	1030	3.55	970
18	2.8	332	3.4	795	3.5	910	3.5	910
19	2.8	332	3.4	795	3.45	852	3.45	852
20	2.8	332	3.4	795	3.45	852	3.45	852
21	2.8	332	3.4	795	3.4	795	3.4	795
22	2.8	332	3.4	795	3.35	745	3.4	795
23	2.7	285	3.4	795	3.3	695	3.35	745
24	2.7	285	3.5	910	3.2	600	3.35	745
25	2.7	285	3.5	910	3.2	600	3.3	690
26	2.7	285	3.5	910	3.2	600	3.2	600
27	2.6	248	3.5	910	3.3	695	3.15	560
28	2.6	248	3.5	910	3.35	745	3.15	560
29	2.6	248	3.5	910	3.4	795	3.1	520
30	2.6	248	3.6	1030	3.45	852	3.05	485
31	2.6	248	......	......	3.4	795	......	......

MONTHLY DISCHARGE of Waterton River, at Waterton Mills, for 1910.

[Drainage area, 228 square miles.]

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	2,650	520	1,106	4.85	5.41	65,812
May	2,650	1,485	2,145	9.41	10.85	131,891
June	2,925	1,165	1,819	7.98	8.9	108,238
July	1,165	450	830	3.65	4.2	51,114
August	450	248	347	1.52	1.76	21,360
September	1,030	248	591	2.59	2.89	35,155
October	1,770	600	1,061	4.66	5.37	65,264
November	970	485	731	3.20	3.58	43,488
The period						522,322

CROOKED CREEK, NEAR WATERTON MILLS.

This gauging station, located on the S.E. ¼ Sec. 22, Tp. 2, Rge. 29, W. 4th Mer., was established September 15th, 1909, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, placed at the right bank. It is referred to a bench mark on a fence post, 150 feet northeast of the gauge, elevation 15.97.

The channel is straight for 20 feet above and below the station. Both banks are high, wooded, and not liable to overflow. The bed is of clean sand and gravel.

Discharge measurements are taken from a bridge, ½ mile downstream from the gauge, during high stages. In low stages the stream is waded a little below the bridge, the initial point for soundings being at a stake on the left bank.

The gauge was read daily by Mr. H. H. Hanson.

Discharge Measurements of Crooked Creek, near Waterton Mills, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
June 3	H. C. Ritchie	12.7	15.84	0.976	1.97	15.45
June 28	"	7	3.59	1.35	1.7	4.85
July 16	"	6	2.34	0.78	1.55	1.83
Aug. 11	"	5.3	1.477	0.45	1.47	0.66
Sept. 5	"	7.4	4.95	1.51	1.77	7.45
Oct. 6	"	9	7.55	1.69	1.96	12.75
Oct. 31	"	7.9	5.82	1.54	1.85	8.95

Daily Gauge Height and Discharge of Crooked Creek, near Waterton Mills, in 1910.

Day.	June.		July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			1.5	1.1	1.2	0.0	1.4	0.2	2.4	34.4
2			1.5	1.1	1.2	0.0	1.4	0.2	2.4	34.4
3	2.0	14.3	1.5	1.1	1.3	0.0	1.4	0.2	2.3	28.9
4	2.0	14.3	1.5	1.1	1.3	0.0	1.5	1.1	2.2	23.6
5	2.0	14.3	1.5	1.1	1.3	0.0	1.7	1.8	2.1	18.6
6	2.0	14.3	1.5	1.1	1.4	0.2	1.6	2.7	1.96	12.7
7	2.1	18.6	1.5	1.1	1.4	0.2	1.5	1.1	2.3	28.9
8	2.2	23.6	1.6	2.7	1.5	1.1	1.5	1.1	2.5	40.0
9	2.1	18.6	1.7	4.8	1.5	1.1	1.6	2.7	2.45	37.2
10	2.0	14.3	1.7	4.8	1.5	1.1	1.6	2.7	2.4	34.4
11	2.0	14.3	1.7	4.8	1.5	1.1	1.6	2.7	2.35	31.6
12	2.0	14.3	1.6	2.7	1.5	1.1	1.7	4.8	2.3	28.9
13	1.9	10.5	1.5	1.1	1.5	1.1	1.8	7.4	2.25	26.2
14	1.9	10.5	1.5	1.1	1.5	1.1	1.9	10.5	2.2	23.6
15	1.9	10.5	1.5	1.1	1.5	1.1	2.0	14.3	2.2	23.6
16	1.8	7.4	1.5	1.1	1.4	0.2	2.0	14.3	2.1	18.6
17	1.9	10.5	1.5	1.1	1.5	1.1	2.1	18.6	1.9	10.5
18	1.8	7.4	1.5	1.1	1.5	1.1	2.1	18.6	1.9	10.5
19	1.8	7.4	1.5	1.1	1.5	1.1	2.1	18.6	1.9	10.5
20	1.8	7.4	1.4	0.2	1.5	1.1	2.1	18.6	1.9	10.5
21	1.8	7.4	1.4	0.2	1.5	1.1	2.1	18.6	1.9	10.5
22	1.8	7.4	1.4	0.2	1.4	0.2	2.2	23.6	1.9	10.5
23	1.8	7.4	1.4	0.2	1.4	0.2	2.2	23.6	1.9	10.5
24	1.7	4.8	1.4	0.2	1.5	1.1	2.2	23.6	1.85	8.9
25	1.7	4.8	1.3	0.0	1.5	1.1	2.4	34.4	1.9	10.5
26	1.7	4.8	1.3	0.0	1.5	1.1	2.4	34.4	1.9	10.5
27	1.7	4.8	1.3	0.0	1.4	0.2	2.4	34.4	2.0	14.3
28	1.7	4.8	1.3	0.0	1.4	0.2	2.3	28.9	2.0	14.3
29	1.6	2.7	1.2	0.0	1.4	0.2	2.4	34.4	1.9	10.5
30	1.6	2.7	1.2	0.0	1.4	0.2	2.4	34.4	1.85	8.9
31			1.2	0.0	1.4	0.2			1.85	8.9

Monthly Discharge of Crooked Creek, near Waterton Mills, for 1910.

Drainage area, 20 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
June 3-30	23.6	2.7	10.14	0.507	0.527	563
July	4.8	0	1.17	0.058	0.067	72
August	1.1	0	0.63	0.031	0.036	39
September	34.4	0.2	14.5	0.725	0.809	863
October	40.0	8.9	19.54	0.977	1.126	1202
The period						2739

Miscellaneous Discharge Measurements of Waterton River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.	*Sq. ft.*	*Sec.-ft.*
August 13	Cottonwood Creek	20-2-29-4	H. C. Ritchie	9.1	3.79	4.41
October 31	" "	"	"	16.7	13.09	12.74
August 26	Crooked Creek	S.E. 22-2-29-4	J. S. Tempest	6	5.17	3.26
August 26	Little Crooked Creek	"	"	*	....	0.56
June 29	Oil Creek	Near Waterton Mills.	H. C. Ritchie	44	47.9	154.
July 15	"	" "	"	30.5	47.59	66.94
August 12	"	15-1-30-4	"	28	25.91	22.03
September 5	"	"	"	28.5	27.04	22.32
November 1	"	"	"	35	42.84	66.33
June 29	Pass Creek	Near Waterton Mills.	"	34	47.81	167.57
July 15	"	" "	"	32	33.54	78.56
August 12	"	S.W. 27-1-30-4	"	31.5	21.23	28.41
September 5	"	"	"	33.1	36.18	71.13
November 1	"	"	"	34.5	42.96	108.76
August 13	Pine Creek	21-3-29-4	"	12.5	1.71	4.89
August 19	"	N.E. 24-3-29-4	J. S. Tempest	...	....	4.59
November 2	"	S.E. 21-3-29-4	H. C. Ritchie	16.5	7.36	11.11
August 19	Waterton River	N.W. 19-3-28-4	J. S. Tempest	....	....	202.96
August 13	Yarrow River South	S.W. 8-4-29-4	H. C. Ritchie	23.2	14.39	13.5
November 2	" "	"	"	27.8	27.23	48.1
August 13	" North.	N.W. 17-4-29-4	"	19.4	9.68	12.64
November 2	" "	"	"	24	17.14	36.39

* Weir measurement.

BELLY RIVER DRAINAGE BASIN.

General Description.

Belly River rises near Chief Mountain in Northern Montana. The main stream is augmented on the United States side of the boundary line by Middle Fork and on the Canadian side by North Fork. From the junction with North Fork on Sec. 21, Tp. 1, Rge. 28, W. 4th Mer., it flows in a winding, but northeasterly course until it is joined by Oldman River in Sec. 27, Tp. 9, Rge. 23, W. 4th Mer., where it turns southeasterly, and after making a loop flows in a north and easterly direction until it joins Bow River in Sec. 27, Tp. 11, Rge. 13, W. 4th Mer., and forms the South Saskatchewan River.

The topography of the basin is of the most varied character, ranging from the mountainous regions of Montana, the rolling prairie and foothills at the boundary to the level prairie from Lethbridge to the junction with Bow River. The upper tributaries drain a forested region but the main stream flows through a deep valley with many bluffs of large whitewood on its banks.

There is an abundant snowfall in the upper portion of the basin, but the precipitation diminishes into semi-arid conditions near Lethbridge. At first Belly River is a comparatively clear stream but soon after crossing the boundary line it gradually becomes turbid, especially at times of high water. The greater portion of the sediment is caused by the washing away of banks and cutting of new channels. Freshets caused by melting snow and heavy rains are frequent in the summer. The maximum flow usually occurs in June or July, and after that the flow gradually decreases until it reaches the minimum in January or February.

As yet very little use has been made of the water in this basin. In the upper regions where water could easily be diverted it is not required for irrigation purposes and further downstream it would be an expensive undertaking. There are, however, a number of feasible power sites which will no doubt be developed when there is a market.

Belly River, near Stand Off.

A gauging station was established on this river as early as 1906. On September 18th of that year Mr. J. F. Hamilton placed a gauge rod within 800 yards of the Police detachment at Big Bend, Alta. Measurements were taken in this vicinity until September 14th, 1908, when, owing to the changeable conditions at the station it was abandoned.

On May 27th, 1909, Mr. H. C. Ritchie established a new station at Stand Off.

The gauge consists of a plain staff, graduated to feet and hundredths. It is secured by braces to the bank at a point near Mr. G. Pearson's buildings and is read daily by him. It is referenced by two bench marks on spikes in two fence posts 25 feet and 37 feet upstream, the elevations being 7.49 and 8.35 respectively.

The discharge measurements are taken from the traffic bridge on the S.E. ¼ Sec. 24, Tp. 6, Rge. 25, W. 4th Mer., the points for soundings being painted on the lower chord of the superstructure.

For a distance of 75 feet above and 60 feet below the section the river is straight, running smoothly with a moderate velocity over a bed of clean gravel. Both banks are low, free from brush, and liable to overflow during high stages of the river.

Since the establishment of this station the cross-section has changed very little, if any, but owing to the sharp turns in the channel the river is liable to take a new course altogether in times of extreme flood.

DISCHARGE MEASUREMENTS of Belly River at Stand Off, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 30	H. C. Ritchie	96	271.57	3.451	2.05	937.55
June 25	"	93	201.60	2.476	1.55	499.24
July 13	"	91.5	184.35	2.184	1.42	402.75
August 9	"	85	138.75	1.6	1.07	222.28
September 2	"	84	110.41	1.257	0.89	138.79
October 3	"	94	208.99	2.51	1.64	524.64
October 28	"	93.5	192.56	2.17	1.49	417.01
December 12	W. H. Greene	83.5	110.83	1.096	1.0	121.47

DAILY GAUGE HEIGHT AND DISCHARGE of Belly River, at Stand Off, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.4	1,310	2.1	990	2.1	990	1.6	535
2	2.5	1,430	2.0	890	2.1	990	1.7	615
3	2.4	1,310	2.0	890	2.0	890	1.7	615
4	2.3	1,200	1.9	795	2.0	890	1.7	615
5	2.2	1,090	1.7	615	1.9	795	1.6	535
6	2.1	990	1.5	460	1.8	700	1.6	535
7	2.1	990	1.5	460	1.8	700	1.6	535
8	2.0	890	1.6	535	1.7	615	1.5	460
9	2.0	890	2.2	1,090	1.8	700	1.5	460
10	1.9	795	2.3	1,200	1.9	795	1.5	460
11	1.9	795	2.2	1,090	2.0	890	1.5	460
12	1.8	700	2.2	1,090	2.0	890	1.5	460
13	1.7	615	2.0	890	2.0	890	1.5	460
14	1.6	535	2.0	890	1.9	795	1.4	395
15	1.4	395	1.9	795	1.8	700	1.5	460
16	1.3	340	1.8	700	1.8	700	1.5	460
17	1.4	395	1.8	700	1.8	700	1.6	535
18	1.4	395	1.7	615	1.7	615	1.5	460
19	1.5	460	1.7	615	1.7	615	1.5	460
20	1.5	460	1.9	795	1.7	615	1.5	460
21	1.7	615	1.9	795	1.6	535	1.4	395
22	1.7	615	1.9	795	1.6	535	1.4	395
23	1.7	615	2.0	890	1.6	535	1.3	340
24	1.6	535	2.0	890	1.5	460	1.3	340
25	1.7	615	2.1	990	1.5	460	1.3	340
26	1.8	700	2.1	990	1.5	460	1.3	340
27	2.0	890	2.2	1,090	1.5	460	1.3	340
28	2.1	990	2.1	990	1.5	460	1.2	285
29	2.2	1,090	2.1	990	1.6	535	1.2	285
30	2.1	990	2.0	890	1.6	535	1.2	285
31			2.1	990			1.2	285

Daily Gauge Height and Discharge of Belly River, at Stand Off, for 1910.—*Continued.*

Day.	August.		September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.2	285	.9	145	1.45	392	‡			
2	1.2	285	.85	122	1.5	425				
3	1.2	285	.8	100	1.64	530				
4	1.2	285	.9	145	1.7	575				
5	1.1	235	1.0	190	1.8	655				
6	1.1	235	1.1	235	1.75	615				
7	1.1	235	1.1	235	1.64	530				
8	1.1	235	1.2	285	1.64	530				
9	1.15	260	1.3	340	1.7	575				
10	1.15	260	1.3	340	1.85	697				
11	1.16	265	1.3	340	1.95	788				
12	1.16	265	1.27	324	1.9	740				
13	1.17	270	1.23	301	1.85	697				
14	1.17	270	1.2	285	1.8	655				
15	1.2	285	1.2	285	1.75	615				
16	1.2	285	1.28	330	1.65	538				
17	1.1	235	1.6	†535	1.6	500				
18	1.05	212	1.8	†700	1.55	462				
19	1.0	190	1.75	†650	1.5	425				
20	1.03	203	1.6	†520	1.45	392				
21	.95	167	1.55	†485	1.4	360			*‡	
22	.95	168	1.7	†595	1.39	355			.4	
23	.9	145	1.8	†680	1.3	305			.9	
24	1.0	190	1.9	†765	1.3	305			.85	
25	1.1	235	1.9	†760	1.35	333			1.1	
26	.95	167	1.85	†705	1.4	360			1.1	
27	.9	145	1.75	†615	1.49	419			1.1	
28	.85	122	1.55	463	1.5	425			.9	
29	.85	123	1.5	425	1.48	412			.9	
30	.9	145	1.5	425	1.4	360			.9	
31	.9	145			1.4	360			.85	

‡ No gauge height observations from Nov. 1 to Dec. 21.
† Changing conditions, Bolster method applied.
* Ice conditions during December.

Monthly Discharge of Belly River at Stand Off, for 1910.

Drainage area, 461 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	1,430	340	788	1.69	1.89	46,889
May	1,200	460	852	1.85	2.13	52,375
June	990	460	682	1.48	1.65	40,564
July	615	285	439	0.952	1.1	26,987
August	285	122	220	0.478	0.551	13,552
September	765	100	410.8	0.891	0.994	24,444
October	788	305	494	1.07	1.23	30,405
The period						235,216

Mami Creek, near Mountain View.

This gauging station, located at the traffic bridge on the road allowance north of the N.E. ¼ Sec. 18, Tp. 2, Rge. 27, W. 4th Mer., was established August 13th, 1909, by H. C. Ritchie.

The gauge is a plain staff, graduated to feet and hundredths, fastened to a pile supporting the bridge. It is referred to a bench mark on a pile at the right bank: elevation 9.30.

The channel is curved for about 100 feet above the bridge and straight for 200 feet below. Both banks are high, clean, rocky and liable to overflow in extreme high water. The bed of the stream is stones covered with sand and gravel.

Discharge measurements during high water are taken from the bridge, which is just below the junction of the east and west branches. In low water the east branch dries up and the west branch is waded just above the junction.

The gauge was read daily by Mr. James Cowcill.

Discharge Measurements of Mami Creek, at Mountain View, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
June 27	H. C. Ritchie	6	0.88	0.69	1.75	0.61
September 3	"	4	0.72	0.847	1.73	0.61
August 27	J. S. Tempest	......	......	......	......	Dry.
October 29	"	6.5	2.63	0.88	1.86	2.31

Daily Gauge Height and Discharge of Mami Creek, at Mountain View, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	2.0	10.4	1.9	3.8	1.9	3.8
2	2.0	10.4	1.9	3.8	1.9	3.8
3	2.0	10.4	1.9	3.8	1.9	3.8
4	1.95	6.7	1.9	3.8	1.9	3.8
5	1.9	3.8	1.9	3.8	1.9	3.8
6	1.9	3.8	1.9	3.8	1.9	3.8
7	2.0	10.4	1.9	3.8	1.9	3.8
8	1.9	3.8	1.9	3.8	2.0	10.4
9	1.9	3.8	1.9	3.8	2.0	10.4
10	1.9	3.8	1.9	3.8	2.0	10.4
11	1.95	6.7	2.0	10.4	1.9	3.8
12	1.9	3.8	1.9	3.8	1.9	3.8
13	1.9	3.8	1.9	3.8	1.9	3.8
14	1.9	3.8	1.9	3.8	1.9	3.8
15	1.9	3.8	2.0	10.4	1.9	3.8
16	1.9	3.8	2.0	10.4	1.8	1.2
17	1.9	3.8	2.0	10.4	1.8	1.2
18	1.9	3.8	2.0	10.4	1.8	1.2
19	1.9	3.8	2.1	20.0	1.8	1.2
20	1.9	3.8	2.1	20.0	1.8	1.2
21	1.9	3.8	2.0	10.4	1.8	1.2
22	1.9	3.8	2.0	10.4	1.8	1.2
23	1.9	3.8	2.0	10.4	1.8	1.2
24	1.9	3.8	2.0	10.4	1.8	1.2
25	1.9	3.8	2.0	10.4	1.8	1.2
26	1.9	3.8	1.9	3.8	1.8	1.2
27	1.9	3.8	1.9	3.8	1.7	.4
28	1.9	3.8	1.9	3.8	1.7	.4
29	1.9	3.8	1.9	3.8	1.7	.4
30	1.9	3.8	1.9	3.8	1.7	.4
31	......	......	1.9	3.8	......	......

DAILY GAUGE HEIGHT AND DISCHARGE of Mami Creek, at Mountain View, for 1910.—*Continued.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.7	.4	1.0	0	1.0	0	1.9	3.8
2	1.7	.4	.9	0	1.6	.2	1.9	3.8
3	1.7	.4	.8	0	1.7	.4	1.9	3.8
4	1.7	.4	.7	0	1.7	.4	1.9	3.8
5	1.7	.4	.7	0	1.8	1.2	1.9	3.8
6	1.7	.4	.7	0	1.8	1.2	1.9	3.8
7	1.7	.4	.7	0	1.8	1.2	1.9	3.8
8	1.7	.4	.7	0	1.8	1.2	1.9	3.8
9	1.7	.4	.7	0	1.8	1.2	1.9	3.8
10	1.7	.4	.7	0	1.8	1.2	1.9	3.8
11	1.7	.4	.7	0	1.8	1.2	1.9	3.8
12	1.7	.4	.6	0	1.9	3.8	1.9	3.8
13	1.7	.4	.6	0	1.9	3.8	1.9	3.8
14	1.6	.2	.6	0	1.8	1.2	1.9	3.8
15	1.6	.2	.6	0	1.9	3.8	1.9	3.8
16	1.6	.2	.6	0	1.9	3.8	1.8	1.2
17	1.6	.2	.5	0	1.9	3.8	1.8	1.2
18	1.5	.0	.5	0	1.9	3.8	1.8	1.2
19	1.5	.0	.5	0	1.9	3.8	1.9	3.8
20	1.4	.0	.4	0	1.8	1.2	1.9	3.8
21	1.4	.0	.4	0	[a]1.8	1.2	1.9	3.8
22	1.4	.0	.3	0	1.95	6.7	1.9	3.8
23	1.4	.0	.3	0	2.0	10.4	1.9	3.8
24	1.3	.0	.5	0	1.9	3.8	1.9	3.8
25	1.3	.0	.6	0	1.9	3.8	1.9	3.8
26	1.3	.0	.6	0	1.9	3.8	1.9	3.8
27	1.3	.0	.6	0	1.9	3.8	1.9	3.8
28	1.2	.0	.6	0	1.9	3.8	1.9	3.8
29	1.1	.0	.8	0	1.9	3.8	1.9	3.8
30	1.1	.0	.9	0	1.9	3.8	1.9	3.8
31	1.0	.0	1.0	0	....	....	1.9	3.8

MONTHLY DISCHARGE of Mami Creek at Mountain View, for 1910.

Drainage area, 21 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	10.4	3.8	4.14	0.197	0.22	246
May	20.0	3.8	6.97	0.332	0.383	429
June	10.4	0.4	3.05	0.193	0.215	181
July	0.4	0.0	0.2	0.009	0.0104	12
August	0.0	0.0	0.0	0.0	0.0	....
September	10.4	0.0	2.78	0.132	0.147	165
October	3.8	1.2	3.55	0.169	0.195	218
The period						1251

MISCELLANEOUS DISCHARGE MEASUREMENTS in Belly River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge
				Feet.		*Sec.-ft.*
June 27	Belly River	1-3-28-4	H. C. Ritchie	92.5	262.20	667.87
November 18	"	7-10-16-4	"	416.5	1,919.12	2,941.64
August 1	"	Lethbridge, Alta.	"	341.0	1,493.85	1,706.63
August 31	"	"	"	323.0	1,252.47	1,000.16
September 23	"	"	"	357.0	1,764.06	2,700.05
October 26	"	"	"	352.0	1,699.80	2,429.58
November 17	"	N.W. 1-9-22-4	"	361.0	1,859.25	2,908.79
September 11	Chin Coulee	S.W. 6-10-18-4	J. S. Tempest	16.8	31.09	†30.53

† Water spilling into coulee.

ST. MARY RIVER DRAINAGE BASIN.

General Description.

St. Mary River, an important tributary of the Belly River and so indirectly of the South Saskatchewan River, heads in northern Montana on the eastern slope of the main range of the Rocky Mountains. It starts from the great Blackfoot Glacier and receives affluents from numerous lesser glaciers. These streams unite within a short distance from their source and flow into Upper St. Mary Lake. Below this lake and in close proximity is Lower St. Mary Lake, the aggregate length of the two being about 22 miles. The river flows out of the lower lake, at an elevation of 4,460 feet above mean sea level, and takes a northerly course through the foothills to the International Boundary. From the boundary it flows in a north and westerly direction, through a rolling prairie country, finally emptying into the Belly River near Lethbridge, Alta.

The basin is bounded on the south by the Rocky Mountains, on the west by the watershed between Belly and St. Mary Rivers and the east by the watershed between Milk and St. Mary Rivers. The upper portion of the basin is heavily timbered and receives its precipitation mostly in the shape of snowfall, but the lower and major portion is totally devoid of tree growth, and has a small precipitation.

The river flows through a very deep valley having steep banks making the diversion of water from this stream for irrigation an expensive undertaking. In Canada, the Alberta Railway and Irrigation Company, has water rights on this river. The headgates of their canal is at Kimball 5 miles north of the international boundary, and they already have 231 miles of ditch constructed which irrigates land surrounding Lethbridge. Further construction is being planned and the works, when completed, will irrigate approximately 500,000 acres of, at present semi-arid land.

As this is an international river, discharge measurements are taken on it by the Hydrographic Surveys Branches of both the Canadian and American governments.

LEE CREEK AT CARDSTON.

A regular gauging station was established on Lee Creek, by H. C. Ritchie on June 28th, 1909. It is situated in the eastern portion of the town of Cardston, in the N.W. ¼ Sec. 10, Tp. 3, Rge. 25, W. 4th. Mer.

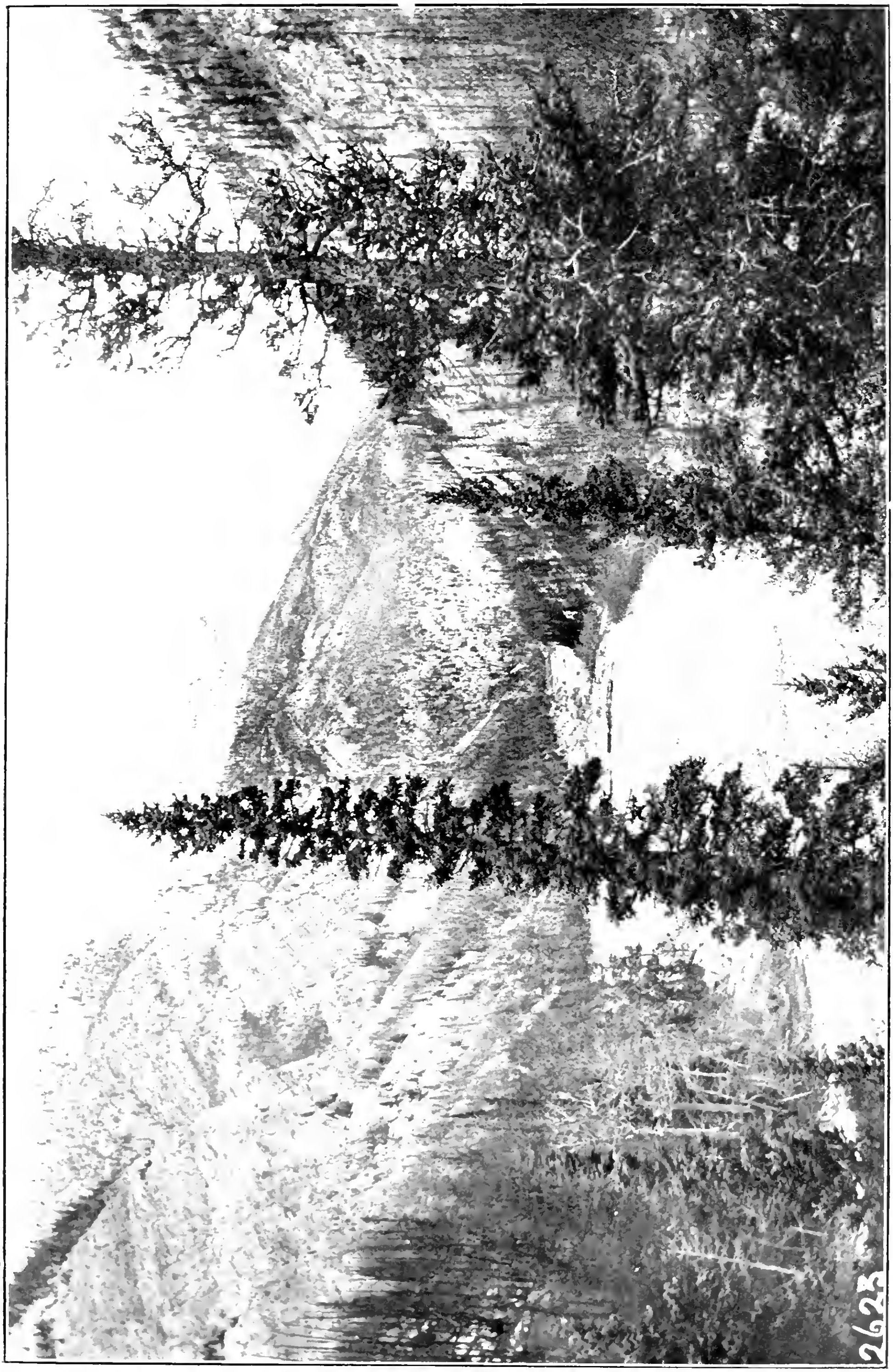
The gauge which consisted of a plain staff, graduated to feet and hundredths, was securely fastened to the foot-bridge, crossing the creek at this point. It was referred to a bench mark nearby; elevation 8.45. On the 28th of July the foot-bridge was washed out by the flood, taking the gauge with it. On August 11th, Mr. Ritchie put in a new gauge which he securely fastened to a post, placed in the right bank of the stream. The new location of the gauge is about 50 feet upstream from the old and is referred to a bench mark of elevation 8.40.

Before the flood, the discharge measurements were taken at a wading section near the foot-bridge. Since establishing the new gauge measurements have been taken at a wading station about 40 feet above the present location of the gauge; a permanent initial point for soundings being established by driving a stake into the right bank.

The channel is straight for about 100 feet above and 300 feet below the section. The bed is composed of a shallow layer of soft sand over a gravel formation. The current which has a medium velocity is quite uniform. The right bank is a high clay while the left is low and stony and liable to overflow in high water.

The gauge is read by Mr. Sterling Williams.

PLATE No. 15.



"The Gap", on Oldman River, at the Livingstone Range of Mountains.

Discharge Measurements of Lee Creek at Cardston, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec*	*Feet.*	*Sec.-ft.*
April 11	L. J. Gieeson	47.6	45.5	1.15	1.7	52.3*
April 23	"	48.3	34.8	0.94	1.65	32.8*
May 7	"	33.5	33.1	0.97	1.65	32.2*
May 21	"	54.5	52.7	2.31	2.03	121.8
June 4	"	35.9	43.0	1.26	1.72	54.1
June 18	"	33.4	34.9	1.09	1.64	38.0*
July 4	"	32.8	25.1	0.88	1.47	22.2*
July 27	F. H. Peters	20.0	8.79	0.80	1.28	6.02*
August 9	"	14.1	8.02	0.87	1.25	5.95*
September 5	N. M. Sutherland	20.0	20.2	2.51	1.68	50.8*
September 20	"	18.5	18.3	2.38	1.59	43.6*
October 7	"	20.4	21.1	2.79	1.62	58.9*
October 8	"	20.5	21.6	2.92	1.64	63.0*
October 24	"	20.2	17.0	2.0	1.75	34.0*
November 10	"	20.4	16.6	2.04	1.45	33.9*
December 20	W. H. Greene	29.0	23.1	0.815	2.15	18.82*

* Measurements taken at wading stations near regular station.

Daily Gauge Height and Discharge of Lee Creek at Cardston, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.5	23.8	1.6	26.5	1.7	50.2	1.5	25.0
2	1.5	23.8	1.7	39.2	1.7	50.2	1.4	16.2
3	1.5	23.8	1.7	39.2	1.7	50.2	1.4	16.2
4	1.5	23.8	1.7	39.2	1.7	50.2	1.4	16.2
5	1.5	23.8	1.6	26.5	1.7	50.0	1.4	16.5
6	1.5	23.8	1.6	26.5	1.7	50.0	1.4	16.5
7	1.5	23.8	1.6	26.5	1.8	71.2	1.4	16.5
8	1.5	23.8	1.6	28.2	2.0	117.8	1.4	16.5
9	1.6	35.5	1.5	19.8	1.9	93.8	1.4	16.5
10	1.6	35.5	1.6	30.8	1.8	71.0	1.4	16.5
11	1.6	35.5	1.7	46.0	1.8	71.0	1.4	16.5
12	1.6	35.0	1.7	46.8	1.8	70.8	1.4	16.5
13	1.7	50.8	1.7	47.0	1.7	49.2	1.4	16.5
14	1.7	50.0	1.7	47.0	1.7	49.0	1.4	16.5
15	1.6	33.2	1.7	47.2	1.7	48.8	1.4	16.5
16	1.6	32.5	1.7	47.5	1.7	48.5	1.3	10.0
17	1.6	31.8	1.8	62.5	1.6	32.8	1.3	9.8
18	1.6	30.8	1.9	91.2	1.6	32.5	1.3	9.8
19	1.6	30.0	2.1	138.0	1.6	33.0	1.3	9.5
20	1.7	43.2	2.0	115.0	1.6	33.5	1.3	9.5
21	1.7	42.2	2.0	115.0	1.6	34.0	1.3	9.2
22	1.6	27.8	1.9	92.5	1.5	23.0	1.3	9.2
23	1.6	26.8	1.9	92.5	1.5	23.2	1.3	9.0
24	1.6	26.8	1.9	92.8	1.5	23.5	1.3	8.8
25	1.6	26.8	1.8	70.2	1.5	23.8	1.3	8.5
26	1.6	26.8	1.8	70.5	1.5	24.0	1.2	4.2
27	1.6	26.8	1.8	70.5	1.5	24.2	1.2	4.0
28	1.6	26.8	1.8	70.8	1.5	24.5	1.2	4.2
29	1.6	26.8	1.8	71.0	1.5	24.8	1.2	4.3
30	1.6	26.8	1.8	71.2	1.5	24.8	1.2	4.4
31			1.8	71.5			1.2	4.5

DAILY GAUGE HEIGHT AND DISCHARGE of Lee Creek at Cardston, for 1910.—*Continued.*

Date	August.		September.		October.		November.		December.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.2	4.6	1.3	14.8	1.9	124.0	1.4	25.5	....	....
2	1.2	4.6	1.4	22.0	1.8	97.0	1.4	25.8	....	....
3	1.2	4.7	1.4	22.5	1.8	97.5	1.4	25.8	....	....
4	1.2	4.7	1.4	23.2	1.7	75.0	1.4	25.8	....	....
5	1.2	4.8	1.5	34.8	1.7	75.8	1.4	25.8	....	....
6	1.1	2.0	1.5	34.7	1.6	54.0	1.4	26.0	....	....
7	1.1	2.1	1.6	50.8	1.6	54.8	1.4	26.0	....	....
8	1.1	2.2	1.6	50.2	1.6	54.2	1.4	26.2	....	....
9	1.1	2.5	1.6	50.0	1.6	54.8	1.4	26.2	....	....
10	1.1	2.5	1.6	49.8	1.6	55.0	1.5	39.0	....	....
11	1.1	2.8	1.6	49.5	1.6	55.5	1.5	....	....	....
12	1.1	3.0	1.6	49.2	1.6	56.0	1.5	....	....	....
13	1.2	6.5	1.6	49.0	1.6	56.2	1.5	....	....	....
14	1.2	6.8	1.6	48.5	1.6	56.5	1.5	....	....	....
15	1.2	7.2	1.6	48.0	1.5	38.8	1.5	....	....	....
16	1.2	7.4	1.6	47.5	1.5	38.8	1.5	....	....	....
17	1.2	7.6	1.7	67.5	1.5	38.8	1.5	....	....	....
18	1.2	7.8	1.7	67.0	1.5	38.8	1.5	....	....	....
19	1.2	8.0	1.7	66.2	1.5	38.8	1.5	....	....	....
20	1.2	8.1	1.7	65.8	1.5	38.5	1.5	....	2.15	....
21	1.2	8.2	1.7	66.5	1.5	38.2	1.5	....	2.15	....
22	1.2	8.5	1.8	90.0	1.5	38.0	1.5	....	1.7	....
23	1.2	8.6	1.9	114.8	1.5	37.5	1.5	....	1.6	....
24	1.2	8.6	1.9	114.8	1.5	37.2	1.5	....	2.2	....
25	1.2	8.7	1.8	92.2	1.4	25.0	1.5	....	2.3	....
26	1.2	8.8	1.8	93.2	1.4	25.0	1.5	....	2.5	....
27	1.2	8.8	1.8	94.0	1.4	25.0	1.5	....	2.5	....
28	1.2	8.8	1.8	94.5	1.4	25.0	1.5	....	2.4	....
29	1.3	14.8	1.9	117.8	1.4	25.2	1.5	....	1.7	....
30	1.3	14.8	1.9	118.2	1.4	25.2	1.5	....	1.6	....
31	1.3	14.8	....	....	1.4	25.5	....	....	1.6	....

No observations Dec. 1st to Dec. 20th. Ice conditions from Nov. 20th.

MONTHLY DISCHARGE of Lee Creek at Cardston, for 1910.

[Drainage area, 103 square miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	50.8	23.8	30.6	0.297	0.331	1,821
May	138.0	19.8	60.6	0.588	0.678	3,726
June	117.8	23.0	45.8	0.445	0.496	2,725
July	25.0	4.0	8.8	0.085	0.098	541
August	14.8	2.0	60.9	0.067	0.077	424
September	118.2	14.8	63.7	0.617	0.688	3,784
October	124.0	25.0	49.2	0.478	0.551	3,025
The period						16,046

ST. MARY RIVER AT KIMBALL.

This station was established by the Alberta Railway and Irrigation Company, in 1905. It is located on the S.W. ¼ Sec. 25, Tp. 1, Rge, 25. W. 4th Mer., about one half mile above the company's dam and headgate.

The channel is straight for about 450 feet above and 400 feet below the station. Both banks are high and not liable to overflow. The right bank is partly covered with scrub above the station, but at and below the station it is clear. The bed of the stream is of gravel and is liable to slight changes. Since the flood of 1908, the cross-section and current have been quite uniform.

Discharge measurements are made by means of a cable, car, and tagged wire. The initial point for soundings is zero of the tagged wire, which is 44.8 feet from the inside edge of the cable support on the right bank.

The gauge, which is a plain staff, graduated to feet and tenths, is set in the right bank, a few feet above the cable. A trench lined with plank, connects a stilling box about the gauge with the channel in low water. The zero of the gauge is 14.12 feet below the top of the east end of the lower sill of the cable support, on the right bank.

In 1910, the gauge was read by J. M. Dunn, Ditch Rider for A. R. & I. Co.

DISCHARGE MEASUREMENTS of St. Mary River at Kimball, in 1910.

DATE	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dicsharge.
1910		*Feet.*	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 9	L. J. Gleeson	217.6	396.1	1.63	2.79	644
April 12	"	220.1	428.8	1.78	3.01	753
April 22	"	223.7	544.9	2.38	3.51	1,299
April 25	"	223.9	576.2	2.51	3.61	1,443
May 6	"	223.9	587.9	2.69	3.67	1,584
May 7	"	225.1	724.8	3.46	4.26	2,506
May 23	"	224.2	645.9	2.96	3.93	1,912
June 6	"	226.0	686.0	3.15	4.05	2,158
June 20	"	224.0	709.5	3.28	4.10	2,317
July 2	"	224.0	625.6	2.82	3.75	1,764
July 26	F. H. Peters	223.5	472.5	2.20	3.25	1,040
August 6	"	222.3	412.2	1.68	2.95	694
August 10	"	222.3	390.1	1.59	2.85	620
September 3	N. M. Sutherland	220.4	320.7	1.16	2.53	372
September 9	"	221.2	350.0	1.29	2.65	453
September 19	"	221.7	399.5	1.54	2.86	617
September 22	"	222.5	425.9	1.73	2.99	735
October 5	"	225.0	578.8	2.18	3.385	1,134
October 10	"	225.3	614.3	2.70	3.75	1,658
October 25	"	222.2	411.7	1.66	2.95	681
October 26	"	223.0	487.8	2.14	3.24	1,044
November 8	"	221.7	398.3	1.58	2.88	625
December 3	W. H. Greene	227.6	119.7	2.20	5.15	264*
December 19	"	68.1	109.4	2.58	4.47	282*

* Ice Conditions.

DAILY GAUGE HEIGHT AND DISCHARGE of St. Mary River at Kimball, for 1910.

DAY.	April.		May.		June.		July.	
	Gauge. Height.	Dis-charge.	Gauge. Height.	Dis-charge.	Gauge. Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet..*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.81	575	4.01	2,085	4.50	2,985	3.75	1,655
2	2.81	575	3.91	1,915	4.40	2,800	3.75	1,655
3	2.71	500	3.81	1,750	4.38	2,765	3.70	1,580
4	2.71	500	3.71	1,590	4.29	2,595	3.70	1,580
5	2.71	500	3.67	1,535	4.14	2,320	3.66	1,520
6	2.71	500	3.65	1,505	4.03	2,120	3.72	1,610
7	2.81	575	3.75	1,655	4.03	2,120	3.69	1,565
8	2.81	575	4.05	2,160	4.20	2,430	3.57	1,385
9	2.81	575	4.25	2,520	4.16	2,360	3.53	1,325
10	2.91	660	4.41	2,820	4.10	2,245	3.46	1,230
11	3.01	750	4.41	2,820	4.10	2,245	3.43	1,190
12	3.01	750	4.31	2,635	4.13	2,300	3.39	1,140
13	3.14	870	4.21	2,450	4.27	2,550	3.40	1,150
14	3.11	840	4.21	2,450	4.16	2,360	3.39	1,140
15	3.11	840	4.11	2,265	4.10	2,245	3.40	1,150
16	3.11	840	4.11	2,265	4.20	2,430	3.44	1,205
17	3.11	840	4.01	2,085	4.20	2,430	3.45	1,220
18	3.11	840	3.91	1,915	4.20	2,430	3.44	1,205
19	3.21	940	4.01	2,085	4.16	2,360	3.42	1,180
20	3.53	1,090	3.99	2,050	4.10	2,245	3.40	1,150
21	3.53	1,325	3.91	1,915	4.00	2,070	3.37	1,115
22	3.59	1,415	3.81	1,750	3.98	2,035	3.34	1,075
23	3.51	1,300	3.90	1,900	3.90	1,900	3.30	1,035
24	3.51	1,300	4.04	2,140	3.89	1,880	3.29	1,025
25	3.61	1,445	4.24	2,500	3.78	1,705	3.26	990
26	3.85	1,815	4.40	2,800	3.66	1,520	3.26	990
27	4.04	2,140	4.40	2,800	3.71	1,590	3.20	930
28	4.21	2,450	4.40	2,800	3.80	1,740	3.14	870
29	4.21	2,450	4.33	2,670	3.80	1,740	3.08	810
30	4.11	2,265	4.40	2,800	3.80	1,740	3.05	785
31			4.40	2,800			3.01	750

DAILY GAUGE HEIGHT AND DISCHARGE of St. Mary River at Kimball, for 1910. *Continued.*

Day.	August.		September.		October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.01	775	2.48	335	2.96	705	3.18	910	2.78	....
2	3.01	750	2.50	350	3.18	910	3.07	800	2.77	....
3	3.01	750	2.53	370	3.38	1,125	3.07	800	5.38	....
4	3.00	740	2.58	405	3.42	1,180	3.06	795	5.58	....
5	2.99	730	2.61	425	3.40	1,150	3.07	800	6.43	....
6	2.95	695	2.65	455	3.39	1,140	3.07	800	4.83	....
7	2.94	685	2.67	470	3.39	1,140	2.98	720	4.73	....
8	2.92	665	2.65	455	3.69	1,565	2.87	625	4.75	....
9	2.89	640	2.65	455	3.74	1,640	2.89	640	4.68	....
10	2.85	610	2.65	455	3.75	1,655	3.00	740	4.78	....
11	2.85	610	2.66	465	3.75	1,655	2.98	720	4.83	....
12	2.85	610	2.65	455	3.69	1,565	2.97	710	6.13	....
13	2.86	615	2.64	445	3.61	1,445	2.94	685	4.98	....
14	2.85	610	2.61	425	3.55	1,355	2.92	665	4.66	....
15	2.85	610	2.62	435	3.46	1,230	2.91	660	4.38	....
16	2.82	585	2.73	515	3.38	1,125	2.98	720	4.70	....
17	2.78	555	2.90	650	3.33	1,065	3.09	820	4.99	....
18	2.76	540	2.90	650	3.28	1,010	3.07	800	4.61	....
19	2.73	515	2.87	625	3.26	990	3.01	775	4.50	....
20	2.69	485	2.85	610	3.25	980	3.02	755	4.48	....
21	2.68	475	2.85	610	3.20	930	3.01	750	4.97	....
22	2.66	465	2.99	730	3.08	810	3.00	740	5.03	....
23	2.65	455	3.00	740	3.03	765	2.98	720	....	....
24	2.70	490	3.00	740	2.97	710	2.96	700	5.33	....
25	2.67	470	2.98	720	2.97	710	2.93	675	5.88	....
26	2.59	410	2.96	700	3.20	930	2.89	640	6.08	....
27	2.57	400	2.94	685	3.26	990	2.85	610	5.25	....
28	2.55	385	2.91	660	3.28	1,010	2.77	545	6.35	....
29	2.55	385	2.88	635	3.31	1,015	2.72	505	6.46	....
30	2.53	370	2.89	640	3.29	1,025	2.70	495	6.45	....
31	2.49	345	....	....	3.26	990	....	....	6.44	....

Ice Conditions after Nov. 24.
Dec. 3, Ice on A. R. & I. Dam, backed water on rod.

MONTHLY DISCHARGE of St. Mary River at Kimball, for 1910.

[Drainage area 472 sq. miles.]

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	2,450	500	1,068	2.26	2.525	63,550
May	2,820	1,505	2,206	4.69	5.407	135,612
June	2,985	1,520	2,208	4.68	5.219	131,382
July	1,655	750	1,176	2.49	2.873	72,312
August	775	345	562	1.19	1.373	34,556
September	740	335	544	1.15	1.286	32,370
October	1,655	705	1,114	2.36	2.721	68,498
November	910	495	711	1.50	1.675	42,307
The period	....	....	....	....	....	580,617

ALBERTA RAILWAY AND IRRIGATION COMPANY'S CANAL, NEAR KIMBALL.

This station was established on July 26th, 1910, by F. H. Peters. Discharge measurements are made from a foot-bridge, erected for that purpose by the A. R. and I. Co., at the middle of the flume over Rolph Creek.

This flume which carries all the water delivered to the Company's system is located on Sec. 21, Tp. 2, Rge. 24, W. 4th Mer. It is about 6 miles from Kimball and about 15 miles from Cardston.

The gauge used in 1910 was the Company's old rod at the upper end of the flume which was divided into feet and inches. On October 25th, 1910, a new rod was set on the right side of the flume and will be used in future. This gauge was made of 1 inch by 4 inches material 6 feet long with a bevelled edge and is divided into feet and inches.

The initial point for soundings is the inside face of the left side of the flume. The datum of the gauge is the bottom of the flume.

The gauge is read daily by J. M. Dunn, the Company's ditch rider.

Discharge Measurements of The Alberta Railway & Irrigation Company's Canal, near Kimball in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq.-ft.	Ft. per sec	Inches.	Sec.-ft.
May 7	L. J. Gleeson	37.8	125.9	1.37	....	172†
May 9	"	40.8	155.4	1.20	....	274†
June 20	F. H. Peters	47.5	280.3	3.05	....	855†
July 26	"	27.2	85.1	5.57	36	474*
August 8	"	44.2	207.1	2.62	....	542†
August 8	"	27.2	88.4	6.05	38	535*
September 8	N. M. Sutherland	27.2	78.8	5.47	33	431*
September 21	"	27.2	88.4	5.91	37	523*
October 3	"	27.2	62.6	4.81	25	301*
October 4	"	27.2	55.8	4.38	23	244*
October 5	"	27.2	36.7	3.10	14	111*
October 6	"	27.2	27.2	2.49	10	685*

† At Bridge No. 1, near Intake of Canal.
* At Flume.

Daily Gauge Height and Discharge of The Alberta Railway and Irrigation Company's Canal, near Kimball, for 1910.

Day.	May.		June.		July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge. Height.	Dis-charge.	Gauge. Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Ins.	Sec.-ft.	Ins.	Sec.-ft.	Ins.	Sec.-ft.	Ins.	Sec.-ft.	Ins.	Sec.-ft.	Ins.	Sec.-ft.
1	17	155	31	398	44	660	40	576	27	323	32	417
2	17	155	31	398	44	660	40	576	28	341	32	417
3	17	155	31	398	44	660	39	555	28	341	26	305
4	17	155	31	398	44	660	38	535	28	341	22	236
5	17	155	36	495	43	638	38	535	29	360	14	114
6	17	155	36	495	43	638	37	515	29	360	10	68
7	17	155	41	597	42	618	37	515	31	398	......	......
8	21	219	42	618	42	618	38	535	32	417	......	......
9	24	270	44	660	42	618	37	515	32	417	......	......
10	24	270	48	748	41	597	37	515	32	417	......	......
11	24	270	49	770	41	597	37	515	32	417	......	......
12	24	270	43	638	41	597	37	515	32	417	......	......
13	23	253	44	660	40	576	37	515	32	417	......	......
14	24	270	44	660	40	576	37	515	31	398	......	......
15	21	219	45	682	40	576	37	515	32	417	......	......
16	21	219	45	682	40	576	37	515	34	455	......	......
17	23	253	44	660	40	576	36	495	37	515	......	......
18	27	323	45	682	40	576	36	495	36	495	......	......
19	29	360	45	682	40	576	35	475	36	495	......	......
20	30	379	53	858	40	576	34	455	26	305	......	......
21	30	379	44	660	39	555	34	455	37	515	......	......
22	30	379	44	660	38	535	33	436	37	515	......	......
23	30	379	45	682	38	535	32	417	37	515	......	......
24	30	379	45	682	37	515	33	436	36	495	......	......
25	31	398	44	660	36	495	32	417	32	417	......	......
26	31	398	44	660	36	495	30	379	30	379	......	......
27	31	398	43	638	36	495	29	360	30	379	......	......
28	31	398	44	660	36	495	29	360	30	379	......	......
29	31	398	45	682	35	475	28	341	30	379	......	......
30	31	398	45	682	35	475	27	323	31	398	......	......
31	31	398	......	......	35	475	27	323	......	......	......	......

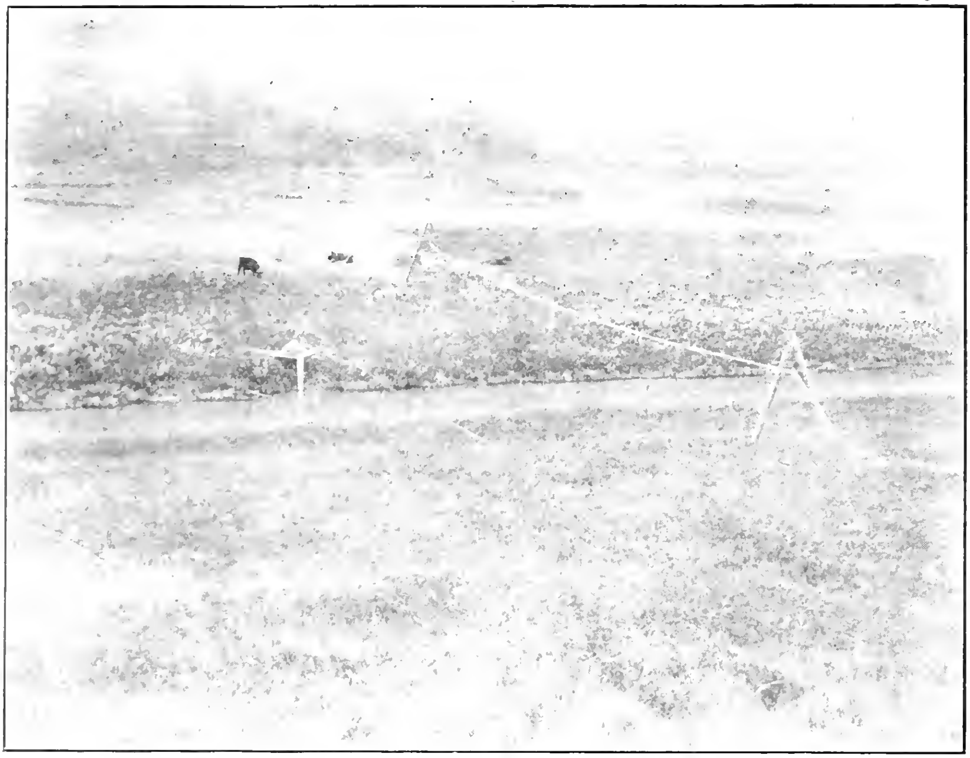
MONTHLY DISCHARGE of The Alberta Railway & Irrigation Company's Canal, near Kimball, for 1910.

Month.	Discharge in Second-Feet.			
	Maximum.	Minimum.	Mean.	Total Discharge in acre-feet.
May	398	155	289	17,776
June	770	398	628	37,369
July	660	475	571	35,109
August	576	323	472	29,022
September	515	305	414	24,635
October (1-6)	417	68	260	3,088
The period				146,999

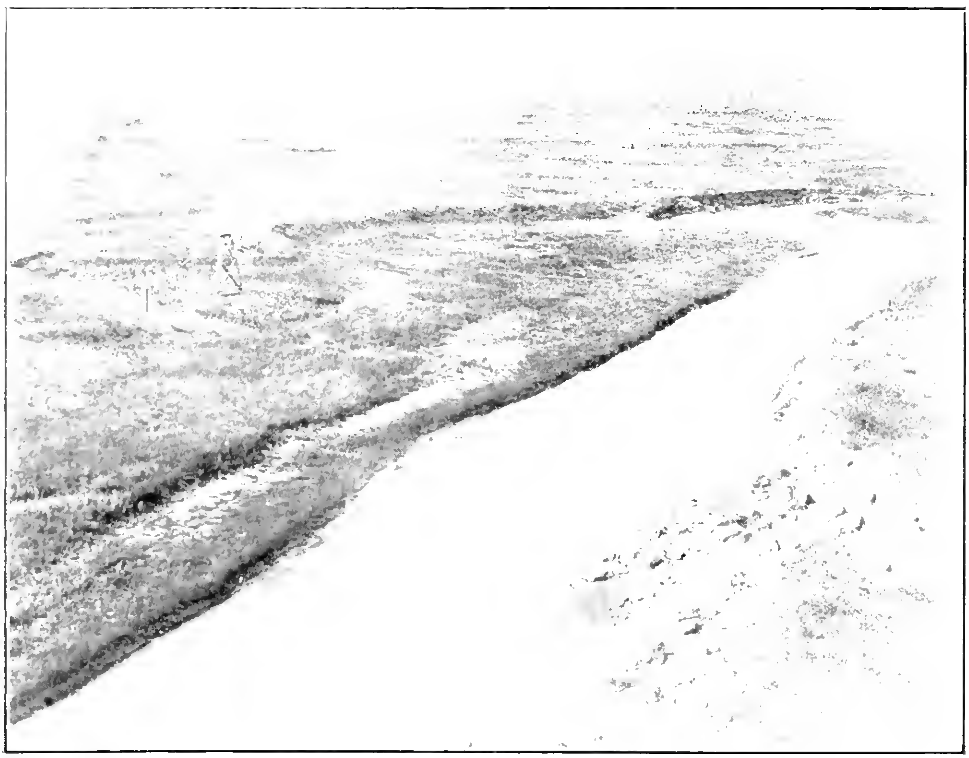
MISCELLANEOUS DISCHARGE MEASUREMENTS of St. Mary River Drainage Basin, in 1910.

DATE	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		Sec.-ft.
April 12	Aetna Creek	near Aetna, Alta.	L. J. Gleeson	*		0.10
June 20	"	"	"	*		0.10
August 28	Boundary Creek	S.E. 19-1-26-4	J. S. Tempest	†		0.41
April 12	Rolph Creek	Taylorville, Alta.	L. J. Gleeson	*	15.00	7.50
April 26	"	"	"	* 5.0	1.50	2.10
May 6	"	"	"	4.5	3.60	1.32
May 21	"	"	"	* 5.0	5.00	3.00
May 24	"	"	"	11.9	6.98	8.04
June 3	"	"	"	* 7.0	3.50	2.45
June 7	"	"	"	* 7.0	3.50	2.45
June 17	"	"	"	* 5.0	1.50	1.50
June 21	"	"	"	* 5.0	1.25	1.25
July 1	"	"	"			Dry
October 1	"	"	N. M. Sutherland	10.0	2.70	1.99
October 10	"	22-1-24-4	"			Nil
October 24	"	"	"			0.20

† Weir measurement.
* Float measurement.



Cable Station on North Branch of Milk River, at Peter's Ranche.



Cable Station on North Branch of Milk River, at Knight's Ranche.

MILK RIVER DRAINAGE BASIN.

General Description.

Milk River rises on the eastern slope of the foothills, in the Blackfeet Indian Reserve, in the United States. Its headwaters run down in two main streams, which are known, after entering Canada, as the north and south branches. The north branch runs in a north-easterly direction through the Blackfeet Reserve for a distance of about 15 miles and then enters Canada near the south-east corner of the south-west quarter of Section 3, Township 1, Range 23, West of the 4th Meridian. From the international boundary the stream continues in a north-easterly direction for about nine miles when it bends to the east and runs in an easterly direction through the second tier of townships to its junction with the South branch at the south-west corner of the north-east quarter of Section 20, Township 2, Range 18, West of the 4th Meridian.

The south branch runs to the south and east of, and parallels the north branch for a distance of about 48 miles, as the crow flies, through the Blackfeet Reserve and then enters Canada near the south-east corner of the south-west quarter of Section 1, Township 1, Range 20, West of the 4th Meridian. From the international boundary it runs in a north-easterly direction to its junction with the north branch. From the junction of the two branches, Milk River runs in an easterly direction through the second tier of townships in Canada to the east boundary of Range 7. From this point, the river runs in a south-easterly direction to its first point of crossing the international boundary into the United States. This first point of crossing is near the south-west corner of the south-east quarter of Section 5, Township 1, Range 5, West of the 4th Meridian. From this point the river meanders in an easterly direction through Canada and United States to a point on the international boundary about 900 feet west of the east boundary of Section 1, Township 1, Range 5, West of the 4th Meridian where it finally crosses into the United States. This point is known as the "Eastern Crossing." The length of the course of Milk River in Canada from the western crossing of the north branch to the eastern crossing is 179 miles. The length of the course of the south branch in Canada is 20 miles.

Throughout its course in Canada from the western crossing of the north branch to the eastern crossing Milk River runs through a well defined valley bordered on each side by a range of hills. The whole of its watershed in Canada is bald prairie land. The river receives a number of small tributary creeks along its course all of which discharge a considerable volume of water during the spring freshets; they all dry up by July 1 (about), and have no considerable discharge again until late in the fall when some of them have a small flow for perhaps a month before the freeze up. The same remarks apply to the South branch in its course through Canada.

The general conditions of flow in the river are such as are typical of all rivers which have a watershed devoid of tree growth; that is, it is subject to extreme floods during the freshet period and to correspondingly low flow during the summer months. From its headwaters to the eastern crossing the total area of the watershed of Milk River is 2,448 square miles. Of this total amount 1,645 square miles are in Canada and 803 square miles in the United States.

North Branch of Milk River at Peter's Ranche.

This station was established by P. M. Sauder and F. H. Peters on July 21st, 1909. It is located 150 feet upstream from the north boundary of Sec. 13, Tp. 1, Rge. 23, W. 4th Mer. It is 7 miles by trail from Taylorville, P.O. and 15 miles from Kimball.

The stream flows in one channel, which is about 40 feet wide at ordinary stages. The channel is straight for about 200 feet above the station and is almost straight for about 300 feet below. Both banks are composed of solid clay. The right is high and not liable to overflow, but the left may overflow at extreme flood stage of the stream. The bed of the stream is composed of a layer of soft mud and stones over a solid clay formation.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is the face of a post on the left bank.

The gauge which is a plain staff, graduated to feet and hundredths, is fixed to a post at the left bank. It is referred to the top of the post at the initial point for soundings; elevation, 13.13 above the datum of the gauge. During 1910, it was read by Bert Mecham.

DISCHARGE MEASUREMENTS of North Branch of Milk River at Peter's Ranche, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1910.		Feet.	Sq.-ft.	Ft. per sec.	Feet.	Sec.-ft.
April 9	L. J. Gleeson	40.5	59.0	0.69	1.79	40.8
April 13	"	40.8	59.2	0.78	1.79	46.1
April 21	"	40.6	54.7	0.75	1.69	40.9
April 26	"	42.5	41.8	0.74	1.70	30.9
May 5	"	41.3	52.5	0.68	1.66	35.6
May 11	"	41.5	62.7	0.85	2.00	53.3
May 20	"	42.0	65.0	0.91	2.03	59.2
May 24	"	41.4	54.0	0.58	1.68	31.3
June 3	"	42.0	61.4	0.50	1.76	31.0
June 8	"	41.9	75.6	0.88	2.21	66.1*
June 16	"				1.80	25.2*
June 21	"				1.67	29.5*
June 30	"				1.71	25.9*
July 6	"				1.65	23.1*
July 23	F. H. Peters				1.51	20.0*
July 29	"				1.51	20.4*
August 5	"				1.51	19.4*
August 11	"				1.47	18.4*
September 2	N. M. Sutherland	41.6	50.2	0.55	1.60	27.7*
September 10	"				1.58	26.3*
September 18	"				1.49	22.0*
September 23	"				1.58	26.4*
September 30	"				1.50	23.6*
October 11	"	41.3	48.3	0.43	1.47	20.7*
October 23	"				1.44	21.0*
October 27	"				1.72	17.5*†
November 5	"				1.68	34.3*
November 12	"	41.6	46.6	0.42	1.45	19.7*

* Measurements taken at wading sections.
† Ice Conditions.

DAILY GAUGE HEIGHT AND DISCHARGE of North Branch of Milk River, at Peter's Ranche, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge	Gauge Height.	Dis-charge	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			1.71	36.0	1.72	29.5	1.69	25.0
2			1.70	36.0	1.75	30.5	1.69	25.0
3			1.70	37.5	1.76	31.0	1.68	24.5
4			1.69	37.5	1.77	32.5	1.68	24.5
5			1.67	36.5	1.68	27.5	1.64	22.0
6			1.66	35.5	1.66	27.0	1.63	21.5
7	1.74	37.0	1.65	34.0	1.73	32.0	1.64	22.5
8	1.74	37.0	1.66	33.5	2.21	66.0	1.73	28.5
9	1.74	37.0	1.69	34.0	1.85	41.0	1.75	30.5
10	1.70	35.0	1.69	33.0	1.76	35.0	1.76	31.0
11	1.74	38.5	1.68	31.0	1.68	30.0	1.76	31.5
12	1.74	39.0	1.67	30.5	1.66	29.0	1.72	29.0
13	1.74	39.5	1.67	32.0	1.72	33.0	1.71	29.0
14	1.74	40.0	1.69	33.0	1.75	35.5	1.70	28.5
15	1.74	40.5	1.71	35.0	1.77	36.5	1.70	29.0
16	1.70	38.5	1.71	37.0	1.80	39.0	1.70	29.5
17	1.73	41.0	1.70	35.0	1.81	39.5	1.69	29.0
18	1.74	42.5	1.69	35.0	1.73	37.5	1.69	29.5
19	1.74	43.0	1.70	36.0	1.70	32.0	1.68	29.0
20	1.74	43.5	2.02	58.0	1.71	32.5	1.68	29.5
21	1.70	41.5	1.83	44.5	1.70	32.0	1.67	29.0
22	1.72	40.5	1.74	37.5	1.70	31.5	1.67	29.5
23	1.72	38.5	1.70	34.0	1.69	30.0	1.65	29.0
24	1.72	36.5	1.69	28.5	1.68	28.5	1.53	23.0
25	1.72	34.5	1.68	30.5	1.67	27.0	1.51	22.0
26	1.71	31.0	1.69	31.0	1.67	26.5	1.51	22.0
27	1.70	31.5	1.67	29.0	1.68	27.0	1.51	22.0
28	1.70	32.5	1.66	28.0	1.68	25.5	1.51	22.0
29	1.72	35.0	1.67	28.0	1.69	25.5	1.51	22.0
30	1.72	35.5	1.68	28.0	1.69	25.0	1.51	22.0
31			1.74	31.0			1.51	22.0

DAILY GAUGE HEIGHT AND DISCHARGE of North Branch of Milk River at Peter's Ranche, for 1910 *Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.51	22.0	1.58	26.0	1.51	22.0	1.44	18.0
2	1.51	22.0	1.60	27.5	1.50	21.0	1.52*	22.5
3	1.51	22.0	1.62	28.5	1.50	21.0	1.59*	26.5
4	1.51	22.0	1.73	35.5	1.50	21.0	1.67	32.0
5	1.51	22.0	1.78	39.0	1.50	21.0	1.68	32.5
6	1.51	22.0	1.57	25.5	1.50	21.0	1.57*	25.5
7	1.51	22.0	1.73	35.5	1.50	21.0	1.44	18.0
8	1.50	21.0	1.61	28.0	1.50	21.0	1.46	19.0
9	1.50	21.0	1.57	25.5	1.50	21.0	1.56	25.0
10	1.50	21.0	1.62	28.5	1.50	21.0	1.69	33.0
11	1.50	21.0	1.58	26.0	1.50	21.0	1.58	26.0
12	1.50	21.0	1.55	24.5	1.50	21.0	1.52	22.5
13	1.50	21.0	1.53	23.0	1.50	21.0	1.60	27.5
14	1.51	22.0	1.51	22.0	1.50	21.0	1.60	27.5
15	1.56	25.0	1.51	22.0	1.50	21.0	1.66	31.0
16	1.55	24.5	1.51	22.0	1.50	21.0	1.57	25.5
17	1.53	23.0	1.51	22.0	1.52	22.5	1.67	32.0
18	1.51	22.0	1.50	21.0	1.51	22.0	1.63	29.5
19	1.51	22.0	1.49	20.5	1.50	21.0	1.63	29.5
20	1.50	21.0	1.48	20.0	1.50	21.0	1.61	28.0
21	1.48	20.0	1.50	21.0	1.49	20.5	1.61	28.0
22	1.46	19.0	1.63	29.5	1.49	20.5	1.61	28.0
23	1.51	22.0	1.58	26.0	1.45	18.5	1.59	26.5
24	1.49	20.5	1.63	29.5	1.44	18.0	1.58	26.0
25	1.50	21.0	1.61	28.0	1.52	22.5	1.59	26.5
26	1.50	21.0	1.59	26.5	1.70	33.5	1.63	29.5
27	1.49	20.5	1.53	23.0	1.50	21.0	1.67	32.0
28	1.47	19.5	1.51	22.0	1.48	20.0	1.67	32.0
29	1.47	19.5	1.51	22.0	1.47	19.5	1.67	32.0
30	1.47	19.5	1.51	22.0	1.47	19.5	1.67	32.0
31	1.45	18.5	....	....	1.47	19.5	....	....

* Observations have been interpolated.

MONTHLY DISCHARGE of North Branch of Milk River at Peter's Ranche, in 1910.

Drainage area, 109 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (7-30)	43.5	31.0	37.9	0.348	0.311	1,803
May	58.0	28.0	34.4	0.316	0.364	2,115
June	66.0	25.0	32.5	0.298	0.332	1,934
July	31.5	21.5	26.2	0.240	0.277	1,611
August	25.0	18.5	21.3	0.195	0.225	1,310
September	39.0	20.0	25.7	0.236	0.263	1,529
October	33.5	18.0	21.2	0.194	0.224	1,304
November	33.0	18.0	27.4	0.251	0.280	1,630
The period						13,236

North Branch Milk River at Knight's Ranche.

This station was established by F. H. Peters and P. M. Sauder on July 17th, 1909. It is located in Sec. 18, Tp. 2, Rge. 20, W. 4th Mer., almost directly south of the Knight Sugar Co.'s Horse-shoe Ranche buildings. It is about 36 miles by trail from Milk River Station.

The stream flows in one channel about 44 feet wide at ordinary stages. It is straight for about 150 feet above and 100 feet below the station. The right bank is composed of clay, is high and not liable to overflow. The left bank is composed of light sandy loam, is low and liable to overflow to quite a distance during high stages of the stream. The bed of the stream is composed of mud, gravel and boulders.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is the face of a cedar post on the right bank. Discharge measurements can be made by wading during low water.

The gauge which is a plain staff, graduated to feet and hundredths, is fixed to a post at the right bank. It is referred to the top of the post at the initial point for soundings on the right bank. elevation, 9.30 feet above the datum of the gauge. It was read from 20th April to 27th June, in 1910, by Robt. Orgill, and during the remainder of the season by Wm. Lewis.

Discharge Measurements of North Branch of Milk River at Knight's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge
1910		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 8	L. J. Gleeson	42.8	67.2	0.75	1.86	50.7
April 14	"	44.6	68.3	0.77	1.86	52.6
April 20	"	43.0	64.8	0.69	1.89	44.4
April 28	"	42.7	64.3	0.68	1.87	43.9
May 4	"	43.0	63.8	0.63	1.84	40.6
May 11	"	43.1	71.0	0.98	2.03	69.4
May 19	"	43.2	67.6	0.84	1.95	56.9
May 25	"	43.0	63.5	0.70	1.85	44.2
June 1	"	42.6	58.5	0.52	1.71	30.7
June 8	"	43.0	66.2	0.87	1.92	57.5
June 15	"				1.70	27.1*
June 22	"				1.67	25.1*
June 29	"				1.63	22.5*
July 6	"				1.61	21.6*
July 23	F. H. Peters				1.56	18.3*
July 29	"				1.56	18.4*
August 4	"				1.56	18.3*
August 11	"				1.56	18.8*
August 20	N. M. Sutherland	41.6	47.2	0.37	1.54	17.5*
August 25	"				1.62	22.2*
September 10	"				1.68	28.2*
September 17	"				1.625	24.2*
September 23	"				1.72	39.0*
September 24	"	42.4	53.4	0.56	1.68	29.7*
September 29	"				1.68	30.5*
October 11	"				1.62	23.5*
October 22	"				1.63	25.4*
October 27	"				1.60	18.3*
November 4	"	42.5	50.8	0.38	1.60	19.3*
November 13	"				1.67	28.0*

* Measurements taken at wading sections.

DAILY GAUGE HEIGHT AND DISCHARGE of North Branch of Milk River at Knight's Ranche, for 1910

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	....	....	1.88*	45.0	1.72*	32.5	1.62	22.5
2	....	....	1.86*	42.5	1.73	35.0	1.62	22.5
3	....	....	1.85*	41.5	1.76	38.0	1.62	22.5
4	....	....	1.84*	40.0	1.79	41.5	1.62	22.5
5	....	....	1.85*	42.5	1.83	46.5	1.61	22.0
6	....	....	1.84*	42.0	1.86	49.5	1.61*	22.0
7	....	....	1.83*	41.5	1.89	53.0	1.63	23.5
8	1.86*	51.0	1.80*	39.0	1.92*	56.5	1.64*	24.0
9	1.86	51.0	1.81*	40.5	1.96*	62.0	1.64	24.0
10	1.86	51.5	1.88*	49.5	1.80*	41.5	1.63	23.5
11	1.86	51.5	2.00*	65.0	1.78*	39.0	1.63	23.5
12	1.86	51.5	1.94*	57.0	1.75*	35.0	1.62	22.5
13	1.86	52.5	1.89*	50.5	1.73*	32.5	1.62	22.5
14	1.86*	52.5	1.92*	54.5	1.72*	30.0	1.61	22.0
15	1.86	50.5	1.95*	58.0	1.70*	27.5	1.61	22.0
16	1.86	48.0	1.98*	62.0	1.72*	29.0	1.60	21.0
17	1.87	47.0	2.01*	66.5	1.71*	28.5	1.60	21.0
18	1.87	45.0	2.04*	69.5	1.70*	27.5	1.59	20.5
19	1.88	44.5	2.07*	73.0	1.69*	27.0	1.59	20.5
20	1.88*	43.0	2.05*	70.5	1.68*	26.0	1.58	19.5
21	1.88*	43.0	2.02*	66.5	1.68*	26.0	1.58	19.5
22	1.81*	35.0	1.92*	58.0	1.67*	25.0	1.57	19.0
23	1.83*	38.0	1.89*	49.5	1.67*	26.5	1.57*	19.0
24	1.87*	42.5	1.87*	46.5	1.67*	26.5	1.57*	19.0
25	1.85*	40.5	1.85*	44.0	1.66*	26.0	1.57*	19.0
26	1.88*	44.5	1.85*	45.0	1.66*	26.0	1.57*	19.0
27	1.87*	44.0	1.84*	44.5	1.66*	26.0	1.57*	19.0
28	1.88*	45.0	1.84*	44.5	1.64*	24.0	1.57*	19.0
29	1.87*	44.0	1.85*	46.5	1.63	23.5	1.56*	18.0
30	1.88*	45.0	1.82*	42.5	1.63	23.5	1.57*	19.0
31	....	....	1.79*	40.0	....	....	1.56*	18.0

* Observations actually made, the others have been interpolated.

DAILY GAUGE HEIGHT AND DISCHARGE of North Branch of Milk River at Knight's Ranche, for 1910.—*Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.56*	18.0	1.62*	22.5	1.67	26.5	1.60	21.0
2	1.56*	18.0	1.63	23.5	1.66	26.0	1.60	21.0
3	1.56*	18.0	1.63	23.5	1.66	26.0	1.60	21.0
4	1.56*	18.0	1.64	24.0	1.65	25.0	1.60*	21.0
5	1.56*	18.0	1.65	25.0	1.64	24.0	1.61	22.0
6	1.56*	18.0	1.65	25.0	1.64	24.0	1.62	22.5
7	1.57*	19.0	1.66	26.0	1.64	24.0	1.62	22.5
8	1.57*	19.0	1.67	26.5	1.64	24.0	1.63	23.5
9	1.57*	19.0	1.67	26.5	1.63	23.5	1.64	24.0
10	1.57*	19.0	1.68*	27.5	1.63	23.5	1.65	25.0
11	1.56*	18.0	1.68*	27.5	1.62*	22.5	1.65	25.0
12	1.56*	18.0	1.67	26.5	1.62	22.5	1.66	26.0
13	1.56*	18.0	1.66	26.0	1.62	22.5	1.67*	26.5
14	1.56*	18.0	1.65	25.0	1.62	22.5	....	....
15	1.56*	18.0	1.65	25.0	1.62	22.5	....	....
16	1.56*	18.0	1.64	24.0	1.62	22.5	....	....
17	1.56*	18.0	1.63*	23.5	1.63	23.5	....	....
18	1.56*	18.0	1.63*	23.5	1.63	23.5	....	....
19	1.56*	18.0	1.65	25.0	1.63	23.5	....	....
20	1.56*	18.0	1.67	26.5	1.63	23.5	....	....
21	1.55*	17.5	1.68	27.5	1.63	23.5	....	....
22	1.55*	17.5	1.70	29.5	1.63*	23.5	....	....
23	1.55*	17.5	1.72	31.5	1.62	22.5	....	....
24	1.60*	21.0	1.68	27.5	1.62	22.5	....	....
25	1.63*	23.5	1.68	27.5	1.61	22.0	....	....
26	1.65*	25.0	1.68	27.5	1.61	22.0	....	....
27	1.65*	25.0	1.68	27.5	1.60*	21.0	....	....
28	1.60*	21.0	1.68	27.5	1.60	21.0	....	....
29	1.61*	22.0	1.68*	27.5	1.60	21.0	....	....
30	1.61*	22.0	1.67	26.5	1.60	21.0	....	....
31	1.62*	22.5	....	....	1.60	21.0	....	....

* Observations actually made, the others have been interpolated.

MONTHLY DISCHARGE of North Branch of Milk River at Knight's Ranche, for 1910.

Drainage area, 239 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (8-30)	52.5	35.0	46.1	0.193	0.165	2,104
May	73.0	39.0	50.9	0.213	0.246	3,130
June	62.0	23.5	33.7	0.141	0.157	2,005
July	24.0	18.0	21.0	0.088	0.102	1,291
August	25.0	17.5	19.3	0.081	0.093	1,187
September	31.5	22.5	26.1	0.109	0.122	1,553
October	26.5	21.0	23.1	0.096	0.111	1,420
November (1-13)	26.5	21.0	23.2	0.097	0.052	598
The period						13,288

NORTH BRANCH OF MILK RIVER AT MACKIE'S RANCHE.

This station was established July 15th, 1909 ,by P. M. Sauder and F. H. Peters. It is located on the S.W. ¼ Sec. 19, Tp. 2, Rge. 18, W. 4th Mer. It is 3 miles north of Mackie Bros. Ranche buildings and is 17 miles by trail from Milk River.

The river flows in one channel which at ordinary stages is about 60 feet wide. It is straight for 200 feet above and about 150 feet below the station. Both banks are low and liable to overflow at high stages. The bed of the stream is composed of gravel and has a shifting bottom.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is the face of a cedar post planted in the north bank and marked 0 + 00.

The gauge which is a plain staff, graduated to feet and hundredths, is fixed to a post at the right bank. It is referred to the top of a post on the right bank; elevation, 8.59 above the datum of the gauge. During 1910, it was read by Mrs. E. R. Lowe.

DISCHARGE MEASUREMENTS of North Branch of Milk River at Mackie's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1910		*Feet.*	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 7	L. J. Gleeson	59.9	89.5	0.65	2.17	58.6
April 14	"	60.5	90.9	0.64	2.19	58.1
April 19	"	60.1	87.9	0.59	2.05	52.2
April 28	"	60.2	84.3	0.54	2.02	45.1
May 3	"	61.2	88.8	0.60	2.06	53.2
May 12	"	60.7	94.7	0.74	2.24	69.9
May 17	"	60.7	93.7	0.70	2.18	67.2
May 26	"	59.8	85.7	0.55	2.03	47.4
May 31	"	59.4	77.6	0.38	1.94	29.7
June 9	"	60.9	102.0	0.81	2.27	82.3
June 15	"				1.87	30.3*
June 23	"				1.84	27.2*
June 29	"				1.80	20.7*
July 7	"				1.77	21.6*
July 22	F. H. Peters				1.75	17.4*
July 30	"				1.72	17.8*
August 4	"				1.73	17.4*
August 12	"				1.74	18.3*
August 20	N. M. Sutherland				1.76	19.3*
September 11	"				1.905	32.5*
September 17	"				1.83	26.7*
September 25	"				1.90	32.0*
September 29	"				1.91	34.5*
October 12	"				1.80	24.2*
October 22	"				1.85	26.6*
October 28	"	60.7	77.4	0.49	1.93	37.6*
November 4	"				1.76	20.6*
November 14	"				1.74	14.8*

* Measurements taken at wading sections.

DAILY GAUGE HEIGHT AND DISCHARGE of N. Branch of Milk River at Mackie's Ranche, for 1910

DAY.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.17*	58.5	2.05	51.2	1.93	30.8	1.71	15.8
2	2.17	58.5	2.06	52.5	1.92	29.8	1.72	16.8
3	2.17*	58.5	2.06*	53.2	1.91	29.5	1.73	17.5
4	2.17	58.5	2.06	51.2	1.90	29.2	1.74	18.2
5	2.17	58.5	2.06	50.5	1.89	28.5	1.75	19.5
6	2.17*	58.5	2.06	49.2	1.87*	26.8	1.76	20.5
7	2.17*	58.5	2.06*	48.2	1.91	30.0	1.77*	21.5
8	2.17	58.5	2.09	51.2	1.95	34.8	1.76	20.8
9	2.17	56.8	2.13	56.2	2.27	82.2	1.75	20.0
10	2.17	56.8	2.16	59.8	1.91	32.8	1.75	19.8
11	2.17*	56.8	2.20	64.8	1.90	31.2	1.75	19.8
12	2.17	54.8	2.24*	70.0	1.89	32.0	1.75	19.5
13	2.17*	54.8	2.23	70.0	1.88	31.8	1.75	19.5
14	2.20*	59.5	2.22	69.5	1.87	31.2	1.75	19.2
15	2.17	57.8	2.21	69.2	1.87	30.2	1.75	19.0
16	2.14	56.2	2.20	69.0	1.87	30.2	1.75*	18.8
17	2.11	55.0	2.18*	67.0	1.87	30.2	1.75	18.8
18	2.08	53.5	2.16	64.8	1.87*	30.2	1.75	18.5
19	2.05*	52.2	2.14	61.8	1.86	29.2	1.74	17.5
20	2.05	51.5	2.10	59.0	1.86	29.8	1.74	17.8
21	2.05	51.5	2.10	56.5	1.85	28.0	1.73	16.8
22	2.05	51.2	2.08	53.5	1.85	28.0	1.72*	15.8
23	2.04	49.2	2.06	51.0	1.84*	27.0	1.72	16.0
24	2.04	48.8	2.04*	48.8	1.82	25.0	1.72	16.2
25	2.04	48.5	2.04	48.5	1.79	22.0	1.72*	16.5
26	2.01*	48.5	2.03*	47.5	1.76	19.5	1.72	17.0
27	2.03	46.8	2.01	43.8	1.73	17.2	1.72	17.0
28	2.02*	45.0	2.00	41.0	1.70*	15.2	1.72	17.2
29	2.03	47.0	1.98	37.2	1.70*	14.8	1.72	17.5
30	2.04	49.0	1.96	33.8	1.70	15.0	1.72	17.8
31			1.94*	29.8			1.72	17.2

* Observations actually made; the others are interpolated.

DAILY GAUGE HEIGHT AND DISCHARGE of N. Branch of Milk River at Mackie's Ranche, for 1910. *Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.72	17.2	1.88	28.5	1.90	33.8	1.85	29.2
2	1.73	17.8	1.89	29.5	1.90	34.0	1.82	26.2
3	1.73	17.8	1.90	30.5	1.89	33.0	1.79	23.5
4	1.73*	17.8	1.91	31.5	1.88	32.0	1.76*	20.5
5	1.73	17.8	1.92	32.5	1.87	30.8	1.76	20.2
6	1.73	17.8	1.93	33.5	1.86	29.8	1.76	20.0
7	1.73	17.8	1.95*	36.0	1.85	28.8	1.76	19.5
8	1.74	18.2	1.94	34.8	1.84	28.0	1.76	19.0
9	1.74	18.2	1.93	33.5	1.83	26.2	1.76	18.5
10	1.74	18.2	1.92	32.5	1.82	26.0	1.75	17.5
11	1.74	18.2	1.90*	32.5	1.81	25.0	1.75	16.8
12	1.74*	18.2	1.89	31.0	1.80*	24.2	1.75	16.5
13	1.74	18.2	1.88	30.5	1.80	24.0	1.74	15.5
14	1.74	18.2	1.87	29.5	1.80	24.0	1.74*	14.8
15	1.75	18.8	1.86	29.0	1.81	24.5	....	....
16	1.75	18.8	1.85	28.2	1.82	25.0	....	....
17	1.75	18.8	1.83*	26.5	1.83	25.8	....	....
18	1.76	19.5	1.83	26.5	1.84	26.5	....	....
19	1.76	19.5	1.84	27.0	1.85	27.2	....	....
20	1.76*	19.5	1.85	28.0	1.85	26.8	....	....
21	1.77	20.0	1.86*	28.8	1.85	26.8	....	....
22	1.78	20.8	1.87	29.2	1.85*	26.5	....	....
23	1.79	21.5	1.88	30.2	1.86	27.8	....	....
24	1.80	22.0	1.89	30.8	1.87	29.5	....	....
25	1.81	22.8	1.90*	32.0	1.88	31.2	....	....
26	1.82	23.5	1.90	32.5	1.89	31.8	....	....
27	1.83	24.2	1.90	32.8	1.91	34.5	....	....
28	1.84	25.0	1.91	34.2	1.93*	37.5	....	....
29	1.85	26.0	1.91*	34.5	1.91	35.0	....	....
30	1.86	26.8	1.91	34.8	1.89	33.2	....	....
31	1.87	27.5	....	....	1.87	30.8	....	....

* Observations actually made; the others are interpolated.

MONTHLY DISCHARGE of North Branch of Milk River at Mackie's Ranche, for 1910.
Drainage area, 435 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile	Depth in inches on Drainage area.	Total in acre-feet.
April	59.5	45.0	54.0	0.124	0.138	3,213
May	70.0	29.8	54.2	0.125	0.144	3,333
June	82.2	14.8	29.1	0.067	0.075	1,732
July	21.5	15.8	18.2	0.042	0.048	1,119
August	27.5	17.2	20.2	0.046	0.053	1,242
September	36.0	26.5	31.0	0.071	0.079	1,845
October	37.5	24.0	29.0	0.067	0.077	1,783
November (1-14)	29.2	14.8	19.84	0.046	0.024	551
The period						14,818

SOUTH BRANCH OF MILK RIVER AT MACKIE'S RANCHE.

This station was established July 14th, 1909, by P. M. Sauder and F. H. Peters. It is 17 miles by trail from Milk River and is located on Sec. 31, Tp. 1, Rge. 18, W. 4th Mer., about ¼ mile upstream from Mackie Bros.' ranche buildings.

The stream flows in one channel straight for about 150 feet above the station and is straight for 100 feet below. The right bank is composed of sand and gravel and is liable to overflow. The left bank is composed of clay and is high. The bed of the stream consists of gravel and sand and is liable to shift.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is the face of a cedar post planted in the left bank.

The gauge, which is a plain staff, graduated to feet and hundredths, is fixed to a post at the left bank. It is referred to the top of the post at the initial point for soundings, elevation, 13.25 above the datum of the gauge. During 1910, it was read by Mrs. E. R. Lowe and Mrs. Wm. Knox.

DISCHARGE MEASUREMENTS of South Branch of Milk River at Mackie's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
April 6	L. J. Gleeson	68.5	70.9	1.12	2.56	79.3
April 15	"	86.1	112.6	1.53	3.00	172
April 19	"	86.1	96.5	1.38	2.85	133
April 29	"	87.5	100.6	1.43	2.90	144
May 3	"	86.9	84.6	1.29	2.72	109
May 13	"	86.4	104.6	1.48	2.92	155
May 17	"	86.4	93.6	1.37	2.83	128
May 27	"	86.2	85.3	1.21	2.71	104
May 31	"	85.4	71.7	1.04	2.53	74.6
June 10	"	87.5	130.0	1.86	3.23	242
June 13	"	67.6	68.0	1.07	2.51	72.9
June 24	"	60.0	51.2	0.78	2.24	40.0
June 27	"	57.9	48.3	0.77	2.18	37.3
July 8	"	55.6	40.0	0.55	2.03	22.3
July 21	F. H. Peters				1.75	4.67*
July 30	"				1.64	2.02*
August 3	"				1.61	1.44*
August 12	"				1.71	3.50*
August 19	N. M. Sutherland				1.62	1.29*
September 11	"	60.0	46.4	0.93	2.21	43.3*
September 17	"				2.05	31.1*
September 25	"				2.17	43.5*
September 28	"				2.14	36.3*
October 12	"	57.2	38.8	0.74	2.05	28.6*
October 21	"				2.07	29.4*
October 28	"				2.02	24.2*
November 14	"				2.14	35.2*

* Measurements taken at wading sections

DAILY GAUGE HEIGHT AND DISCHARGE of South Branch of Milk River, at Mackie's Ranche, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	2.61	87.5	2.79	120.0	2.53	76.0	2.20	41.0
2	2.62	89.0	2.75	112.0	2.49	71.0	2.12	34.0
3	2.66	95.0	2.72	106.0	2.44	65.0	2.07	30.0
4	2.61	87.5	2.67*	97.0	2.42	62.5	2.04	27.5
5	2.57	81.5	2.62*	89.0	2.48	69.5	2.02	25.5
6	2.56	80.0	2.56	80.0	2.46	67.0	2.02*	25.5
7	2.67	97.0	2.57	81.5	2.43	64.0	2.03	26.5
8	2.91	148.5	2.57	81.5	2.82	126.5	2.03	26.5
9	2.91	148.5	2.55	79.0	2.94	156.5	2.02	25.5
10	2.93	154.0	2.70	102.5	3.23	242.0	2.04	27.5
11	3.01	176.5	2.70	102.5	2.94	156.5	2.01	25.0
12	3.21	236.5	2.95	159.5	2.66	95.5	1.98	22.5
13	3.11	206.0	2.91	148.5	2.53	76.0	1.94	19.5
14	3.22	239.5	2.83	128.5	2.45	66.0	1.91	17.0
15	3.01	176.5	2.77	115.5	2.43	64.0	1.89	15.5
16	2.81	124.5	2.85	133.0	2.40	60.5	1.85	12.5
17	2.84	131.0	2.87	138.0	2.37	57.5	1.80	9.5
18	2.84	131.0	3.23	242.0	2.35	55.5	1.79	8.9
19	2.85	133.0	3.08	197.0	2.33	53.5	1.76	7.3
20	2.83	128.5	3.00	173.5	2.29	49.5	1.74	6.2
21	2.97	165.0	3.17	224.5	2.25	45.5	1.74	6.2
22	2.98	167.5	3.00	173.5	2.25	45.5	1.71	4.7
23	2.85	133.0	2.84	131.0	2.23	44.0	1.68	3.5
24	2.77	115.5	2.75	112.0	2.23	44.0	1.66	2.6
25	2.77	115.5	2.71	104.0	2.21	42.0	1.65	2.2
26	2.84	131.0	2.70	102.5	2.22	43.0	1.65	2.2
27	2.86	135.5	2.67	97.0	2.19	40.0	1.65	2.2
28	2.86	135.5	2.64	92.0	2.14	35.5	1.65	2.2
29	2.91	148.5	2.58	83.0	2.12	34.0	1.65	2.2
30	2.85	133.0	2.54	77.5	2.13	35.0	1.64	2.0
31			2.52	75.0			1.63	1.6

* Observations have been interpolated.

DAILY GAUGE HEIGHT AND DISCHARGE of South Branch of Milk River at Mackie's Ranche, for 1910.—*Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.62	1.4	1.85	12.5	2.15	36.5	2.13	35.0
2	1.61	1.0	1.87	14.0	2.13	35.0	2.06	29.0
3	1.62*	1.4	1.89	15.5	2.13	35.0	2.08	30.5
4	1.63	1.6	1.99*	23.5	2.12*	34.0	2.10	32.5
5	1.63	1.6	2.09*	31.5	2.11	33.5	2.10	32.5
6	1.64	2.0	2.19	40.0	2.08	30.5	2.01	25.0
7	1.64	2.0	2.23	44.0	2.06	29.0	2.07	30.0
8	1.64	2.0	2.25	45.5	2.09	31.5	2.13	35.0
9	1.64	2.0	2.21	42.0	2.07	30.0	2.15	36.5
10	1.64	2.0	2.18	39.5	2.08	30.5	2.14	35.5
11	1.67	3.1	2.18	39.5	2.07	30.0	2.14	35.5
12	1.70	4.2	2.16	37.5	2.05	28.0	2.14	35.5
13	1.71	4.7	2.14	35.5	2.07	30.0	2.16	37.5
14	1.70	4.2	2.13	35.0	2.06	29.0	2.33	53.5
15	1.68	3.5	2.08	30.5	2.05	28.0	2.26	46.5
16	1.65	2.2	2.06	29.0	2.04	27.5	2.17	38.5
17	1.63	1.6	2.03	26.5	2.04	27.5	2.18	39.5
18	1.63	1.6	2.01	25.0	2.03	26.5	2.27	47.5
19	1.63	1.6	1.98	22.5	2.04	27.5	2.18	39.5
20	1.68	3.5	1.91	17.0	2.05	28.0	2.24	44.5
21	1.73	5.8	1.93	18.5	2.06	29.0	2.19	40.0
22	1.73	5.8	1.92	17.5	2.07	30.0	2.15	36.5
23	1.71	4.7	1.96	21.0	2.07	30.0	2.18	39.5
24	1.71	4.7	1.98	22.5	2.04	27.5	2.31	51.5
25	1.73	5.8	2.08	30.5	2.05	28.0	2.36	56.5
26	1.73	5.8	2.18	39.5	2.06	29.0	2.09	31.5
27	1.78*	8.4	2.26	46.5	2.06	29.0	2.08	30.5
28	1.82*	11.0	2.24	44.5	2.04	27.5	....	....
29	1.87	14.0	2.18	39.5	2.00	24.0	....	....
30	1.85	12.5	2.16	37.5	2.07	30.0	....	....
31	1.83	11.5	....	....	2.13	35.0	....	....

* Observations have been interpolated.

MONTHLY DISCHARGE of South Branch of Milk River at Mackie's Ranche, for 1910.

Drainage area, 441 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	239.5	80.0	137.7	0.312	0.348	8,195
May	242.0	75.0	121.2	0.275	0.317	7,452
June	242.0	34.0	71.4	0.162	0.181	4,248
July	41.0	1.6	15.0	0.034	0.039	922
August	14.0	1.0	4.43	0.010	0.012	272
September	46.5	12.5	30.8	0.070	0.081	1,833
October	36.5	24.0	29.9	0.068	0.078	1,838
November (1-27)	56.5	25.0	37.98	0.086	0.086	2,033
The period	....	....	....	....	....	24,760

MILK RIVER, AT MILK RIVER.

This station was established by H. C. Ritchie on May 18th, 1909, and re-established by F. H. Peters on July 3rd, 1909. It is located on Sec. 28, Tp. 2, Rge. 16, W. 4th Mer., at the A. R. & I. railway bridge, ¼ mile south of the town of Milk River.

Discharge measurements are made from the down stream side of the bridge at high water and in low water a wading section, about 50 feet upstream is used.

The stream flows in one channel at all stages and in ordinary stages is not more than 140 feet wide. The channel is almost straight for 500 feet above and below the station. The right bank is sandy, fairly high, and not liable to overflow. The left bank is lower and overflows during high water. The bed of the stream is composed of sand and shifts during all stages.

The gauge, which is a plain staff, graduated to feet and hundredths, is nailed to an old bridge pile about 12 feet above the present bridge. It is referred to the top of a cedar post on the south bank of the river, about 50 feet above the bridge; elevation, 15.90. As this gauge is liable to be carried out by ice or flood water, a chain gauge has been attached to the bridge and will be read if the staff goes out. The datum of the chain gauge is the same as that of the staff. The gauge was read once each day by D. O'Connell, the A. R. & I. Co.'s section foreman at Milk River.

DISCHARGE MEASUREMENTS of Milk River at Milk River, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1910		*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 18	L. J. Gleeson	126.1	123.6	1.45	1.72	179
May 2	"	126.2	130.5	1.37	1.74	180
May 10	F. H. Peters	124.0	102.8	1.32	1.55	136
May 16	L. J. Gleeson	128.2	133.6	1.41	1.80	189
May 28	"	125.5	107.0	1.28	1.62	137
May 30	N. M. Sutherland	123.3	93.4	1.30	1.50	122
June 11	L. J. Gleeson	128.6	153.2	1.54	2.00	236
June 13	"	123.2	96.9	1.28	1.52	125
June 21	N. M. Sutherland	119.6	64.0	1.24	1.25	79.2
June 25	L. J. Gleeson				1.18	64.6*
June 27	"				1.18	63.0*
July 4	N. M. Sutherland	116.4	45.2	1.04	1.08	47.2*
July 9	L. J. Gleeson				1.05	40.3*
July 18	N. M. Sutherland	112.7	23.2	0.99	0.86	22.9*
July 21	F. H. Peters				0.83	20.9*
August 1	"				0.73	13.1*
August 10	N. M. Sutherland	110.4	19.6	0.85	0.76	16.6*
August 16	F. H. Peters				0.76	19.7*
August 22	L. J. Gleeson				0.74	17.2*
September 12	G. H. Whyte				1.19	65.0*
September 26	"				1.09	57.4*
October 10	"				1.02	42.8*
October 21	N. M. Sutherland				1.05	52.9*
October 29	"				1.06	57.2*
October 31	"	116.6	55.2	0.95	1.06	52.2*
November 4	G. H. Whyte				1.045	43.9*
November 4	"				1.055	45.3*

* Measurements made at wading stations.

DAILY GAUGE HEIGHT AND DISCHARGE of Milk River, at Milk River, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.50	130.0	1.70	169.5	1.40	101.5	1.10	51.0
2	1.70	173.5	1.70	169.5	1.40	101.5	1.11	52.0
3	1.70	173.5	1.70	169.5	1.40	101.5	1.10	50.0
4	1.70	173.5	1.70	169.5	1.40	101.5	1.09	48.5
5	1.70	173.5	1.62	151.5	1.40	101.5	1.08	46.5
6	1.70	173.5	1.60	147.0	1.40	101.5	1.06	43.5
7	1.70	173.5	1.51	127.0	1.33	88.5	1.04	40.0
8	1.83	204.0	1.50	125.0	1.37	96.0	1.02	37.0
9	1.90	221.0	1.42	108.5	1.40	101.5	1.01	35.5
10	1.81	199.5	1.62	151.0	2.29	304.0	1.02	37.5
11	1.98	238.5	1.70	169.5	1.90	211.5	1.01	36.5
12	2.08	264.0	1.86	205.0	1.64	152.5	1.00	35.5
13	2.03	254.5	1.90	214.0	1.50	122.0	1.00	36.5
14	2.00	245.0	1.85	201.0	1.50	122.5	0.99	35.0
15	2.07	260.5	1.74	175.0	1.40	104.0	0.98	34.5
16	2.01	247.0	1.86	202.5	1.32	90.0	0.97	33.0
17	1.79	195.0	1.90	210.5	1.30	86.5	0.96	32.5
18	1.80	197.5	1.97	226.5	1.30	87.0	0.95	31.0
19	1.82	201.5	2.08	252.0	1.30	87.5	0.91	27.0
20	1.90	220.5	2.07	248.5	1.26	81.0	0.85	22.5
21	1.90	219.5	2.08	250.0	1.25	79.0	0.84	21.5
22	1.90	219.5	2.02	235.0	1.25	78.5	0.82	20.0
23	1.86	210.0	1.86	196.0	1.21	71.0	0.80	18.5
24	1.85	206.5	1.71	165.5	1.20	68.5	0.78	17.5
25	1.73	179.0	1.70	157.5	1.20	68.0	0.77	17.0
26	1.70	172.0	1.70	156.5	1.20	67.5	0.75	15.0
27	1.77	187.0	1.70	155.5	1.12	54.0	0.74	14.5
28	1.80	194.0	1.63	139.0	1.10	50.5	0.74	14.5
29	1.84	203.0	1.50	117.0	1.10	50.5	0.74	14.0
30	1.81	195.0	1.51	124.0	1.10	51.0	0.73	13.5
31	....	....	1.43	106.0	....	....	0.75	14.5

DAILY GAUGE HEIGHT AND DISCHARGE of Milk River, at Milk River, for 1910.—*Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.73	13.0	0.91	34.5	1.13	63.0	1.20	72.5
2	0.73	13.0	0.90	33.0	1.11	58.5	1.16	64.0
3	0.73	13.0	0.90	33.0	1.10	57.0	1.10	53.0
4	0.73	13.5	0.98	42.0	1.03	46.5	1.09	49.5
5	0.73	13.5	1.03	48.0	1.07	51.5	1.05	....
6	0.73	13.5	1.05	50.5	1.06	50.0	1.05	....
7	0.74	14.5	1.22	75.5	1.06	50.0	1.05	....
8	0.77	17.0	1.27	83.5	1.04	46.0	1.08	....
9	0.79	18.0	1.25	79.0	1.04	45.5	1.13	....
10	0.79	18.0	1.24	76.5	1.04	45.5	1.43	....
11	0.78	18.5	1.23	74.0	1.05	47.5	1.42	....
12	0.78	18.5	1.21	68.0	1.05	48.0	1.17	....
13	0.80	21.0	1.19	65.0	1.05	48.5	1.03	....
14	0.79	20.5	1.17	61.5	1.05	49.0	1.36	....
15	0.80	22.0	1.15	59.5	1.03	47.0	1.27	....
16	0.80	23.0	1.11	54.0	1.04	48.5	1.28	....
17	0.78	21.0	1.09	51.5	1.04	49.0	1.46	....
18	0.78	21.0	1.04	45.0	1.05	51.0	1.42	....
19	0.80	22.0	1.00	41.5	1.05	51.5	1.34	....
20	0.78	20.5	0.98	38.5	1.06	54.0	1.35	....
21	0.77	19.5	1.00	41.5	1.08	57.5	1.39	....
22	0.78	20.0	1.00	42.0	1.06	54.5	1.40	....
23	0.79	22.0	0.98	40.0	1.05	53.5	1.40	....
24	0.78	22.0	1.05	50.5	1.05	54.0	1.28	....
25	0.80	22.5	1.09	57.0	1.03	50.5	1.28	....
26	0.83	26.5	1.11	60.5	1.03	51.0	1.28	....
27	0.83	27.0	1.13	63.0	1.13	68.0	1.27	....
28	0.87	31.0	1.13	63.0	1.37	110.5	1.23	....
29	0.90	34.0	1.11	59.5	1.04	54.0	1.20	....
30	0.90	34.0	1.13	62.5	1.06	54.5	1.12	....
31	0.91	34.5	....	....	1.09	56.5	....	....

MONTHLY DISCHARGE of Milk River, at Milk River, for 1910.

Drainage area, 1,077 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	264.0	130.0	203.5	0.189	0.211	12,109
May	252.0	106.0	174.0	0.162	0.186	10,700
June	304.0	50.5	99.4	0.092	0.103	5,915
July	52.0	13.5	30.5	0.028	0.033	1,875
August	34.5	13.0	20.9	0.019	0.022	1,285
September	83.5	33.0	55.1	0.051	0.057	3,279
October	110.5	45.5	53.9	0.051	0.059	3,314
The period	....	....	....	....	....	38,477

Milk River, at Writing-on-Stone Police Detachment.

This station was established on August 2nd, 1909, by F. H. Peters. It is located at the R. N. W. M. P. Post at Writing-on-Stone in the N.W. ¼ Sec. 35, Tp. 1, Rge. 13, W. 4th Mer. It is 17 miles by trail from Coutts and 26 miles from Milk River station.

The river flows in one channel at all stages. It is straight for 300 feet above and 250 feet below the station. Both banks are slightly wooded, high and not liable to overflow except in extreme flood stages of the stream. The bed of the stream is composed of sand which is constantly shifting.

Discharge measurements are made by means of a cable, car, tagged wire and stay wire. The initial point for soundings is 50 feet south of the B. M. post on the right bank. During very low stages of the stream wading sections may be used.

The gauge, which is a plain staff, graduated to feet and hundredths, is fixed to a post at the right bank. It is referred to the top of a cedar post on the right bank, elevation 13.73 feet above the datum of the gauge. It was read during 1910 by Constable A. P. White.

Discharge Measurements of Milk River at Writing-on-Stone Police Detachment, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	Sq.-ft.	Ft. per sec.	Feet.	Sec.-ft.
April 10	F. H. Peters	126.6	116.4	1.87	2.31	218
April 20	N. M. Sutherland	126.2	119.2	1.68	2.19	200
April 29	"	126.6	116.1	1.84	2.22	214
May 4	"	126.4	108.4	1.63	2.115	176
May 11	F. H. Peters	125.6	117.3	1.36	2.07	159
May 18	N. M. Sutherland	126.6	130.2	1.70	2.31	221
May 21	"	126.6	145.6	1.70	2.445	248
May 28	"	126.7	104.6	1.43	2.13	150
May 31	"	125.9	100.6	1.32	2.01	133
June 10	F. H. Peters	65.4	71.8	1.48	1.98	106 *
June 17	N. M. Sutherland				1.79	77.8*
June 22	"				1.74	79.6*
June 29	"				1.595	49.9*
July 4	"	121.8	42.8	1.17	1.60	50.2*
July 9	F. H. Peters				1.52	41.0*
July 19	"	37.1	24.2	0.90	1.27	21.7
July 20	N. M. Sutherland				1.155	19.9*
August 6	"				1.14	14.6*
August 6	"				1.14	14.6*
August 10	"	36.7	18.7	0.71	1.155	13.2*
August 11	"	36.8	19.6	0.80	1.165	15.6
August 16	"	37.1	16.6	0.94	1.195	15.6
August 17	"				1.215	16.6*
August 22	L. J. Gleeson				1.14	15.5*
August 27	"				1.24	20.3*
September 15	G. H. Whyte				1.745	62.2*
September 22	"				1.56	33.3*
September 29	"				1.72	57.1*
October 6	"				1.65	53.7*
October 10	"				1.61	45.2*
October 15	"				1.60	43.7*
October 23	"				1.65	47.8*
October 30	"				1.63	50.1*
November 6	"	114.7	50.4	1.19	1.74	59.9*
November 14	"	35.0	28.4	0.95	1.485	27.0*

* Measurements taken at wading sections.

Daily Gauge Height and Discharge of Milk River, at Writing-on-Stone Police Detachment, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.08	140.0	2.22	213.0	2.00	128.5	1.59	50.0
2	2.12	153.5	2.20	206.0	1.99	124.0	1.58	49.0
3	2.13	157.0	2.14	185.0	2.02	132.5	1.63	55.5
4	2.11	150.0	2.12	177.5	1.97	117.0	1.69	65.0
5	2.10	147.5	2.10	170.5	1.97	112.5	1.54	45.0
6	2.10	147.5	2.06	156.5	1.97	110.5	1.55	45.5
7	2.05	131.0	2.00	136.0	1.97	109.0	1.60	51.0
8	2.07	137.0	1.89	101.5	1.98	110.0	1.55	44.5
9	2.25	197.5	1.82	84.0	1.97	105.0	1.52	41.0
10	2.32	222.0	1.98	128.5	2.08	138.0	1.51	40.5
11	2.32	224.5	2.07	159.0	2.55	307.5	1.49	39.0
12	2.42	259.5	2.07	155.5	2.29	217.5	1.48	38.0
13	2.44	270.5	2.23	208.5	2.15	174.5	1.46	36.5
14	2.44	270.0	2.32	236.5	2.03	139.0	1.44	34.5
15	2.46	279.5	2.29	222.5	1.87	93.0	1.41	32.0
16	2.42	268.5	2.21	192.5	1.84	87.5	1.39	30.5
17	2.24	210.5	2.26	207.0	1.81	82.5	1.36*	28.0
18	2.15	189.5	2.32	229.0	1.80	82.5	1.33*	25.5
19	2.17	190.5	2.34	225.0	1.80	85.0	1.31	24.0
20	2.17	193.5	2.51	274.5	1.78	83.5	1.28	27.0
21	2.22	211.0	2.43	243.5	1.74	77.0	1.26*	25.0
22	2.24	217.5	2.54	278.5	1.72	75.0	1.24*	24.0
23	2.25	222.0	2.48	260.5	1.77	86.5	1.22	22.0
24	2.27	229.5	2.32	209.5	1.75	81.5	1.21	21.5
25	2.23*	216.5	2.21	173.0	1.74	78.5	1.18	19.5
26	2.20*	206.0	2.16	158.5	1.70	70.0	1.15	18.0
27	2.17	196.5	2.12	145.0	1.67	63.5	1.12	17.0
28	2.27	231.0	2.12	146.5	1.68	63.0	1.13	16.5
29	2.22	214.0	2.11	151.5	1.62	53.0	1.13	16.0
30	2.24	221.5	2.06	142.5	1.60	50.5	1.14	16.5
31	....	....	2.01	133.0	....	....	1.13	15.5

* Observations have been interpolated.

Daily Gauge Height and Discharge of Milk River at Writing-on-Stone Police Detachment, for 1910.—*Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.13	15.5	1.43	35.5	1.70	56.5	1.70	56.5
2	1.10	14.0	1.45	37.5	1.69	56.0	1.67	51.0
3	1.11	14.0	1.51	43.5	1.68	55.5	1.70	53.5
4	1.11	14.0	1.52	44.5	1.66	53.5	1.72	55.0
5	1.12	13.5	1.54	46.5	1.65	53.0	1.71	52.5
6	1.16	15.0	1.57	49.5	1.64	52.5	1.68	47.5
7	1.14	14.0	1.66	61.5	1.62	49.0	1.64	44.0
8	1.14	13.5	1.67	62.0	1.62*	48.0	1.65	45.5
9	1.15	13.5	1.73	68.0	1.59	44.0	1.69	49.5
10	1.16	13.5	1.82	90.0	1.60	44.0	1.61	41.0
11	1.17	15.5	1.82	86.5	1.61	45.5	1.64	43.0
12	1.19	16.5*	1.79*	77.0	1.60	44.5	1.78	59.5
13	1.18	15.5	1.77	71.0	1.61	45.5	1.70	47.0
14	1.18	15.5	1.77	69.0	1.59	43.5	1.16	....
15	1.18	15.0	1.74	61.5	1.60	44.5	1.10	....
16	1.19	15.5	1.70	55.0	1.62	46.5	1.44	....
17	1.21	17.0	1.68	52.0	1.62	47.0	1.26	....
18	1.22	17.5	1.65	48.0	1.64	49.0	1.95	....
19	1.23	18.5	1.62	43.5	1.65	51.5	2.07	....
20	1.19	17.5	1.58	38.5	1.63	49.5	2.07	....
21	1.19	17.5	1.58	37.0	1.63	50.0	1.91	....
22	1.19	17.5	1.54	32.0	1.63	50.0	1.74	....
23	1.17	17.0	1.52	31.5	1.65	53.0	1.63	....
24	1.18	17.5	1.56	36.0	1.65	53.0*	1.77*	....
25	1.19	18.0	1.61	41.5	1.64	51.5	1.89	....
26	1.24	20.0	1.65	46.5	1.64	51.5	1.56	....
27	1.25	20.5*	1.68*	51.0	1.53	40.0	1.85	....
28	1.28	23.0	1.71	55.0	1.24	20.0	1.75	....
29	1.34	27.0	1.70	54.5	1.64	51.0	1.75	....
30	1.36	29.0	1.70	55.5	1.67	55.0	1.88	....
31	1.41	33.5	....	....	1.69	56.5	....	....

* Observations have been interpolated.

MONTHLY DISCHARGE of Milk River at Writing-on-Stone Police Detachment, for 1910.

Drainage area, 1,620 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square Mile.	Depth in inches on Drainage area.	Total in acre-feet
April	279.5	131.0	206.8	0.127	0.141	12,305
May	278.5	84.0	184.2	0.114	0.131	11,326
June	307.5	50.5	107.9	0.067	0.075	6,420
July	65.0	15.5	32.7	0.020	0.023	2,011
August	33.5	13.5	17.6	0.011	0.013	1,082
September	90.0	31.5	52.7	0.032	0.036	3,136
October	56.5	20.0	48.7	0.030	0.035	2,994
The period						39,274

MILK RIVER AT PENDANT D'OREILLE POLICE DETACHMENT

This station was established by F. H. Peters on August 5th, 1909. It is located 300 feet upstream from the buildings of the Police Post in Sec. 19, Tp. 2, Rge. 8, W. 4th, Mer., and is about 61 miles by trail from Milk River Station.

Discharge measurements are made by means of a cable, car, tagged wire, and stay wire. The initial point for soundings is the face of a cedar post on the left bank of the river.

The gauge which is a plain staff graduated to feet and hundredths, is at the left bank of the river and about 80 feet below the cable. It is referred to the top of the post at the initial point; elevation 17.35 above the datum of the gauge.

The river flows in one channel which at ordinary stages is about 130 feet wide, It is straight for about 400 feet above and 300 feet below the station. The right bank is low covered with small willows, and liable to overflow at high stages. The left bank is high, almost clear and not liable to overflow. The bed of the stream is composed of sand and is constantly changing.

The gauge is read by Corporal T. B. Caulkin of the R. N. W. M. P.

DISCHARGE MEASUREMENTS of Milk River at Pendant d'Oreille Police Detachment, in 1910.

DATE	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 12	F. H. Peters	101.3	115.5	1.88	2.76	217
April 22	N. M. Sutherland	102.1	107.5	1.78	2.545	191
April 28	"	101.4	101.6	1.72	2.57	175
May 5	"	107.9	91.4	1.79	2.705	164
May 12	F. H. Peters	122.2	103.1	1.57	2.69	162
May 16	N. M. Sutherland	131.1	130.8	1.65	2.83	216
May 23	"	148.0	148.8	1.72	3.18	255
May 26	"	152.6	128.1	1.53	2.97	196
June 3	"	152.2	97.8	1.02	2.815	99.6
June 8	F. H. Peters				2.73	110 *
June 16	N. M. Sutherland				2.82	96.1*
June 24	"				2.58	70.7*
June 28	"				2.48	48.4*
July 5	"				2.52	57.4*
July 11	F. H. Peters				2.39	34.6*
July 14	N. M. Sutherland				2.29	25.0*
July 18	F. H. Peters				2.21	18.3*
July 23	N. M. Sutherland				2.17	14.3*
August 4	"				1.99	5.84*
August 11	"				2.00	7.07*
August 15	"				2.09	10.5*
August 24	L. J. Gleeson				2.06	9.11*
August 26	"				2.06	8.86*
September 16	G. H. Whyte				2.50	65.3*
September 20	"				2.415	48.2*
September 30	"				2.47	52.2*
October 4	"				2.47	60.5*
October 11	"				2.38	40.9*
October 14	"				2.41	41.2*
October 24	"				2.42	46.1*
October 28	"				2.335	28.1*
November 8	"	149.0	63.4	0.73	2.43	46.1*
November 13	"				2.60	39.5*

* Measurements taken at wading sections.

DAILY GAUGE HEIGHT AND DISCHARGE of Milk River at Pendant d'Oreille Police Detachment, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.53	132.5	2.78	226.5	2.76*	89.5	2.47	48.0
2	2.53*	132.5	2.76	210.0	2.74	78.5	2.49	51.5
3	2.52*	129.5	2.70	180.0	2.79	92.0	2.51	55.0
4	2.52	129.5	2.75	191.0	2.74	89.0	2.51	55.0
5	2.53	132.5	2.76	185.5	2.69	77.0	2.51	55.0
6	2.54	136.0	2.71	166.0	2.68	80.5	2.49	51.5
7	2.54	136.0	2.68	154.5	2.72	98.0	2.51	55.5
8	2.54	136.0	2.65	146.0	2.75	116.5	2.52	56.5
9	2.53	132.5	2.63	138.5	2.70	97.0	2.40	37.5
10	2.55	139.5	2.64	142.0	2.66	82.5	2.42	39.5
11	2.62	162.5	2.75	186.0	2.76	107.0	2.39	34.5
12	2.76*	217.0	2.75	186.0	3.18	251.5	2.39	34.5
13	2.79*	232.5	2.76	190.0	3.04	195.5	2.37	32.5
14	2.82	250.0	2.78*	197.5	2.93	146.5	2.30	25.5
15	2.85	282.5	2.81*	209.0	2.83	104.5	2.29	24.5
16	2.91	295.0	2.83	216.5	2.81	93.0	2.29	24.5
17	2.87	287.0	2.79	189.0	2.79	93.0	2.29	24.5
18	2.75	244.5	2.77	172.0	2.69	72.0	2.23	19.5
19	2.59	291.0	2.89	197.5	2.64	65.5	2.21*	18.0
20	2.55	181.5	2.96	209.0	2.61	62.5	2.20	17.5
21	2.54	183.5	3.10	248.0	2.59	62.0	2.21	18.0
22	2.58	203.5	3.11	235.0	2.60	67.5	2.20	17.5
23	2.61	201.5	3.18	255.5	2.61	73.5	2.17	15.5
24	2.72	248.0	3.14	246.5	2.59	74.0	2.19	16.5
25	2.66	221.0	3.04	216.5	2.57	69.0	2.14	13.5
26	2.62	201.5	2.95	189.5	2.53*	60.5	2.08	10.0
27	2.59	186.5	2.89	161.0	2.49	52.0	2.09	10.5
28	2.54	163.5	2.91	163.5	2.47	47.5	2.04	8.3
29	2.60	176.5	2.82	134.5	2.47	47.5	2.05	8.7
30	2.70	205.0	2.82	119.5	2.47	47.5	2.06	9.2
31	....	....	2.79*	104.0	....	....	2.03	8.0

* Observations have been interpolated.

DAILY GAUGE HEIGHT AND DISCHARGE of Milk River at Pendant d'Oreille Police Detachment, for 1910.—*Continued.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.02	7.5	2.15	21.5	2.48	56.5	2.42*	39.5
2	2.00	6.7	2.13	21.0	2.51	64.5	2.45*	45.5
3	2.00*	6.7	2.12	21.0	2.49	62.5	2.47	49.0
4	1.99*	6.4	2.29	38.0	2.47	60.5	2.44	45.5
5	2.01	7.1	2.39	52.5	2.47	60.5	2.37	37.0
6	2.12	12.0	2.39	52.5	2.45	56.5	2.48	52.5
7	2.19	16.5	2.50	74.0	2.46	57.5	2.32	31.5
8	2.16	14.5	2.49	71.0	2.42	50.0	2.45	49.0
9	2.11	11.5	2.49	70.0	2.42	49.0	2.40	....
10	2.07	9.7	2.55	83.5	2.40	45.0	2.48	....
11	2.07	9.7	2.55	82.0	2.38	41.0	2.58	....
12	2.04	8.3	2.54	77.5	2.37	39.0	2.72	....
13	2.05	8.8	2.57	83.5	2.38	39.0	2.62	....
14	2.08	10.0	2.53	73.5	2.40	40.0	2.57	....
15	2.10	11.0	2.51	68.0	2.40	40.0	2.56	....
16	2.12	12.0	2.53	71.5	2.39	39.0	2.56	....
17	2.09	10.5	2.53	71.5	2.42	43.5	2.54	....
18	2.10	11.0	2.52	69.0	2.43	45.0	2.44	....
19	2.08	10.0	2.47	58.0	2.43	45.0	2.54	....
20	2.07	9.7	2.42	48.0	2.44	48.0	2.53	....
21	2.08	10.0	2.40	46.0	2.42	45.0	2.62	....
22	2.10	11.0	2.36	40.0	2.42	45.0	2.83	....
23	2.05	8.7	2.36	39.5	2.44	49.0	2.71	....
24	2.09	10.5	2.38	41.5	2.42	46.0	2.45	....
25	2.06	9.2	2.40	44.5	2.43	46.0	2.36	....
26	2.06	9.2	2.41*	45.5	2.51	51.0	2.33	....
27	2.06	10.5	2.42*	46.0	2.61	70.0	2.39	....
28	2.04	11.0	2.43	47.0	2.33	27.5	2.50	....
29	2.03	11.5	2.46	52.0	2.42	33.0	2.43	....
30	2.10	17.5	2.48	54.5	2.24	21.0	....	....
31	2.19	25.5	....	....	2.39	36.0	....	....

* Observations have been interpolated.

MONTHLY DISCHARGE of Milk River at Pendant d'Oreille Police Detachment, for 1910.

(Drainage area, 2175 square miles.)

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	295.0	129.5	189.3	0.087	0.097	11,264
May	255.5	104.0	186.0	0.086	0.098	11,437
June	251.5	47.5	89.8	0.041	0.046	5,343
July	56.5	8.0	28.9	0.013	0.015	1,777
August	25.5	6.4	10.8	0.005	0.006	664
September	83.5	21.0	22.1	0.010	0.011	1,315
October	64.5	21.0	46.8	0.022	0.025	2,878
The period						34,678

MILK RIVER AT SPÉNCER'S LOWER RANCHE.

This station was established on August 7th, 1909, by F. H. Peters. It is located in Sec. 1, Tp. 1, Rge. 5, W. 4th Mer., about 1,000 feet upstream from the International Boundary. It is 90 miles by trail from Milk River station, 26 miles from Pendant d'Oreille and 19 miles from Wild Horse Police Detachment.

The river flows in one channel at all stages. It is straight for about 300 feet above and 500 feet beow the station. The right bank is low, wooded and liable to overflow during high flood stages. The left bank is steep, heavily wooded and liable to overflow during extreme flood stage. The bed is composed of sand which is constantly shifting.

Discharge measurements are made by means of a cable, car, tagged wire, and stay wire. The initial point for soundings is the inner face of a round post on the left bank. Discharge measurements can be made by wading during low water.

The gauge, which is a plain staff, graduated to feet and hundredths, is fixed to a post at the right bank. It is referred to the top of a poplar stump on the right bank; elevation, 14.25 feet above the datum of the gauge. It was read during 1910 by Chas. Latimer.

DISCHARGE MEASUREMENTS of Milk River at Spencer's Lower Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 14	F. H. Peters	82.2	117	2.03	2.62	238
April 22	N. M. Sutherland	79.2	104.7	1.94	2.49	204
April 27	"	79.2	98.9	1.80	2.43	178
May 6	"	79.4	92.1	1.73	2.405	159
May 13	"	79.8	97.3	1.59	2.37	155
May 24	"	82.2	124.2	2.03	2.72	252
June 4	"	73.0	72.8	1.56	2.26	113
June 14	"	84.1	110.8	1.82	2.55	201
June 27	"	78.2	52.3	1.15	1.975	60.3
July 6	"				1.86	44.4*
July 11	F. H. Peters	75.0	33.3	1.07	1.74	35.7
July 14	N. M. Sutherland				1.68	26.6*
July 24	"	46.9	12.0	0.80	1.44	9.57*
August 1	"	34.1	8.45	0.66	1.315	5.57*
August 13	"				1.24	2.71*
August 14	"	31.6	5.94	0.64	1.28	3.77*
August 25	L. J. Gleeson				1.26	4.03*
September 19	G. H. Whyte				1.91	54.6*
October 2	"				1.90	46.8*
October 13	"				1.84	36.2*
October 26	"				1.86	40.5*
November 11	"				1.71	24.8*

* Measurements made at wading stations.

DAILY GAUGE HEIGHT AND DISCHARGE of Milk River at Spencer's Lower Ranche, for 1910

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			2.49	196.0	2.38	149.5	1.94	55.0
2			2.50	198.0	2.43	175.0	1.94	55.5
3			2.52	203.0	2.33	134.5	1.93	54.0
4			2.48	188.5	2.28	119.0	1.91	51.0
5			2.44	173.5	2.25	111.0	1.94	55.0
6			2.43	168.5	2.20	99.5	1.88	47.0
7			2.38	154.0	2.17	92.5	1.87	47.0
8			2.32	135.5	2.18	95.0	1.83	43.5
9			2.28	125.0	2.23	107.0	1.79	40.0
10			2.26	120.0	2.20	100.0	1.76	37.5
11			2.30	132.0	2.17	92.5	1.78	40.5
12			2.33	142.0	2.21	101.0	1.77	38.0
13			2.32	139.5	2.57	209.5	1.65	25.0
14	2.62	237.6	2.36	152.0	2.54	197.5	1.68	26.5
15	2.70	266.5	2.47	184.0	2.42	163.5	1.65	24.5
16	2.67	257.5	2.50	191.5	2.31	133.0	1.65	25.0
17	2.69	266.5	2.54	204.0	2.23	119.5	1.59	20.5
18	2.70	271.5	2.45	172.5	2.17	110.5	1.56	18.5
19	2.61	242.0	2.46	175.5	2.14	106.0	1.53	16.0
20	2.52	212.0	2.53	202.5	2.19	115.0	1.51	15.0
21	2.47	196.0	2.56	204.5	2.05	90.0	1.48	13.0
22	2.46	193.0	2.77	274.5	2.05	88.5	1.48	12.5
23	2.49	202.5	2.70	249.0	2.06	88.5	1.49	12.5
24	2.52	217.5	2.75	264.0	2.06	85.5	1.45	10.0
25	2.55	222.5	2.79	279.5	2.05	80.0	1.44	10.0
26	2.52	211.5	2.69	246.5	2.03	73.0	1.43	9.7
27	2.43	178.0	2.58	210.5	1.97	59.5	1.39	8.0
28	2.42	169.0	2.50	183.5	1.93	54.0	1.34	7.5
29	2.45	183.5	2.45	168.5	1.85	43.5	1.33	7.0
30	2.47	189.5	2.41	163.0	1.89	47.5	1.32	5.5
31			2.32	130.5			1.32	5.7

Daily Gauge Height and Discharge of Milk River at Spencer's Lower Ranche, for 1910.—*Con.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.32	5.5	1.36	12.3	1.88	45.0	1.83	37.5
2	1.31	5.1	1.42	16.0	1.91	48.0	1.88	44.0
3	1.31	5.1	1.44	17.5	1.94	52.0	1.91	47.0
4	1.29	4.4	1.51	18.0	1.92	49.0	1.95	52.5
5	1.26	3.2	1.71	42.0	1.94	51.5	1.90	46.0
6	1.26	3.2	1.60	30.0	1.92	48.5	1.87	41.5
7	1.27	3.7	1.64	33.5	1.93	49.0	2.03	68.5
8	1.26	3.2	1.69	38.5	1.88	43.0	1.87	42.0
9	1.27	3.7	1.74	43.5	1.87	39.0	2.03	68.5
10	1.28	4.0	1.77	46.5	1.87	41.0	1.93	48.5
11	1.27	3.7	1.79	48.0	1.85	38.5	1.87	41.5
12	1.26	3.2	1.84	54.5	1.84	37.0	1.82	....
13	1.25	3.0	1.91	64.5	1.84	36.0	1.75	....
14	1.28	3.7	1.94	68.0	1.85	38.0	1.95	....
15	1.30	3.9	1.93	65.5	1.85	38.0	1.94	....
16	1.32	4.0	1.94	65.5	1.83	36.0	2.11	....
17	1.32	4.0	1.92	60.5	1.84	37.5	2.12	....
18	1.30	3.9	1.90	55.5	1.84	37.5	1.92	....
19	1.28	3.8	1.91	54.5	1.87	40.5	1.96	....
20	1.26	3.7	1.91	53.5	1.89	43.0	1.96	....
21	1.26	3.7	1.90	52.5	1.95	51.0	1.99	....
22	1.26	3.7	1.83	42.5	1.88	42.5	1.92	....
23	1.25	3.7	1.86	45.5	1.87	42.5	2.00	....
24	1.26	3.7	1.83	41.0	1.87	42.5	2.33	....
25	1.27	3.5	1.84	42.0	1.87	42.5	2.88	....
26	1.26	4.5	1.86	44.5	1.87	42.5	2.25	....
27	1.28	6.2	1.84	41.0	1.82	36.0	2.50	....
28	1.28	6.8	1.82	38.5	1.85	39.5	2.37	....
29	1.29	7.9	1.82	38.5	1.83	37.0	2.33	....
30	1.31	9.5	1.85	41.5	1.86	40.5	2.35	....
31	1.34	11.0	....	....	1.89	44.5	....	....

Monthly Discharge of Milk River at Spencer's Lower Ranche, for 1910.

Drainage area, 2,448 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (14-30)	271.5	169.0	218.6	0.089	0.056	7,372
May	279.5	120.0	184.9	0.076	0.088	11,369
June	209.5	43.5	108.0	0.044	0.049	6,426
July	55.5	5.5	27.0	0.011	0.013	1,660
August	11.0	3.0	4.6	0.002	0.002	282
September	68.0	12.3	43.8	0.018	0.020	2,606
October	52.0	36.0	42.2	0.017	0.020	2,595
The period						32,310

STUDY OF CONDITIONS OF RUN-OFF WATERSHED of the Milk River from its head waters to its eastern crossing from Canada in Sec. 3, Tp. 1, Rge. 5, W. 4th Mer. For the period from August 1st to October 31, 1910.

Station.	Area of Watershed—Square Miles. Additional to last station.			Area of Watershed—Square Miles. Total for station.			Run-off—Ac. ft.		Run-off per sq. mile ac. ft.	
	Canada.	U.S.A.	Total	Canada.	U.S.A.	Total	Additional to last station.	Total for station.	For additional area.	For total area.
Peters Ranche, 13-1-23-4	....	....	....	18	91	109	....	4,143	....	38.00
Knights Ranche, 13-2-21-4	121	6	130	142	97	239	0017	4,160	0.13	17.40
Mackies' Ranche, N.B., 19-2-18-4	196	0	196	338	97	435	0710	4,870	3.62	11.19
Junction, N. & S. Branch, 23-2-18-4	68	390	458	406	487	893	+ 3943	8,813	8.60	9.87
Milk River, 28-2-16-4	182	2	184	588	489	1,077	— 0935	7,878	0.00	7.31
Writing-on-Stone, 35-1-13-4	414	129	543	1,002	618	1,620	— 0666	7,212	0.00	4.45
Pendant d'Oreille, 16-2-8-4	397	158	555	1,399	776	2,175	— 2355	4,857	0.00	2.23
Spencer's Lower, 3-1-5-4	246	27	273	1,645	803	2,448	626	5,483	2.29	2.19

Miscellaneous Discharge Measurements in Milk River Drainage Basin in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.	*Sq.-ft.*	*Sec.-ft.*
April 11	Beargulch Creek	Sec. 30-2-9-4	F. H. Peters			0.6
April 21	"	"	N. M. Sutherland			0.2
April 29	"	"	"			0.25
May 17	"	"	"			0.15
May 22	"	"	"			0.0
April 10	Creek	Sec. 34-1-13-4	F. H. Peters			0.3
April 27	"	S.E. 27-1-21-4	L. J. Gleeson	10	10	3.0
May 11	"	"	"	4	2	1.44
May 19	"	"	"	3	1.5	3.0
May 25	"	"	"	3	1.5	2.55
June 8	"	"	"	10	5	5.0
April 13	"	S.E. 24-1-23-4	"	4	1	0.66
April 13	"	S.E. 27-1-21-4	"	12	12	6.0
April 14	"	S.W. 19-2-20-4	"	15	7.5	11.25
April 14	"	S.W. 19-2-18-4	"	5	10	5.0
April 21	"	S.W. 19-2-20-4	"	15	7.5	5.4
May 12	"	"	"	5	5	1.65
April 21	"	S.E. 24-1-23-4	"	3	0.5	0.25
May 11	"	"	"	4	1.2	0.6
May 20	"	"	"	3	1.2	1.2
May 24	"	"	"	3	1.2	1.2
June 3	"	"	"	3	1.2	1.2
June 8	"	"	"	5	2.5	3.0
June 21	"	"	"			0.75
April 19	"	S.W. 19-2-18-4	"	5	5	2.0
April 11	Deer Creek	Sec. 36-1-12-4	F. H. Peters			0.0
April 11	Deadhorse Creek	N.W. 4-1-11-4	"			0.33
April 21	"	"	N. M. Sutherland			0.10
April 29	"	"	"			0.12
May 17	"	"	"			0.10
May 22	"	"	"			0.12
May 27	"	"	"			0.10
June 1	"	"	"			0.10
June 17	"	"	"			0.05
June 23	"	"	"			0.08
September 16	"	"	G. H. Whyte			0.02
September 29	"	"	"			0.02
October 5	"	"	"			0.04
October 11	"	"	"			0.03
October 15	"	"	"			0.04
October 24	"	"	"			0.02
October 29	"	"	"			0.03
November 7	"	"	"			0.05
November 14	"	"	"			0.10
April 11	Halfbreed Creek	Sec. 28-2-10-4	F. H. Peters			0.4
April 21	"	"	N. M. Sutherland			0.25
April 29	"	"	"			0.15
May 12	"	"	F. H. Peters			0.08
May 17	"	"	N. M. Sutherland			0.0
May 22	"	"	"			0.0
April 14	Kennedy Creek	Sec. 2-1-5-4	F. H. Peters			Nil.
April 22	"	"	N. M. Sutherland			Nil.
April 23	Lost River	Sec. 2-1-4-4	"			0.0
May 13	"	"	"			0.08
May 14	"	"	F. H. Peters			Nil.
April 14	Lonely Valley River	Sec. 28-2-20-4	L. J. Gleeson	5	10	5.0
April 21	"	"	"	5	5	2.0
April 28	"	"	"	6	4.2	2.1
May 17	"	"	"	5	5	2.0
May 26	"	"	"	5	5	2.0
June 8	"	"	"	5	0.5	0.34
June 22	"	"	"			1.0
October 1	"	"	N. M. Sutherland			0.1
April 21	Miners Coulee	Sec. 10-2-11-4	"			Nil.
April 20	Police Creek	Sec. 34-1-13-4	"			Nil.
May 18	"	"	"			0.1
May 4	Red Creek	Sec. 18-1-15-4	F. H. Peters			Nil.
May 8	"	"	"			Nil.

PAKOWKI LAKE DRAINAGE BASIN.

General Description.

The drainage into Pakowki Lake comes from three different directions, from the west by way of Etzikom Coulee, from the southeast in Canal Creek and from the northeast in Manyberries Creek. The lake has no outlet. The streams making up the drainage basin are very similar in their general characteristics, all having narrow, deep and well defined valleys, with sparse growths of brush along the bottoms, and all draining a sandy and very unproductive appearing soil. The drainage consists almost entirely of the spring run-off, the soil being so devoid of moisture as to take care of any ordinary rainfalls without allowing for any drainage into the streams.

Very little information has been collected as yet regarding the flow in any of the above mentioned streams, the only one touched upon, as yet being the Manyberries Creek.

Manyberries Creek at Hooper and Huckvale's Ranche.

This station was established June 17th, 1910, by H. R. Carscallen. It is located on Sec. 3, Tp. 5, Rge. 6, W. 4th Mer., at Hooper and Huckvale's ranche, below the junction of the creek with its south branch and about seven miles east of Pakowki Lake.

The creek flows in one channel It is straight for 400 feet above and 500 feet below the station. Both banks are high and do not overflow. They are composed of a sandy loam and are sparsely covered with brush. The bed of the stream is composed of sand and gravel.

The gauge, which is a plain staff, graduated to feet and hundredths, is spiked vertically to a post sunk in the bed of the creek at the right bank and stayed. It is referred to bench marks as follows:—(1) A spikehead in hub beside the final point stake on the right bank; elevation, 20.52. (2) A spike-head in a willow stump at chainage 75 feet on left bank; elevation, 8.65.

Discharge measurements are made with current meter by wading. The initial point for soundings is a stake driven close to the ground on the left bank and marked I.P.o.o. At extreme low water stage a weir is used.

The spring run-off for 1910 had passed before this station was established, and the creek was dry at that time. A heavy rain in July started a flow and gauge height observations were made by Mr. Sidney Hooper covering the period of flow, July 4 to 7. The readings were 2.9, 2.1, 1.5 and 0.9, but as the district hydrographer was not in this locality at the time, the daily discharges have not been computed.

SAGE CREEK DRAINAGE BASIN.

General Description.

Sage is a small but important tributary of Milk River, which rises in the hills or "bad-lands." A few miles north of the International Boundary it widens out and forms Wild Horse Lake and finally empties into Milk River on the south side of the Boundary.

There is only a small rain-fall in this basin and the greatest run-off is in the early spring when the melting snow is going out. Being bare of all tree growth, the water runs off very rapidly and has cut deep coulees and ravines in the basin.

Sage Creek at Wild Horse Police Detachment.

This station was established on August 10, 1909, by F. H. Peters. It is located in Sec. 9, Tp. 1, Rge. 2, W. 4th Mer., about $1\frac{1}{4}$ miles from Wild Horse Police Post. It is about 115 miles by trail from Milk River station.

The channel is straight for 40 feet above and below the station. The banks are composed of hard clay, are high, but liable to overflow at flood stage of the stream. The bed is composed of hard gumbo clay.

Discharge measurements are made by wading. The initial point for soundings is the face of a post on the right bank marked o oo in red paint.

The gauge which is a plain staff, graduated to feet and hundredths, is fixed to a post in the centre of the channel. It is referred to the top of the post at the initial point for soundings.

In 1910, Sage Creek ran from March 17 to April 15, and the gauge was read during that time by Corp. Tom Brewer, but as the district hydrographer was not in the locality at the time, estimates of the discharge have not been made.

LODGE CREEK DRAINAGE BASIN.

General Description.

Lodge Creek rises in Tp. 7, Rge. 3, W. 4th Mer., flows in a southerly direction for about 12 miles, then turns south-eastward, crosses the International Boundary in Sec. 4, Tp. 1, Rge. 28, W. 3rd Mer., and eventually empties into Milk River near Chinook, Montana. Its principal tributary is Middle Creek which joins it in Sec. 4, Tp. 2, Rge. 29, W. 3rd Mer.

Near its head the valley is very deep and narrow, but it broadens out considerably lower down, giving rise to large flats and meadows. The upper part of the drainage basin is cut up to a great extent by deep coulees which drain into the creek. This part of the creek is thickly covered with brush along the banks, but lower down is totally devoid of tree growth. The valley is rather unproductive owing to the absence of moisture but a few good hay meadows have been developed along its course through the storage of the creek waters and their application to the soil by irrigation. As is the case with many of the streams in this locality the flow in Lodge Creek is not continuous throughout the season, the creek being dry, with the exception of pools of standing water, during the greater part of the summer months. At flood stages the creek carries a very considerable amount of water and as a result its channel is wide and well defined throughout the whole length of its course.

Two stations have been established on this creek one at Willow Creek Police Detachment near the International Boundary, and the other near the head of the creek at Hart's ranche. Descriptions of these stations are given below.

Measuring the Velocity with a Current Meter by Wading.

Hydrographer's Flying Camp.

Lodge Creek at Willow Creek Police Detachment.

This station was established by F. H. Peters, on August 13, 1909. It is located on the S.E. ¼ Sec. 12, Tp. 1, Rge. 29, W. 3rd Mer., and about 500 feet east of the house at Willow Creek Detachment. It is about 140 miles by trail from Milk River station and about 75 miles by trail from Maple Creek.

The stream flows in one channel, which is straight for about 200 feet above and 150 feet below the station. The right bank is steep, composed of solid clay and not liable to overflow. The left bank gradually rises, is composed of solid clay and stones, and not liable to overflow.

The gauge, which is a plain staff, graduated to feet and hundredths is fixed to a post at the left bank. It is referred to the top of a post on the right bank; elevation, 11.55 feet above the datum of the gauge.

During ordinary stages of flow, discharge measurements are made by wading at the gauge. The initial point for soundings is the face of the B. M. post. During 1910 the flow became so small that on May 16th a 24″ sharp crested rectagular weir was established about 6 ft. above the gauge. An auxiliary gauge was also established for the weir on the same date.

The gauge was read during 1910, by Constable C. H. Cuthbertson.

Discharge Measurements of Lodge Creek at Willow Creek Police Detachment, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 25	N. M. Sutherland	20.05	9.72	0.708	0.94	6.91
May 9	"	16.6	5.72	0.052	0.685	0.30
May 12	"	16.5	4.45	0.054	0.65	0.24
May 18	F. H. Peters				9.34	0.15*
June 13	H. R. Carscallen					Nil.

* Discharge determined by using a 24 inch weir.

Daily Gauge Height and Discharge of Lodge Creek at Willow Creek Police Detachment, for 1910.

Day.	April.		May.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.88	4.34
2			0.86	3.60
3			0.87	3.96
4			0.83	2.60
5			0.81	2.05
6			0.75	0.86
7			0.73	0.60
8			0.70	0.37
9			0.68	0.28
10			0.67	0.26
11			0.66	0.25
12			0.65	0.24
13			0.63	0.20
14			0.62	0.17
15				*
16				
17				
18				
19				
20				
21				
22				
23				
24				
25	0.94	6.91		
26	0.94	6.91		
27	0.94	6.91		
28	0.93	6.47		
29	0.92	6.02		
30	0.90	5.15		
31				

* Creek dry from June 14 to end of year.

Monthly Discharge of Lodge Creek at Willow Creek Police Detachment, for 1910.

Drainage area, 834 square miles.

Month.	Discharge in Second-feet.			Run-off.		
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (25-30)	6.91	5.15	6.40	0.008	0.002	76
May (1-14)	4.34	0.17	1.41	0.002	0.001	39
The period						115

Lodge Creek at Hart's Ranche.

This station was established July 22, 1909, by F. T. Fletcher. It is located 54 feet south of the road allowance between Sec's 15 and 10, Tp. 6, Rge. 3, W. 4th Mer., about ½ mile below the junction of the east and west branches of Lodge Creek and is about 45 miles south of Medicine Hat.

The channel is straight for about 60 feet above and 250 feet below the station. The banks are high, steep and not liable to overflow. Both banks are covered with a dense growth of willow brush. The bed of the stream is composed of clay and there is one channel at all stages. On account of the narrow channel and the steep banks, the water will be very deep at high stages of the stream and could not be waded.

The gauge is a plain staff, graduated to feet and hundredths, spiked to an upright sunk in the bed of the creek at the left bank and braced. It is referred to two bench marks:—(1) A spike-head in top of a stake driven close to the ground elevation, 13.71; (2) a row of 5″ spikes, 6″ above the ground in a gate post near J. E. Hart's house, elevation, 14.13.

This station was visited in June and on July 12,1910, by H. R. Carscallen, and on both occasions the creek was dry, and from evidence obtained on the ground it appears to have been dry during the whole year.

Middle Creek at Hammond's Ranche.

This station was established June 13, 1910, by H. R. Carscallen. It is located on the N.W. ¼ Sec. 4, Tp. 2, Rge. 29, W. 3rd Mer., about 7 miles above the Willow Creek Police Detachment and about ¼ of a mile above the junction of Middle and Lodge Creeks.

The channel is straight for 200 feet above and 125 feet below the station. Both banks are high and fairly steep, free from brush and not liable to overflow. The bed of the stream is sandy and may shift at high stages. The station, being located so close to the junction with Lodge Creek, may be affected by backwater from that creek at high water stages.

Discharge measurements are made at the station by wading and at extreme low stages a weir may be used. High water measurements are not attainable, as there is no structure at the station to support the engineer in taking the gaugings when the water becomes too deep for wading. The initial point for soundings is a stake driven close to the ground on the left bank and marked I. P. O. O.

The gauge is a plain staff, graduated to feet and hundredths, spiked to a post set vertically in the bed of the creek at the left bank and stayed. It is referred to two bench marks:—(1) Two spikes in a log at northwest corner of D. A. Hammond's house, elevation 15.20 above datum; (2) a spike-head in a hub driven close to the ground beside the final point stake on the right bank, elevation, 10.52 above datum.

At the time the station was established and during the balance of the year there was water in pools at this point, but there was no surface flow.

Middle Creek, at Ross' Ranche.

This station was established July 20, 1908, by H. R. Carscallen. It is located on Sec. 30, Tp. 5, Rge. 29, W. 3rd Mer., about four miles from Battle Creek P.O.

The channel is straight for 50 feet above and below the station. The right bank is high, but the left is low and liable to overflow in flood stages of the stream. The bed of the stream is composed of sand and coarse gravel with a little vegetation at the section, and probably shifts slightly during high water. There is only one channel at low stages, but in extreme flood stages water breaks out over the left bank and forms two channels. The current is sluggish at low stages and moderate at higher stages.

Discharge measurements are made by wading at moderate stages and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. O. O.

The gauge, which is read once each day by Mr. Ross is a plain staff, graduated to feet and hundredths, nailed to a pine post sunk in the bed of the creek at the left bank and securely stayed. It is referred to bench marks as follows:—(1) The top of the final point driven close to the ground on the right bank and marked B. M. in red paint; elevation, 5.91 feet above the zero of the gauge. (2) The heads of three spikes driven into the top of the ground-log between the stable and the hen-house facing the gauge and marked B. M. in red paint; elevation, 10.63 feet above the zero of the gauge.

DISCHARGE MEASUREMENTS of Middle Creek, at Ross' Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 22	H. R. Cascallen	9.2	5.10	0.163	0.73	0.83*
May 16	"	8.7	4.35	0.111	0.66	0.48*
June 10	"	8.8	4.34	0.092	0.65	0.40*
July 2	"	9.0	4.63	0.059	0.66	0.27*
July 25	"	8.7	4.16	0.071	0.66	0.296*
August 12	"	9.0	3.87	0.070	0.64	0.27*
September 3	"	8.9	4.29	0.077	0 66	0.33*
September 29	R. G. Swan	8.8	4.32	0.091	0.68	0.39
October 25	"	4.0	4.00	0.090	0.64	0.36

* Discharge determined by using a 15 inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Middle Creek, at Ross' Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.70	0.54	0.65	0.35
2			0.70	0.54	0.65	0.35
3			0.70	0.54	0.65	0.35
4			0.70	0.54	0.65	p.35
5	0.70	0.54	0.70	0.54	0.65	0.35
6	0.70	0.54	0.70	0.54	0.65	0.35
7	0.70	0.54	0.70	0.54	0.65	0.35
8	0.80	1.00	0.70	0.54	0.65	0.35
9	0.80	1.00	0.70	0.54	0.65	0.35
10	0.80	1.00	0.70	0.54	0.65	0.35
11	0.80	1.00	0.70	0.54	0.65	0.35
12	0.80	1.00	0.70	0.54	0.65	0.35
13	0.80	1.00	0.70	0.54	0.65	0.35
14	0.80	1.00	0.70	0.54	0.65	0.35
15	0.70	0.54	0.70	0.54	0.65	0.35
16	0.70	0.54	0.65	0.35	0.65	0.35
17	0.70	0.54	0.65	0 35	0.80	1.00
18	0.70	0.54	0.65	0.35	0.70	0.54
19	1.30	3.58	0.70	0.54	0.65	0.35
20	1.20	3.06	0.70	0.54	0.65	0.35
21	1.00	2.02	0.70	0.54	0.65	0.35
22	0.80	1.00	0.65	0.35	0.65	0.35
23	0.70	0.54	0.65	0.35	0.65	0.35
24	0.70	0.54	0.65	0.35	0.65	0.35
25	0.70	0.54	0.65	0.35	0.65	0.35
26	0.70	0.54	0.65	0.35	0.65	0.35
27	0.70	0.54	0.65	0.35	0.65	0.35
28	0.70	0.54	0.65	0.35	0.65	0.35
29	0.70	0.54	0.65	0.35	0.65	0.35
30	0.70	0.54	0.65	0.35	0.75	0.76
31			0.65	0.35		

DAILY GAUGE HEIGHT AND DISCHARGE of Middle Creek, at Ross' Ranche, for 1910.—*Continued*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.75	0.76	0.64	0.32	0.68	0.46	0.67	0.43
2	0.70	0.54	0.63	0.29	0.66	0.39	0.67	0.43
3	0.70	0.54	0.63	0.29	0.66	0.39	0.67	0.43
4	0.70	0.54	0.63	0.29	0.66	0.39	0.67	0.43
5	0.70	0.54	0.65	0.35	0.68	0.46	0.67	0.43
6	0.70	0.54	0.66	0.39	0.69	0.50	0.67	0.43
7	0.70	0.54	0.69	0.50	0.69	0.50	0.67	0.43
8	0.70	0.54	0.67	0.43	0.69	0.50	0.67	0.43
9	0.70	0.54	0.66	0.39	0.68	0.46	0.67	0.43
10	0.70	0.54	0.66	0.39	0.67	0.43	0.67	0.43
11	0.70	0.54	0.65	0.35	0.67	0.43	0.67	0.43
12	0.70	0.54	0.65	0.35	0.67	0.43	0.67	0.43
13	0.70	0.54	0.67	0.43	0.66	0.39	0.67	0.43
14	0.70	0.54	0.67	0.43	0.66	0.39	0.67	0.43
15	0.70	0.54	0.70	0.54	0.66	0.39	0.67	0.43
16	0.70	0.54	0.70	0.54	0.66	0.39	0.67	0.43
17	0.70	0.54	0.70	0.54	0.66	0.39	0.67	0.43
18	0.70	0.54	0.69	0.50	0.66	0.39	0.67	0.43
19	0.70	0.54	0.68	0.46	0.67	0.43	0.67	0.43
20	0.70	0.54	0.68	0.46	0.67	0.43	0.67	0.43
21	0.70	0.54	0.68	0.46	0.67	0.43	0.67	0.43
22	0.70	0.54	C.68	p.46	0.67	0.43	0:67	0.43
23	0.70	0.54	0.68	0.46	0.67	0.43	0.67	0.43
24	0.70	0.54	0.68	0.46	0.67	0.43	0.67	0.43
25	0.65	0.35	0.68	0.46	0.67	0.43	0.67	p.43
26	0.65	0.35	0.67	0.43	0.67	0.43	0.67	0.43
27	0.65	0.35	0.67	0.43	0.67	0.43	0.66	0.39
28	0.70	0.54	0.68	0.46	0.67	0.43	0.65	0.35
29	0.67	0.43	0.68	0.46	0.67	0.43	0.64	0.32
30	0.66	0.39	0.68	0.46	0.67	0.43	0.64	0.32
31	0.66	0.39	0.68	0.46	....	....	0.64	0.32

MONTHLY DISCHARGE of Middle Creek, at Ross' Ranche, for 1910.

Drainage area, 168 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (5-30)	3.58	0.54	0.952	0.006	0.004	49
May	0.54	0.35	0.460	0.003	0.003	28
June	1.00	0.35	0.392	0.002	0.002	23
July	0.76	0.35	0.515	0.003	0.003	32
August	0.54	0.29	0.427	0.003	0.003	26
September	0.50	0.39	0.428	0.003	0.003	25
October	0.43	0.32	0.415	0.002	0.002	25
The period	....	....	....	....	....	208

MIDDLE CREEK AT MCKINNON'S RANCHE.

This station was established June 21, 1910, by H. R. Carscallen. It is located on the S.W. ¼ Sec. 35, Tp. 5, Rge. 1, W. 4th Mer., about 11 miles southwest of Battle Creek, P.O.

The channel is slightly curved but is comparatively straight for about 150 feet above and 100 feet below the station. The right bank is high with a gradual slope; the left bank is high and steep. Neither bank is liable to overflow except in extreme flood. The bed of the stream is composed of sand and coarse gravel.

During ordinary stages, discharge measurements are made with current meter by wading, and at extreme low stages a weir is used.

The gauge is a plain staff, graduated to feet and hundredths, spiked to an upright, braced in the bed of the creek at the left bank. It is referred to bench marks as follows:—(1) A spike-head on hub driven close to the ground beside the initial point stake on the left bank, elevation 7.58; (2) A spike-head in hub driven close to ground beside final point stake on right bank, elevation, 6.29.

The gauge was read once each day by Angus McKinnon, whose house is within 500 yards of the station.

DISCHARGE MEASUREMENTS of Middle Creek at McKinnon's Ranche in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 21	H. R. Carscallan				0.76	0.47*
July 11	"				0.74	0.32*
July 29	"	10.0	3.79	0.045	0.68	0.17*
August 16	"	10.0	4.23	0.061	0.68	0.26*
September 3	"	10.6	3.87	0.087	0.67	0.34*
September 29	R. G. Swan	10.2	4.18	0.071	0.64	0.30*
October 25	"				0.66	0.35*

* Discharge determined by using a 15-inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Middle Creek, at McKinnon's Ranche, for 1910.

Day.	June.		July.		August.		September.	
	Gauge Height.	Discharge	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.85	0.78	0.66	0.22	0.66	0.22
2			0.80	0.60	0.66	0.22	0.66	0.22
3			0.90	0.99	0.67	0.24	0.66	0.22
4			0.90	0.99	0.66	0.22	0.72	0.36
5			1.00	1.45	0.67	0.24	0.73	0.39
6			0.85	0.78	0.67	0.24	0.72	0.36
7			0.75	0.44	0.66	0.22	0.73	0.39
8			0.70	0.31	0.66	0.22	0.72	0.36
9			0.70	0.31	0.65	0.20	0.71	0.33
10			0.75	0.44	0.64	0.18	0.71	0.33
11			0.75	0.44	0.65	0.20	0.70	0.31
12			0.70	0.31	0.65	0.20	0.70	0.31
13			0.75	0.44	0.71	0.34	0.66	0.22
14			0.70	0.31	0.70	0.31	0.66	0.22
15			0.65	0.20	0.69	0.29	0.66	0.22
16			0.65	0.20	0.69	0.29	0.66	0.22
17			0.65	0.20	0.67	0.24	0.67	0.24
18			0.65	0.20	0.67	0.24	0.66	0.22
19			0.65	0.20	0.65	0.20	0.66	0.22
20			0.65	0.20	0.65	0.20	0.66	0.22
21	0.75	0.44	0.65	0.20	0.65	0.20	0.65	0.20
22	0.75	0.44	0.65	0.20	0.65	0.20	0.65	0.20
23	0.75	0.44	0.85	0.78	0.66	0.22	0.65	0.20
24	0.75	0.44	0.75	0.44	0.66	0.22	0.66	0.22
25	0.75	0.44	0.75	0.44	0.67	0.24	0.66	0.22
26	0.72	0.36	0.75	0.44	0.67	0.24	0.66	0.22
27	0.70	0.31	0.70	0.31	0.67	0.24	0.65	0.20
28	0.70	0.31	0.70	0.31	0.66	0.22	0.65	0.20
29	0.70	0.31	0.66	0.22	0.66	0.22	0.65	0.20
30	0.70	0.31	0.66	0.22	0.66	0.22	0.66	0.22
31			0.66	0.22	0.66	0.22		

DAILY GAUGE HEIGHT AND DISCHARGE of Middle Creek, at McKinnon's Ranche, for 1910.—*Con.*

Day.	October.		November.		December.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.66	0.22	0.66	0.22	0.63	0.17
2	0.66	0.22	0.66	0.22	0.63	0.17
3	0.66	0.22	0.66	0.22	0.63	0.17
4	0.67	0.24	0.66	0.22	0.63	0.17
5	0.67	0.24	0.66	0.22	0.63	0.17
6	0.66	0.22	0.65	0.20	0.63	0.17
7	0.66	0.22	0.65	0.20	0.63	0.17
8	0.66	0.22	0.65	0.20	0.63	0.17
9	0.65	0.20	0.65	0.20	0.63	0.17
10	0.65	0.20	0.65	0.20	0.63	0.17
11	0.65	0.20	0.65	0.20	0.63	0.17
12	0.65	0.20	0.66	0.22	0.63	0.17
13	0.65	0.20	0.66	0.22	0.63	0.17
14	0.65	0.20	0.66	0.22	0.63	0.17
15	0.65	0.20	0.66	0.22	0.63	0.17
16	0.65	0.20	0.66	0.22	0.63	0.17
17	0.65	0.20	0.66	0.22	0.63	0.17
18	0.65	0.20	0.65	0.20	0.63	0.17
19	0.66	0.22	0.65	0.20	0.63	0.17
20	0.66	0.22	0.64	0.19	0.63	0.17
21	0.66	0.22	0.64	0.19	0.63	0.17
22	0.66	0.22	0.64	0.19	0.63	0.17
23	0.66	0.22	0.64	0.19	0.63	0.17
24	0.66	0.22	0.64	0.19	0.63	0.17
25	0.66	0.22	0.64	0.19	0.63	0.17
26	0.66	0.22	0.64	0.19	0.63	0.17
27	0.66	0.22	0.64	0.19	0.63	0.17
28	0.66	0.22	0.64	0.19	0.63	0.17
29	0.66	0.22	0.63	0.17	0.63	0.17
30	0.66	0.22	0.63	0.17	0.63	0.17
31	0.66	0.22	....	....	0.62	0.15

MONTHLY DISCHARGE of Middle Creek, at McKinnon's Ranche, for 1910.

Drainage area, 125 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
June (21-30)	0.44	0.31	0.38	0.0030	0.0011	8
July	1.45	0.20	0.44	0.0035	0.0040	27
August	0.34	0.18	0.23	0 0018	0.0021	14
September	0.39	0.20	0.25	0.0020	0.0022	16
October	0.24	0.20	0.22	0.0017	0.0020	13
November	0.22	0.17	0.20	0.0016	0.0018	12
December	0.17	0.15	0.17	0.0013	0.0015	10
The period						100

MISCELLANEOUS DISCHARGE MEASUREMENTS of Lodge Creek Drainage Basin, in 1910.

Date	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		*Sec.-ft.*
July 29	Small, Branch of Middle Creek	2-6-1-4	H. R. Carscallen	* 1.25	....	0.05
July 30	"	16-7-2-4	"	* 1.25	....	0.02
July 13	Lodge Creek, E. Branch of	19-7-2-4	"	* 1.25	....	0.02
June 14	Middle Creek	9-4-29-3	"	*	....	0.1
July 9	"	"	"	*	....	0.08
July 28	"	"	"	* 1.25	....	0.03
August 15	"	"	"	*	....	0.04
June 13	"	4-2-29-3	"	....	....	Nil.

* Weir measurements.

BATTLE CREEK DRAINAGE BASIN.

General Description.

Battle Creek rises in Tp. 8, Rge. 2, W. 4th Mer., and flows in an easterly direction for about eight miles, where it crosses the 4th Meridian then turns in a southeasterly direction and crosses the International Boundary in Sec. 3, Tp. 1, Rge. 26, W. 3rd Mer., eventually emptying into Milk River near Chinook, Montana. As is characteristic of the streams in this locality, the valley is narrow and deep near the source and gradually broadens out into large flats and meadows. These large flats are first noticed in the vicinity of Battle Creek P. O. Near the head of the stream the valley is well wooded with fair sized timber, but this diminishes to a growth of willow brush along the banks and finally disappears altogether.

The chief tributaries of Battle Creek are Tenmile Creek joining it in Sec. 4, Tp. 6, Rge 29, W. 3rd Mer., and Sixmile Coulee, joining it in Sec. 21, Tp. 6, Rge. 29, W. 3rd Mer. Stations have been established on both of these streams.

There are three stations on Battle Creek at the following places.—Nash's Ranche, Wilson's Ranche, and Tenmile Police Detachment. The latter station is located below the intake of Lindner Bros.' irrigation ditch, and a station was therefore established on the ditch.

BATTLE CREEK AT NASH'S RANCHE.

This station was established by N. M. Sutherland on May 11, 1910. It is located in Sec. 3, Tp. 3, Rge. 27, W. 3rd Mer., and is 270 feet west of E. R. Nash's house. It is about 70 miles by trail from Maple Creek.

Discharge measurements are made at low water and ordinary stages by wading, but during high water the stream cannot be waded and the discharge is computed from slope measurements.

The gauge rod which is of the standard type, is at the left bank and about 9 feet below the section. It is fastened to a 6 inch post driven into the bed of the stream. The bench mark, which is the top of a cedar post, is on the left bank, 55 feet from the edge. The initial point for soundings is the face of the B. M. marked 0.00 in red paint.

The stream is straight for about 250 feet above and about 300 feet below the station. The right bank is solid clay, high and not liable to overflow. The left bank is also of clay, but is low, and liable to overflow during high stages of the stream.

The stream flows in one channel about 45 feet wide at ordinary stages. The bed of the stream is composed of sand and gravel.

The gauge was read daily in 1910 by E. R. Nash.

DISCHARGE MEASUREMENTS of Battle Creek, at Nash's Ranche, in 1910.

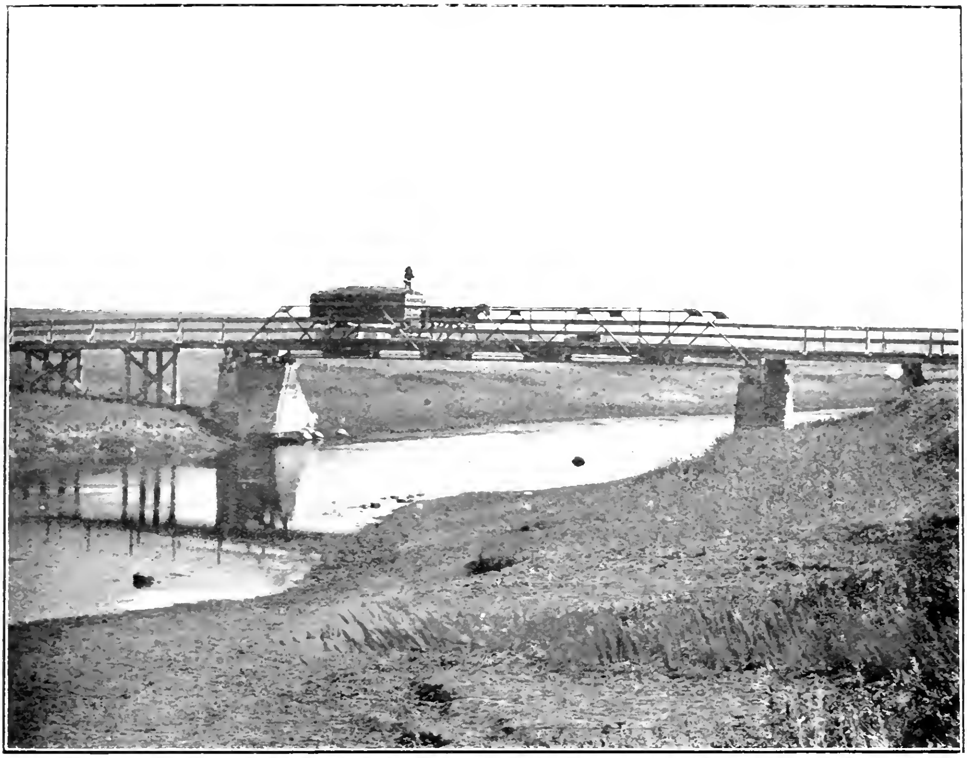
Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
1910		*Feet.*	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 11	N. M. Sutherland	47.2	23.7	0.71	1.05	18.4
May 17	F. H. Peters	43.0	20.7	0.78	1.03	16.4
June 4	"	22.7	7.23	0.34	0.68	2.43
July 9	N. M. Sutherland				0.50	0.75*
July 15	F. H. Peters				0.35	Nil.
July 27	N. M. Sutherland					Nil.
September 27	R. G. Swan	40.0	15.9	0.29	0.76	4.60
October 21	"	26.0	9.50	0.19	0.74	1.85

* Discharge determined by using floats.

Daily Gauge Height and Discharge of Battle Creek, at Nash's Ranche, for 1910.

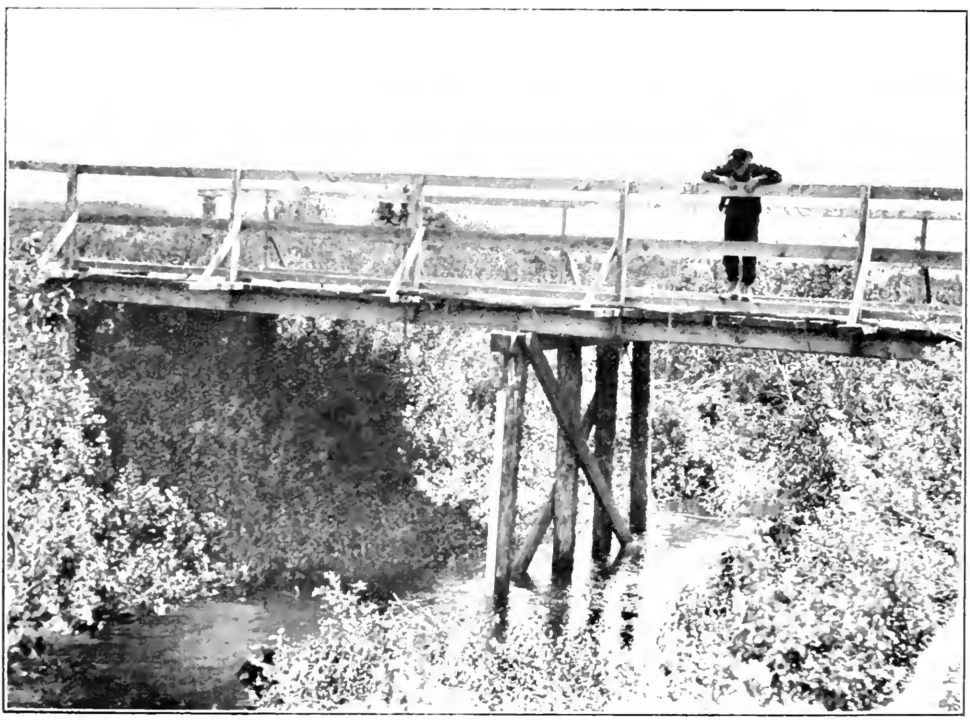
Day.	May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.60	1.60	0.55	1.15
2			0.67	2.45	0.55	1.15
3			0.85	6.30	0.55	1.15
4			0.70	2.90	0.70	2.90
5			0.65	2.20	0.55	1.15
6			0.62	1.85	0.54	1.05
7			0.65	2.20	0.45	0.45
8			0.65	2.20	0.45	0.45
9			0.70	2.90	0.53	1.00
10			0.72	3.20	0.48	0.60
11	1.05	18.0	0.70	2.90	0.45	0.45
12	1.07	19.8	0.65	2.20	0.45	0.45
13	1.05	18.0	0.65	2.20	0.45	0.45
14	1.05	18.0	0.70	2.90	0.40	0.20
15	0.95	10.6	0.70	2.90	0.35	0.00
16	0.95	10.6	0.72	3.20	*	
17	1.03	16.4	0.65	2.20		
18	1.02	15.4	0.68	2.60		
19	1.20	30.5	0.70	2.90		
20	1.00	13.9	0.65	2.20		
21	1.11	23.0	0.70	2.90		
22	1.00	13.9	0.70	2.90		
23	0.98	12.4	0.84	6.00		
24	0.98	12.4	0.80	4.95		
25	1.00	13.9	0.65	2.20		
26	0.98	12.4	0.60	1.60		
27	0.88	7.35	0.55	1.15		
28	0.85	6.30	0.55	1.15		
29	0.78	4.45	0.55	1.15		
30	0.75	3.80	0.55	1.15		
31	0.67	2.45				

* Creek dry from July 16 to Aug. 12.



Traffic Bridge at Swift Current, Sask.

PLATE No. 21.



Bridge over Bear Creek near Unsworth's Ranche.

DAILY GAUGE HEIGHT AND DISCHARGE of Battle Creek, at Nash's Ranche, for 1910.—*Con.*

Day.	August.		September.		October.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	....	....	0.68	2.60	0.76	4.00	0.95	10.6
2	....	....	0.65	2.20	0.80	4.95	0.97	11.8
3	....	....	0.63	1.95	0.78	4.45	0.90	8.15
4	....	....	0.65	2.20	0.78	4.45	0.85	6.30
5	....	....	0.63	1.95	0.80	4.95	0.94	10.0
6	....	....	0.68	2.60	0.77	4.20	0.94	10.0
7	....	....	0.70	2.90	0.80	4.95	0.90	8.15
8	....	....	0.75	3.80	0.84	6.00	0.97	11.8
9	....	....	0.83	5.70	0.80	4.95	0.98	12.4
10	....	....	0.83	5.70	0.79	4.65	1.05	18.0
11	....	....	0.85	6.30	0.85	6.30	0.95	10.6
12	....	....	0.85	6.30	0.85	6.30	1.04	17.2
13	0.30	0.00	0.90	8.15	0.85	6.30	1.10	22.2
14	0.55	1.15	0.90	8.15	0.85	6.30	1.20	30.5
15	0.55	1.15	0.90	8.15	0.85	6.30	1.15	26.4
16	0.47	0.55	0.88	7.35	0.86	6.65	....	....
17	0.52	0.90	0.86	6.65	0.86	6.65	....	....
18	0.53	1.00	0.85	6.30	0.87	7.00	....	....
19	0.55	1.15	0.85	6.30	0.85	6.30	....	....
20	0.53	1.00	0.85	6.30	0.76	4.00	....	....
21	0.54	1.05	0.78	4.45	0.73	3.40	....	....
22	0.54	1.05	0.78	4.45	0.64	2.05	....	....
23	0.54	1.05	0.76	4.00	0.59	1.50	....	....
24	0.60	1.60	0.75	3.80	0.55	1.15	....	....
25	0.63	1.95	0.74	3.60	0.55	1.15	....	....
26	0.60	1.60	0.76	4.00	0.55	1.15	....	....
27	0.60	1.60	0.76	4.00	0.55	1.15	....	....
28	0.60	1.60	0.75	3.80	0.50	0.75	....	....
29	0.60	1.60	0.74	3.60	0.51	0.85	....	....
30	0.62	1.85	0.74	3.60	0.54	1.05	....	....
31	0.62	1.85	....	....	0.90	8.15	....	....

MONTHLY DISCHARGE of Battle Creek, at Nash's Ranche, for 1910.

Drainage area, 502 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square Mile.	Depth in inches on Drainage area.	Total in acre-feet.
May (11-31)	30.5	2.45	13.5	0.027	0.021	562
June	6.30	1.15	2.64	0.005	0.006	157
July (1-15)	2.90	0.00	0.90	0.001	0.001	250
August (13-31)	1.95	0.00	1.32	0.026	0.173	470
September	8.15	1.95	4.69	0.009	0.010	279
October	8.15	0.75	4.26	0.008	0.009	262
November (1-15)	30.50	6.30	14.30	0.028	0.016	425
The period						2,405

BATTLE CREEK AT WILSON'S RANCHE.

This station was established July 5, 1910, by H. R. Carscallen. It is situated below the intake of W. S. Wilson's ditch, which is in course of construction, about ten miles east of Battle Creek P. O.

The channel is straight for about 200 feet above and 125 feet below the station. Both banks are high, sparsely covered with brush and not liable to overflow. The bed is composed of sand and gravel.

The gauge is a plain staff, graduated to feet and hundredths, spiked to an upright post sunk into the bed of the stream at the left bank. It is referred to bench marks as follows:—(1) A spike head in the top of a willow stump 15 feet upstream; elevation, 7.12. (2) A spike-head in a hub driven close to the final point stake on the right bank; elevation, 12.68.

Discharge measurements are made at or near the station by wading. The initial point for soundings is a squared stake driven within 1 foot of the ground in the left bank 73 feet from the gauge height and marked I. P. 0.0.

The gauge is read once each day by W. S. Wilson, whose house is situated within ½ mile of the station.

DISCHARGE MEASUREMENTS of Battle Creek, at Wilson's Ranche, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
July 6	H. R. Carscallen	35.5	32.38	0.106	1.07	3.44
July 22	"	34.0	30.37	0.088	1.04	2.68
August 10	"	34.0	29.77	0.099	1.03	2.95
September 2	"	35.0	31.36	0.095	1.06	2.99
September 27	R. G. Swan	35.5	37.22	0.189	1.22	7.05
October 20	"	35.6	33.05	0.123	1.09	4.07

DAILY GAUGE HEIGHT AND DISCHARGE of Battle Creek, at Wilson's Ranche, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			1.00	2.30	1.10	4.10	1.26	8.32
2			1.00	2.30	1.12	4.54	1.27	8.64
3			1.00	2.30	1.13	4.76	1.26	8.32
4			1.00	2.30	1.17	5.72	1.25	8.00
5	1.08	3.70	1.20	2.62	1.25	8.00	1.25	8.00
6	1.07	3.50	1.16	5.46	1.30	9.60	1.26	8.32
7	1.08	3.70	1.04	2.94	1.34	10.96	1.30	9.60
8	1.08	3.70	1.04	2.94	1.37	12.06	1.30	9.60
9	1.08	3.70	1.04	2.94	1.39	12.82	1.30	9.60
10	1.08	3.70	1.02	2.62	1.40	13.20	1.30	9.60
11	1.08	3.70	1.02	2.62	1.35	11.30	1.30	9.60
12	1.08	3.70	1.02	2.62	1.30	9.60	1.30	9.60
13	1.07	3.50	1.04	2.94	1.32	10.28	1.28	8.96
14	1.07	3.50	1.02	2.62	1.33	10.62	1.27	8.64
15	1.06	3.30	1.02	2.62	1.30	9.60	1.26	8.32
16	1.05	3.10	1.02	2.62	1.28	8.96	1.20	6.50
17	1.04	2.94	1.01	2.46	1.26	8.32	1.04	2.94
18	1.00	2.30	1.01	2.46	1.23	7.40	1.11	4.32
19	1.04	2.94	1.00	2.30	1.21	6.80	1.10	4.10
20	1.05	3.10	1.00	2.30	1.20	6.50	1.10	4.10
21	1.05	3.10	1.01	2.46	1.19	6.24	1.15	5.20
22	1.05	3.10	1.02	2.62	1.18	5.98	1.35	11.30
23	1.07	3.50	1.03	2.78	1.19	6.24	1.35	11.30
24	1.07	3.50	1.02	2.62	1.19	6.24	1.35	11.30
25	1.06	3.30	1.02	2.62	1.16	5.46	1.32	10.28
26	1.05	3.10	1.02	2.62	1.16	5.46	1.31	9.94
27	1.04	2.94	1.02	2.62	1.21	6.80	1.35	11.30
28	1.02	2.62	1.03	2.78	1.22	7.10	1.40	13.20
29	1.01	2.46	1.03	2.78	1.24	7.70	1.45	15.20
30	1.00	2.30	1.04	2.94	1.25	8.00	1.40	13.20
31	1.00	2.30	1.09	3.90			1.38	12.44

MONTHLY DISCHARGE of Battle Creek, at Wilson's Ranche, for 1910.

Drainage area, 263 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
July (5-31)	3.7	2.3	3.20	.012	.013	171
August	5.5	2.3	2.74	.010	.012	169
September	13.2	4.1	8.01	.030	.033	477
October	15.2	2.9	9.02	.034	.039	555
The period						1,372

BATTLE CREEK AT TENMILE POLICE DETACHMENT

This station was established June 3, 1909, by F. T. Fletcher. It is located below the mouth of Tenmile Creek at the highway bridge on the surveyed trail from Maple Creek to Tenmile and about 400 yards from the Tenmile Police Detachment. It is practically in the centre of Sec. 33 Tp. 5, Rge. 29, W. 3rd Mer., about two miles south of Battle Creek post office and 55 miles south of Maple Creek. The bridge is a steel structure of the pony truss type, consisting of one 80 foot span, supported by two timber, rock-filled piers and having a twenty-foot approach at each end of the bridge. There is only one channel at all ordinary stages of the stream, but, owing to the presence of the two piers supporting the pony truss, there are three channels in cases of extreme floods.

This channel is straight for 500 feet above and 300 feet below the station. Both banks are high and not liable to overflow except in extreme floods, when the water breaks over the right bank some distance above the station and flows around the gauge. The right bank is free of brush for some distance above and below the station; the left bank is sparsely covered with willows near the station. The bed of the stream is sandy and may shift somewhat in high stages of the stream. The current is very sluggish, and at very low stages vegetation appears in the bed of the stream at the station.

A standard chain gauge, is located about the centre of the steel truss and is securely fastened to the guard-rail on the downstream side of the bridge. The length of the chain from the bottom of the weight to the marker is 19.10 feet. The gauge is referred to bench marks as follows:—(1) A bolthead in the top of the left pier on the downstream side of the bridge, marked B. M. in black paint; elevation, 13.97 feet above the datum of the gauge. (2) The top of the iron pin in road mound at the corner of the police fence, about 20 feet from the bridge on the left bank: elevation, 13.51 feet above the datum of the gauge.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the right abutment and marked 0 in black paint. Low-water measurements are made at a wading section about 400 yards upstream from the station.

The gauge was read once each day by Const. W. A. Doak, of the R. N. W. M. P., until the 1st of May, 1910, when H. M. Covey took charge of the gauge height observations.

DISCHARGE MEASUREMENTS of Battle Creek, at Tenmile Police Detachment, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 22	H. R. Carscallen	31.5	55.35	0.574	2.96	31.75
May 16	"	32.0	52.77	0.709	3.03	37.43
June 10	"	26.0	37.42	0.155	2.49	5.80
July 2	"	26.0	40.98	0.031	2.17	1.28*
July 25	"	26.0	33.21	0.036	2.14	1.21*
August 13	"	26.0	39.32	0.056	2.29	2.20*
September 5	"	29.5	43.57	0.174	2.52	7.56
September 28	R. G. Swan	30.5	51.43	0.196	2.59	10.12

* Discharge determined by using a 36 inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Battle Creek, at Tenmile Police Detachment, for 1910

DAY.	April.		May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	3.4	67.5	2.8	20.5	2.5	7.0	2.25	2.0
2	3.4	67.5	2.7	15.0	2.5	7.0	2.2	1.5
3	3.4	67.5	2.7	15.0	2.5	7.0	2.2	1.5
4	3.3	59.0	2.7	15.0	2.5	7.0	2.2	1.5
5	3.3	59.0	2.7	15.0	2.5	7.0	2.2	1.5
6	3.2	50.5	2.7	15.0	2.5	7.0	2.4	4.0
7	3.2	50.5	2.7	15.0	2.5	7.0	2.4	4.0
8	3.2	50.5	2.9	27.5	2.5	7.0	2.4	4.0
9	3.2	50.5	2.9	27.5	2.5	7.0	2.4	4.0
10	3.2	50.5	2.9	27.5	2.5	7.0	2.4	4.0
11	3.2	50.5	2.9	27.5	2.5	7.0	2.4	4.0
12	3.2	50.5	2.9	27.5	2.5	7.0	2.4	4.0
13	3.2	50.5	2.9	27.5	2.45	6.5	2.4	4.0
14	3.2	50.5	2.9	27.5	2.45	6.5	2.35	3.25
15	3.1	42.5	3.0	35.0	2.4	4.0	2.15	1.12
16	3.0	35.0	3.0	35.0	2.45	6.5	2.15	1.12
17	3.0	35.0	2.9	27.5	2.6	10.5	2.1	1.0
18	3.0	35.0	2.9	27.5	2.6	10.5	2.1	1.0
19	3.0	35.0	2.9	27.5	2.55	8.75	2.1	1.0
20	3.0	35.0	2.9	27.5	2.5	7.0	2.1	1.0
21	3.0	35.0	2.9	27.5	2.5	7.0	2.1	1.0
22	2.9	27.5	2.8	20.5	2.5	7.0	2.1	1.0
23	2.9	27.5	2.8	20.5	2.5	7.0	2.1	1.0
24	2.9	27.5	2.8	20.5	2.5	7.0	2.1	1.0
25	2.9	27.5	2.8	20.5	2.45	5.5	2.14	1.2
26	2.9	27.5	2.7	15.0	2.4	4.0	2.14	1.2
27	2.9	27.5	2.7	15.0	2.4	4.0	2.15	1.25
28	2.9	27.5	2.6	10.5	2.4	4.0	2.17	1.35
29	2.8	20.5	2.6	10.5	2.35	3.25	2.18	1.40
30	2.8	20.5	2.55	18.75	2.3	2.5	2.19	1.45
31	....	....	2.50	7.0	....	....	2.20	1.50

DAILY GAUGE HEIGHT AND DISCHARGE of Battle Creek, at Tenmile Police Detachment, for 1910. *Continued.*

Day.	August.		September.		October.		November.	
	Gauge. Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.20	1.50	2.45	5.50	2.56	9.10	2.55	8.75
2	2.20	1.50	2.47	6.10	2.55	8.75	2.56	9.10
3	2.21	1.60	2.48	6.40	2.54	8.40	2.56	9.10
4	2.23	1.80	2.50	7.00	2.54	8.40	2.62	11.40
5	2.25	2.00	2.52	7.70	2.54	8.40	2.65	12.75
6	2.26	2.10	2.57	9.45	2.54	8.40	2.68	14.10
7	2.26	2.10	2.62	11.40	2.54	8.40	2.70	15.00
8	2.26	2.10	2.67	13.65	2.54	8.40	2.70	15.00
9	2.27	2.20	2.65	12.75	2.53	8.05	2.69	14.55
10	2.28	2.30	2.63	11.85	2.53	8.05	2.68	14.10
11	2.28	2.30	2.61	10.95	2.52	7.70	2.68	14.10
12	2.29	2.40	2.59	10.15	2.52	7.70	2.68	14.10
13	2.29	2.40	2.57	9.45	2.52	7.70	2.67	13.65
14	2.31	2.65	2.55	8.75	2.51	7.35	2.66	13.20
15	2.33	2.95	2.52	7.70	2.51	7.35	2.65	12.75
16	2.35	3.25	2.52	7.70	2.51	7.35	2.64	12.30
17	2.39	3.85	2.52	7.70	2.51	7.35	2.63	11.85
18	2.42	4.60	2.51	7.35	2.52	7.70	2.61	10.95
19	2.37	3.55	2.51	7.35	2.53	8.05	2.60	10.50
20	2.36	3.40	2.50	7.00	2.54	8.40	2.59	10.15
21	2.32	2.80	2.50	7.00	2.55	8.75	2.58	9.80
22	2.34	3.10	2.50	7.00	2.56	9.10	2.56	9.10
23	2.37	3.55	2.51	7.35	2.56	9.10	2.54	8.40
24	2.39	3.85	2.53	8.05	2.56	9.10	2.53	8.05
25	2.40	4.00	2.55	8.75	2.56	9.10	2.52	7.70
26	2.42	4.60	2.57	9.45	2.56	9.10	2.52	7.70
27	2.44	5.20	2.59	10.15	2.55	8.75	2.52	7.70
28	2.44	5.20	2.60	10.50	2.55	8.75	....	....
29	2.44	5.20	2.59	10.15	2.55	8.75	....	....
30	2.44	5.20	2.57	9.45	2.55	8.75	....	....
31	2.44	5.20	....	....	2.55	8.75	....	....

NOTE:—Run-off for Battle Creek cannot be computed as Lindner's Ditch is diverted above the station and records of the flow in this ditch are incomplete.

TENMILE CREEK, AT TENMILE POLICE DETACHMENT.

This station was established July 21, 1909, by H. R. Carscallen. It is located about 300 yards west of the Tenmile Police Detachment near the mouth of the stream. The station is very close to the south boundary of Sec. 4, Tp. 6, Rge. 29, W. 3rd Mer., almost on the quartering line of the section and about 2 miles south of Battle Creek post office.

The channel is straight for 15 feet above and 20 feet below the station. Both banks are high, free from brush and not liable to overflow. The bed of the stream is composed of sand and coarse gravel. There is a small rapid above the station, but the current at the station is rather sluggish.

The gauge, which is read once each day by H. M. Covey, is a plain staff, graduated to feet and hundredths, nailed to an upright post sunk in the bed of the stream at the right bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) The top of the initial point stake driven close to the ground on the left bank and marked B. M. in red paint; elevation, 5.84 feet above the zero of the gauge. (2) The head of a spike driven into the pointed top of a willow stump about 100 feet downstream from the station on the right bank, the stump blazed and marked B. M. in red paint; elevation, 6.15 feet above the zero of the gauge.

Discharge measurements are made at or near the gauge by wading, and at very low stages a weir is used. The initial point for soundings is a square stake close to the ground on the left bank and marked I. P. o. o with red paint.

DISCHARGE MEASUREMENTS of Tenmile Creek, at Tenmile Police Detachment, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 22..........	H. R. Carscallen.................	3.6	1.78	0.233	0.94	0.41
May 16...........	"	....	....	....	0.90	0.34
June 10...........	"	4.3	1.58	0.128	0.87	0.20
July 2............	"	3.3	1.53	0.139	0.84	0.21
July 25...........	"	3.5	1.96	0.092	0.96	0.18
August 13.........	"	3.5	2.44	0.107	1.10	0.26
September 5.......	"	4.8	3.46	0.068	1.31	0.24
September 28......	R. G. Swan.....................	5.4	5.80	0.025	1.71	0.15
October 25........	"	5.2	5.81	0.035	1.76	0.20

Discharges determined by using a 15″ weir.

SIXMILE COULEE AT SODERSTROM'S RANCHE.

This station was established July 22, 1909, by H. R. Carscallen. It is located on Sec. 29, Tp. 7, Rge. 28, W. 3rd Mer., 200 yards west of the surveyed trail from Maple Creek to Tenmile and about thirty miles south of Maple Creek.

The channel is straight for 50 feet above and 20 feet below the station. Both banks are high and not liable to overflow. The right bank is sparsely covered with brush; the left bank is free of brush. The bed of the stream is composed of sand and very coarse gravel with clay at the banks. The current is moderate. A small amount of vegetation is present at the station.

The gauge, which is read once each day by J. M. Soderstrom, is a plain staff, graduated to feet and hundredths, nailed to an upright post sunk in the bed of the creek at the right bank, and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) A nail-head driven into the top of a pointed willow stump on the right bank, about 150 feet upstream from the gauge, the stump blazed and marked B. M. in red paint; elevation, 7.77 feet above gauge zero. (2) Nail-heads in the top of a log near the ground at the southeast corner of Mr. Soderstrom's north stable; elevation, 18.08 feet above gauge zero.

Discharge measurements are made at or near the station by wading, and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. 0. 0 in red paint.

DISCHARGE MEASUREMENTS of Sixmile Coulee, at Soderstrom's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 23...........	H. R. Carscallen.................	4.5	4.34	0.636	1.25	2.76
May 17...........	"	15.0	4.72	1.354	1.69	6.39
June 23...........	"	2.4	2.46	0.239	0.79	0.59*
July 15...........	"	....	....	....	0.49	0.03*
August 3..........	"	....	....	....	0.40	Nil.
August 18.........	"	4.0	0.95	0.073	0.56	0.07*
September 6.......	"	3.8	2.35	0.374	0.86	0.88
September 8.......	"	4.0	2.79	0.581	1.00	1.62
September 29......	R. G. Swan....................	4.0	1.75	0.150	0.66	0.25*

* Discharge determined by using a 15 inch weir.

Daily Gauge Height and Discharge of Sixmile Coulee, at Soderstrom's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.1	10.7	1.1	1.9	1.1	1.9
2	2.2	11.8	1.2	2.4	1.0	1.4
3	2.2	11.8	1.2	2.4	1.3	3.1
4	2.3	13.0	1.1	1.9	1.1	1.9
5	2.2	11.8	1.1	1.9	1.1	1.9
6	2.2	11.8	1.1	1.9	1.0	1.4
7	2.1	10.7	1.1	1.9	1.0	1.4
8	2.1	10.7	1.1	1.9	0.9	0.95
9	2.1	10.7	1.1	1.9	0.9	0.95
10	2.0	9.6	1.1	1.9	0.9	0.95
11	2.0	9.6	1.4	3.8	0.8	0.60
12	1.9	8.5	1.3	3.1	1.0	1.40
13	1.9	8.5	1.3	3.1	0.9	0.95
14	1.8	7.5	1.3	3.1	0.9	0.95
15	1.7	6.5	1.3	3.1	0.8	0.60
16	1.6	5.5	1.85	8.0	0.8	0.60
17	1.6	5.5	1.8	7.5	0.8	0.60
18	1.5	4.6	1.5	4.6	1.0	1.40
19	1.4	3.8	1.6	5.5	0.8	0.60
20	1.5	4.6	1.6	5.5	0.9	0.95
21	1.4	3.8	1.5	4.6	0.8	0.60
22	1.4	3.8	1.4	3.8	0.7	0.35
23	1.3	3.1	1.3	3.1	0.8	0.60
24	1.3	3.1	1.2	2.4	0.8	0.60
25	1.3	3.1	1.1	1.9	0.7	0.35
26	1.2	2.4	1.0	1.4	0.	0.35
27	1.2	2.4	0.9	0.95	0.6	0.15
28	1.1	1.9	1.1	1.9	0.5	0.05
29	1.0	1.4	1.1	1.9	0.6	0.15
30	1.0	1.4	1.0	1.4	0.5	0.05
31	....	....	1.1	1.9	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Sixmile Coulee, at Soderstrom's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.7	0.35	0.4	0.0	0.5	0.05	0.7	0.35
2	0.9	0.95	0.4	0.0	0.4*	0.0	0.7	0.35
3	0.8	0.60	0.4	0.0	0.4	0.0	0.7	0.35
4	0.9	0.95	0.4	0.0	0.4	0.0	0.6	0.15
5	0.8	0.6	0.4	0.0	0.4	0.0	0.9	0.95
6	0.6	0.15	0.8	0.60	0.4	0.0	0.8	0.60
7	0.6	0.15	0.7	0.35	0.9	0.95	0.8	0.60
8	0.6	0.15	0.6	0.15	0.9	0.95	0.7	0.35
9	0.9	0.95	0.6	0.15	0.8	0.60	0.7	0.35
10	0.7	0.35	0.6	0.15	0.7	0.35	0.7	0.35
11	1.0	1.40	0.5	0.05	0.9	0.95	0.7	0.35
12	0.7*	0.35	0.5	0.05	0.8	0.60	0.7	0.35
13	0.7	0.35	0.5	0.05	0.8	0.60	0.7	0.35
14	0.6	0.15	0.7	0.35	0.8	0.60	0.7	0.35
15	0.5	0.05	0.8	0.60	0.8	0.60	0.7	0.35
16	0.4	0.0	0.7	0.35	0.8	0.60	0.7	0.35
17	0.4	0.0	0.6	0.15	0.8	0.60	0.7	0.35
18	0.4	0.0	0.6	0.15	0.8	0.60	0.7	0.35
19	0.4	0.0	0.5	0.05	0.8	0.60	1.0	1.40
20	0.4	0.0	0.5	0.05	0.7	0.35	1.0	1.40
21	0.4	0.0	0.5	0.05	0.7	0.35	0.9	0.95
22	0.4	0.0	0.4*	0.0	0.7	0.35	0.9	0.95
23	0.4	0.0	0.4	0.0	0.7	0.35	0.8	0.60
24	0.4	0.0	0.8	0.60	0.9	0.95	0.8	0.60
25	0.4	0.0	0.8	0.60	0.9	0.95	0.7	0.35
26	0.4	0.0	0.7	0.35	0.8	0.60	0.7	0.35
27	0.4	0.0	0.7	0.35	0.8	0.60	0.9	0.95
28	0.4	0.0	0.6	0.15	0.8	0.60	1.0	1.40
29	0.4	0.0	0.6	0.15	0.7	0.35	0.9	0.95
30	0.4	0.0	0.5	0.05	0.7	0.35	0.9	0.95
31	0.4	0.0	0.5	0.05	....	....	0.9	0.95

* No flow, water standing in pools, July 16-Aug. 5, Aug. 22-23, and Sept. 2-6.

MONTHLY DISCHARGE of Sixmile Coulee, at Soderstrom's Ranche, for 1910.

Drainage area, 21 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	13.00	1.40	6.79	0.323	0.360	404
May	8.00	0.95	2.99	0.142	0,164	184
June	3.10	0.05	0.92	0.044	0.049	55
July	1.40	0.00	0.24	0.011	0.013	15
August	0.60	0.00	0.18	0.009	0.010	11
September	0.95	0.00	0.48	0.023	0.026	29
October	1.40	0.15	0.61	0.029	0.033	38
The period						736

LINDNER'S DITCH, NEAR BATTLE CREEK.

This station was established July 26, 1910, by H. R. Carscallen. It is located on Sec. 10, Tp. 6, Rge. 29, W. 3rd Mer., about 100 feet west of the surveyed trail to Maple Creek. It is about a ¼ of a mile south of Battle Creek P. O., and about 500 yards below the intake of the ditch.

The channel is straight for 200 feet above and 150 feet below the station, where it curves sharply to the right and enters Lindner Bros.' hay meadow. Here it is diverted into a number of different laterals for irrigation purposes. The bed of the ditch is composed of clay and coarse gravel. The current is swift below the station.

The gauge is a plain staff, graduated to feet and hundredths, driven firmly into the bed of the ditch near the right bank about twelve feet upstream from the weir.

Discharge measurements are made by means of a rectangular sharp-crested weir with complete end contractions. A 36 inch steel weir was established temporarily on July 26th and replaced on August 12th by a permanent 42 inch wooden weir.

The irrigation season was practically over at the time the station was established, very little water being diverted into the ditch after the 26th of July. No record of water diverted from Battle Creek into the ditch was obtained before this date and hence records of the total flow past the station on Battle Creek on Sec. 33, Tp. 5, Rge. 29, W. 3rd Mer., are incomplete for the previous months.

DISCHARGE MEASUREMENTS of Lindner's Ditch, near Battle Creek, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
June 11	H. R. Carscallen	7.3	3.59	1.605		5.76
July 4	"	7.8	3.76	1.388		5.22
July 26	"				3.385	3.26*
July 27	"				3.01	0.36*
August 12	"				2.95	0.07*
August 12	"				3.03	0.06†
September 5	"				3.05	0.09†
September 29	R. G. Swan				3.04	0.04†
October 26	"				3.04	0.04†

* Discharge determined by using a 36 inch weir.
† Discharge determined by using a 42 inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Lindner's Ditch, near Battle Creek, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge. Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	....	....	2.95	0.07	3.05	0.08	....	....
2	....	....	2.95	0.07	3.05	0.08	....	....
3	....	....	2.95	0.07	3.05	0.08	....	....
4	....	....	2.95	0.07	3.06	0.09	....	....
5	....	....	2.95	0.07	3.06	0.09	....	....
6	....	....	2.95	0.07	3.06	0.09	....	....
7	....	....	2.95	0.07	3.06	0.09	3.05	0.04
8	....	....	2.95	0.07	3.06	0.09	3.05	0.04
9	....	....	2.95	0.07	*	....	3.05	0.04
10	....	....	2.95	0.07	....	....	3.05	0.04
11	....	....	2.95	0.07	....	....	3.05	0.04
12	....	....	2.95	0.70	....	....	3.05	0.04
13	....	....	3.04	0.07	....	....	3.05	0.04
14	....	....	3.04	0.07	....	....	....	....
15	....	....	3.04	0.07	....	....	....	....
16	....	....	3.00†	0.0	....	....	....	....
17	....	....	3.00	0.0	....	....	....	....
18	....	....	3.00	0.0	....	....	....	....
19	....	....	3.04	0.07	....	....	....	....
20	....	....	3.04	0.07	....	....	....	....
21	....	....	3.04	0.07	....	....	....	....
22	....	....	3.04	0.07	....	....	....	....
23	....	....	3.03	0.06	....	....	....	....
24	....	....	3.03	0.06	....	....	....	....
25	....	....	3.03	0.06	....	....	....	....
26	3.38	3.26	3.04	0.07	....	....	....	....
27	3.00	0.36	3.04	0.07	....	....	....	....
28	3.00	0.36	3.05	0.08	....	....	....	....
29	3.00	0.36	3.05	0.08	....	....	....	....
30	2.95	0.07	3.05	0.08	....	....	....	....
31	2.95	0.07	3.04	0.07	....	....	....	....

* No observer from September 8th to October 7th.
† No flow, water standing in pools, August 16-18.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Battle Creek Drainage Basin, in 1910.

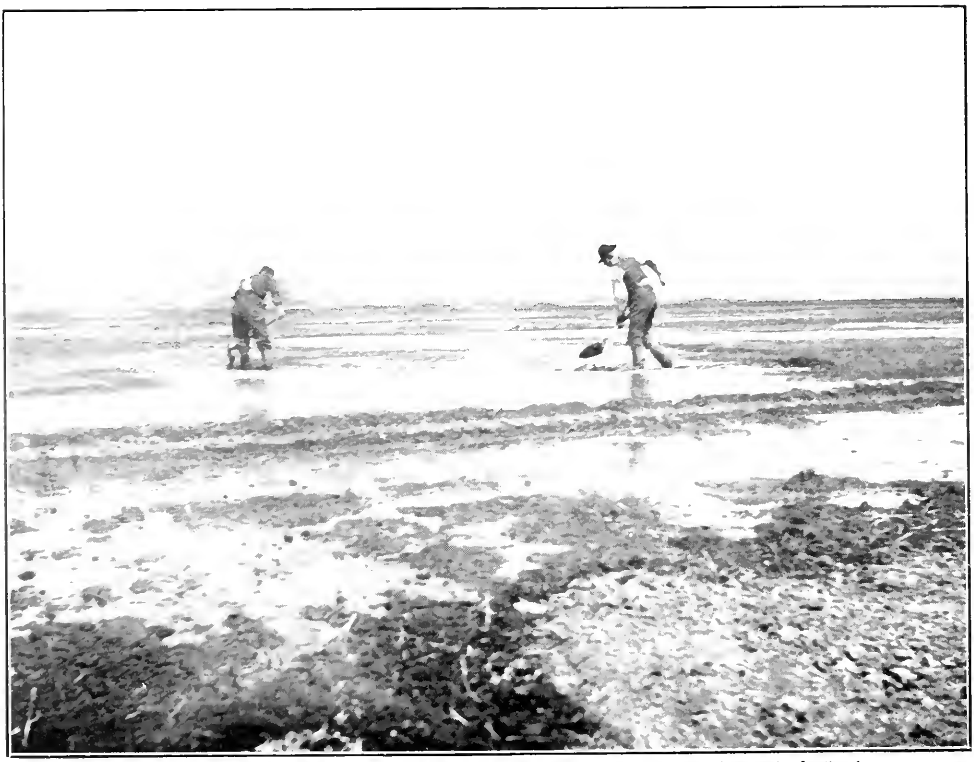
Date	Stream.	Locality.	Hydrographer	Width.	Area of Section.	Discharge.
				Feet.		Sec.-ft.
June 9	Battle Creek	1-6-28-3	H. R. Carscallen	22.0	17.0	7.43
June 11	"	23-8-1-4	F. T. Fletcher	5.3	3.88	5.75
June 30	"	30-5-28-3	H. R. Carscallen	17.5	6.63	4.03
July 6	"	20-4-26-3	"	8.5	3.48	0.88
July 15	"	21-7-29-3	"	21.5	8.87	2.54
August 2	"	31-7-29-3	"	9.5	5.76	2.25
August 10	"	20-4-26-3	"	13	4.92	2.16
August 11	"	29-5-28-3	"	13.3	5.31	2.56
August 18	"	29-7-29-3	"	11.7	6.07	4.47
August 1	Creek, Branch of Battle Creek	21-7-29-3	"	* 1.25	....	0.03
August 17	"	"	"	* 1.25	....	0.13
June 13	Fourmile Creek	S.W. 12-8-29-3	F. T. Fletcher	4.0	1.29	1.49
June 15	Graburn Creek	13-8-1-4	"	6.4	2.78	2.14
July 14	"	"	H. R. Carscallen	7.5	2.46	1.28
August 2	"	"	"	7.5	2.09	0.9
August 17	"	"	"	6.5	1.99	1.31
June 9	Marshall Gaff Ditch	27-5-29-3	"	12.	10.41	9.94
July 4	"	34-5-29-3	"	6.6	4.89	2.14
July 27	"	"	"	3.2	1.88	1.18
August 13	"	"	"	*........	....	0.59
September 28	"	"	R. G. Swan	8.5	8.95	3.82
October 25	"	"	"	6.3	7.44	3.16
October 20	McKinnon's Ditch	30-4-26-3	"	9.6	6.5	2.92
July 15	Mink Creek	S.E. 31-7-29-3	H. R. Carscallen	*........	....	0.03
August 18	"	"	"	*........	....	0.08
July 6	Richardson's Ditch	31-4-26-3	"	7.0	2.21	1.97
July 22	"	"	"	*........	....	0.54
July 15	Wood & Anderson's Ditch	21-7-29-3	"	*........	....	0.02

* Weir measurements.

PLATE No. 22.

Irrigating an oat field at Enright & Strong's Ranche, near East End, Sask.

PLATE No. 23.



Irrigating an oat field at Enright & Strong's Ranche, near East End, Sask.

FRENCHMAN RIVER DRAINAGE BASIN.

General Description.

Frenchman River rises on the southern slope of the Cypress Hills, in Cypress Lake, which is in Tp. 6, Rge. 26, W. 3rd Mer. This lake is about ten miles long and from one to three miles wide, and receives its water supply from a number of small streams, which rise in the hills and flow south to the lake. The largest and most important of these feeders are Oxarart and Sucker Creeks.

After leaving the lake the river receives a further supply from Belanger, Davis and Fairwell Creeks, and a number of coulees. After joining the North Branch in Tp. 6, Rge. 23, W. 3rd Mer., the river receives no appreciable supply while it is in Canada. It crosses the International Boundary in Tp. 1, Rge. 10, W. 3rd Mer., and eventually finds its way into Milk River, near Saco, Montana.

Near the source of the river it flows through a deep valley from two to three hundred feet in depth and from one to two miles wide. After passing East End it widens out, in some places, to a distance of four miles, the depth of the valley increasing to three and four hundred feet.

The bench land along the stream is of rolling prairie, broken by a large number of coulees, which increase in number as you approach the source of the river.

The mean annual rainfall in the drainage basin is about 16 inches, most of it occurring during the months of May, June and July. From November to April the streams are frozen over, and usually there is an abundant snow fall. There are a number of small irrigation ditches in this basin. Enright and Strong's ditch at East End, designed to cover about 3,000 acres, is the largest.

Frenchman River, at Huff's Ranche.

This station was established on May 23, 1910, by F. H. Peters. It is located in Sec. 5, Tp. 5, Rge. 14, W. 3rd Mer., at Huff's Ranche. It is 40 miles by trail from Notre Dame, D'Auvergne P. O., and 75 miles from Swift Current.

During low stages of the stream, discharge measurements are made by wading. The initial point for soundings is the face of post on the left bank, and marked 0+00. When the stream becomes too deep for wading, the discharge is determined by the slope method.

The gauge, which is a plain staff, graduated to feet and hundredths, is fixed to a post at the left bank. It is referred to the top of the post at the initial point for soundings; elevation, 9.75 feet above the datum of the gauge. It was read during 1910, by Roy Wright.

Discharge Measurements of Frenchman River, at Huff's Ranche, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 23	F. H. Peters	37.8	39.54	0.816	2.44	35.27
July 13	R. G. Swan	31.0	14.37	0.212	1.775	3.05
August 23	R. G. Swan					Dry.

DAILY GAUGE HEIGHT AND DISCHARGE of Frenchman River, at Huff's Ranche, for 1910.

Day.	May.		June.		July.		November.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			2.15	15.1	1.94	6.4		
2			2.09	12.0	1.91	5.7	1.71	2.3
3			2.10	12.5	1.85	4.4	1.80	3.5
4			2.08	11.5	1.85	4.4	1.57	1.05
5			2.07	11.1	1.86	4.6	1.89	5.2
6			2.05	10.2	1.84	4.2	1.92	5.9
7			2.03	9.5	1.79	3.35	1.97	7.3
8			2.00	8.35	1.77	3.05	1.93	6.2
9			1.98	7.6	1.77	3.05	1.86	4.6
10			1.95	6.7	1.85	4.4	1.99	7.9
11			1.93	6.2	1.80	3.5	2.04	9.8
12			1.91	5.7	1.70	2.2	2.12	13.5
13			1.89	5.2	1.73	2.55	2.22	19.2
14			1.89	5.2	1.70	2.2	2.22	19.2
15			1.89	5.2	1.66	1.8	2.18	16.8
16			1.89	5.2	1.60	1.25		
17			1.88	5.0	1.55	0.9		
18			1.88	5.0	1.54	0.85		
19			1.92	5.9	1.53	0.8		
20			1.95	6.7	1.50	0.6		
21			1.90	5.45	1.47	0.5		
22	2.44	35.3	1.93	6.2	1.45	0.4		
23	2.44	35.3	1.94	6.4	1.42	0.2		
24	2.44	35.3	1.94	6.4	1.40	0.15		
25	2.43	34.7	1.94	6.4	1.40			
26	2.35	28.5	1.93	6.2	1.33	0.0		
27	2.34	27.6	1.93	6.2		*		
28	2.32	26.1	1.90	5.45				
29	2.32	26.1	1.95	6.7				
30	2.23	19.9	1.94	6.4				
31	2.18	16.8						

* River dry from July 26 to Nov. 1.

MONTHLY DISCHARGE of Frenchman River, at Huff's Ranche, for 1910.

Drainage area, 1,416 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
May (22-31)	35.3	16.8	28.56	0.020	0.007	566
June	15.1	5.0	7.42	0.005	0.006	441
July (1-26)	6.4	0.0	2.37	0.002	0.002	122
November (1-15)	19.2	1.05	8.74	0.006	0.003	244
The period						1,373

FRENCHMAN RIVER, NEAR EAST END.

This station was established July 31, 1908, by F. T. Fletcher. It is located at the Enright and Strong highway bridge on the N. E. ¼ Sec. 31, Tp. 6, Rge. 21, W. 3rd Mer. It is about eight miles south of East End post office and a mile above the East End Police Detachment. Three miles above the station are the dam and headgates of Messrs. Enright and Strong's ditch, and hence the discharge of the stream at the station does not include that of the ditch and the latter must be added in order to obtain the total flow of the Frenchman River. The bridge is a single span, wooden structure set upon timber, rock-filled abutments.

The channel is straight for 400 feet above and 600 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of sand and gravel. The current is sluggish.

The gauge, a plain staff graduated to feet and hundredths, is attached vertically to the upstream side of the left abutment of the bridge. It was read daily during the season of 1910, by D. Savage. The gauge is referred to bench marks as follows:—(1) Nail-head in the top of a long pile at the left bank and 10 feet above the bridge; elevation, 15.89 feet above the zero of the gauge. (2) Nail-heads in the top of the stringer on the left abutment at the upstream side of the bridge, marked B. M. in red paint; elevation, 13.93 feet above the zero of the gauge.

Discharge measurements are made from the lower side of the bridge at high water stages, and at a wading section a short distance upstream at low water stages. The initial point for soundings is the inner face of the left abutment. The bridge is not quite at right angles to the direction of the current.

DISCHARGE MEASUREMENTS of Frenchman River, near East End, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 18	H. R. Carscallen	37.5	83.65	0.76	2.04	63.57
May 11	"	37.5	64.93	0.547	1.75	35.59
May 31	"	37.5	55.43	0.16	1.35	8.88
June 17	R. G. Swan	38	55.53	0.153	1.36	8.52
July 15	"	40	47.75	0.016	1.1	0.77
August 3	R. J. Burley					0.22*
August 3	"					0.24*
August 4	R. G. Swan	39	45.13	0.005	1.06	0.22*
August 6	R. J. Burley					0.29*
August 8	"					0.4 *
August 11	"				1.07	0.24*
August 16	"				1.14	0.66*
August 26	R. G. Swan	39	45.67	0.008	1.1	0.36*
September 16	"	39	44.89	0.021	1.13	0.92*
October 12	"	49	57.07	0.011	1.11	0.72

* Discharge determined by using 36 inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Frenchman River, near East End, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			1.85	44.2	1.30	6.0
2			1.85	44.2	1.30	6.0
3			1.85	44.2	1.30	6.0
4			1.85	44.2	1.30	6.0
5			1.85	44.2	1.30	6.0
6			1.85	44.2	1.30	6.0
7			1.85	44.2	1.35	8.4
8			1.85	44.2	1.35	8.4
9			1.80	39.8	1.35	8.4
10			1.80	39.8	1.35	8.4
11			1.75	35.6	1.40	11.0
12			1.75	35.6	1.40	11.0
13			1.75	35.6	1.40	11.0
14			1.70	31.5	1.40	11.0
15			1.70	31.5	1.40	11.0
16			1.75	35.6	1.40	11.0
17			1.75	35.6	1.40	11.0
18	2.05	64.4	1.75	35.6	1.45	13.9
19	2.05	64.4	1.75	35.6	1.45	13.9
20	2.00	59.2	1.75	35.6	1.45	13.9
21	2.00	59.2	1.60	23.9	1.45	13.9
22	2.00	59.2	1.60	23.9	1.40	11.0
23	2.00	59.2	1.65	27.6	1.40	11.0
24	1.95	54.0	1.65	27.6	1.40	11.0
25	1.95	54.0	1.60	23.9	1.40	11.0
26	1.90	49.0	1.50	17.0	1.40	11.0
27	1.90	49.0	1.40	11.0	1.40	11.0
28	1.85	44.2	1.35	8.4	1.40	11 0
29	1.85	44.2	1.35	8.4	1.40	11.0
30	1.85	41.2	1.35	8.4	1.40	11.0
31			1.35	8.4		

DAILY GAUGE HEIGHT AND DISCHARGE of Frenchman River, near East End, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.40	11.0	1.10	0.5	1.05	0.2	1.14	1.0
2	1.40	11.0	1.10	0.5	1.10	0.5	1.14	1.0
3	1.40	11.0	1.05	0.2	1.10	0.5	1.14	1.0
4	1.40	11.0	1.05	0.2	1.10	0.5	1.14	1.0
5	1.40	11.0	1.05	0.2	1.10	0.5	1.14	1.0
6	1.40	11.0	1.05	0.2	1.03	0.1	1.14	1.0
7	1.30	6.0	1.05	0.2	1.03	0.1	1.14	1.0
8	1.30	6.0	1.10	0.5	1.03	0.1	1.14	1.0
9	1.15	1.1	1.05	0.2	1.03	0.1	1.14	1.0
10	1.15	1.1	1.05	0.2	1.12	0.7	1.14	1.0
11	1.15	1.1	1.05	0.2	1.13	0.8	1.14	1.0
12	1.25	4.0	1.05	0.2	1.13	0.8	1.11	0.6
13	1.25	4.0	1.05	0.2	1.14	1.0	1.11	0.6
14	1.10	0.5	1.05	0.2	1.15	1.1	1.11	0.6
15	1.10	0.5	1.10	0.5	1.15	1.1	1.10	0.5
16	1.10	0.5	1.10	0.5	1.13	0.8	1.10	0.5
17	1.10	0.5	1.10	0.5	1.13	0.8	1.10	0.5
18	1.15	1.1	1.10	0.5	1.13	0.8	1.13	0.8
19	1.15	1.1	1.10	0.5	1.13	0.8	1.13	0.8
20	1.20	2.3	1.09	0.4	1.13	0.8	1.15	1.1
21	1.20	2.3	1.09	0.4	1.13	0.8	1.15	1.1
22	1.20	2.3	1.09	0.4	1.13	0.8	1.12	0.7
23	1.30	6.0	1.09	0.4	1.13	0.8	1.12	0.7
24	1.30	6.0	1.09	0.4	1.15	1.1	1.10	0.5
25	1.30	6.0	1.09	0.4	1.15	1.1	1.10	0.5
26	1.30	6.0	1.10	0.5	1.15	1.1	1.10	0.5
27	1.30	6.0	1.05	0.2	1.15	1.1	1.10	0.5
28	1.30	6.0	1.05	0.2	1.13	0.8	1.10	0.5
29	1.30	6.0	1.05	0.2	1.12	0.7	1.10	0.5
30	1.15	1.1	1.05	0.2	1.12	0.7	1.10	0.5
31	1.10	0.5	1.05	0.2	....	....	1.10	0.5

MONTHLY DISCHARGE of Frenchman River, near East End, for 1910.

Drainage area, 635 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (18-30)	64.40	44.20	54.32	0.086	0.041	1,400
May	46.40	24.30	39.29	0.062	0.071	2,416
June	25.10	13.70	21.34	0.034	0.038	1,270
July	13.70	0.80	6.51	0.010	0.012	400
August	7.60	0.70	5.06	0.008	0.009	311
September	10.00	0.90	6.91	0.011	0.012	411
October	12.50	7.30	10.50	0.017	0.020	646
The period						6,854

NOTE.—The discharges of Enright & Strong's Ditch have been added to those of Frenchman River.

THE ENRIGHT AND STRONG DITCH, NEAR EAST END.

This station was established July 31, 1909, by F. T. Fletcher. It is located on Sec. 36, Tp. 6, Rge. 22, W. 3rd Mer., at the highway bridge on the Chinook trail, about one mile and a half west of the Enright and Strong ranche, and the same distance upstream from the bridge station on the Frenchman River. The station is about a mile and a half below the Headgate of the ditch and two hundred yards above the diversion gates governing the flow of the branches of the ditch. Hence measurements at the station are affected by changes of slope due to different positions of the headgate for the main ditch and two diversion gates.

The ditch is straight for about 1,000 feet upstream and 600 feet downstream, the south ditch continuing in the same straight course an additional distance of 600 feet before turning southward. The current is, in general, moderately fast, but is affected by the position of the governing gates as noted above.

The gauge is a plain staff, graduated to feet and hundredths, attached vertically to the downstream side of the centre of the bridge. Daily observations of gauge height were made during 1910 by D. Savage. The gauge is referred to bench marks as follows:—(1) Nail-heads on the upstream end of the first floor-plank at the right side of the bridge; elevation, 4.93 feet above the datum of the gauge. (2) A square plug driven close to the ground 100 feet south of the bridge and in a line with the upstream hand-rail; elevation, 5.72 feet above the datum of the gauge.

Discharge measurements are made from the upper side of the bridge. The bridge divides the stream into two channels by a central bent. The initial point for soundings is the inner face of the right abutment, marked 0 with white paint.

DISCHARGE MEASUREMENTS of Enright and Strong's Ditch, near East End, in 1910

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 18	H. R. Carscallen					Nil.
May 11	"	10.0	5.28	0.225	0.91	1.19
May 31	"	14.2	12.93	1.251	1.52	16.20
June 17	R. G. Swan	18.8	31.83	0.382	2.64	12.18
July 15	"	7.4	3.76	0.436	0.74	1.64
August 3	R. J. Burley	7.7	3.85	1.196	2.15	4.60
August 4	R. G. Swan	17.0	24.29	0.223	2.29	5.42
August 6	R. J. Burley	7.5	4.11	1.693	2.05	6.93
Auugst 10	"	13.2	11.72	0.677	1.93	7.93
August 16	"	13.0	10.47	0.547	1.75	5.73
August 26	R. G. Swan	7.5	2.50	0.756	0.45	1.89
September 16	"	17.0	22.67	0.371	2.16	8.42
October 12	"	15.5	19.15	0.616	1.92	11.85

DAILY GAUGE HEIGHT AND DISCHARGE of Enright and Strong's Ditch, near East End, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.3	0.0	1.60	17.8
2			0.3	0.0	1.60	17.8
3			0.3	0.0	1.60	17.8
4			0.3	0.0	1.55	16 9
5			0.3	0.0	1.55	16.9
6			0.3	0.0	1.50	15.9
7			0.3	0.0	1.45	15.0
8			0.3	0.0	1.45	15.0
9			0.6	0.1	1.45	15.0
10			0.6	0.1	1.45	15.0
11			0.9	1.15	1.40	14.1
12			0.9	1.15	1.40	14.1
13			0.9	1.15	1.40	14.1
14			1.2	10.8	1.40	14.1
15			1.2	10.8	1.40	14.1
16			1.2	10.8	1.40	14.1
17			1.2	10.8	2.60	11.5
18			1.2	10.8	2.60	11.5
19			1.2	10.8	2.55	10.7
20			1.2	10.8	2.55	10.7
21			1.35	13.3	2.30	7.1
22			1.35	13.3	2.20	6.8
23	0.8	0.65	1.35	13.3	2.20	6.8
24	0.8	0.65	1.50	15.9	2.20	6.8
25	0.8	0.65	1.55	16.9	2.10	4 7
26	0.4	0.00	1.55	16.9	2.00	3.6
27	0.4	0.00	1.50	15.9	1.95	3.1
28	0.3	0.00	1.50	15.9	1.90	2.7
29	0.3	0.00	1.50	15.9	1.90	2.7
30	0.3	0.00	1.50	15.9	1.90	2.7
31			1.50	15.9		

DAILY GAUGE HEIGHT AND DISCHARGE of Enright and Strong's Ditch, near East End, for 1910.—Continued.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.9	2.70	2.15	3.9	1.35	0.7	2.14	8.1
2	1.8	1.90	2.15	3.9	1.60	2.2	2.14	8.1
3	1.6	0.70	2.15	3.9	1.60	2.2	2.14	8.1
4	1.6	0.70	2.29	5.4	1.60	2.2	2.14	8.1
5	1.7	1.20	2.29	5.4	1.60	2.2	2.14	8.1
6	1.75	1.50	2.05	6.9	1.63	2.4	2.14	8.1
7	0.85	1.60	2.00	6.3	1.63	2.4	2.14	8.1
8	0.7	1.35	1.90	7.4	1.65	2.6	2.11	7.8
9	0.6	0.85	1.90	7.4	1.65	2.6	2.11	7.8
10	0.6	0.85	1.90	7.4	2.11	7.8	2.00	6.3
11	0.5	0.40	1.90	7.4	2.11	7.8	2.00	6.3
12	0.5	0.40	1.90	7.4	2.12	7.9	1.92	11.8
13	0.5	0.40	1.88	7.2	2.13	8.0	1.92	11.8
14	0.6	0.85	1.88	7.2	2.17	8.6	1.92	11.8
15	0.74	1.60	1.75	5.5	2.17	8.6	1.90	11.4
16	1.6	0.30	1.75	5.5	2.16	8.4	1.90	11.4
17	1.6	0.30	1.73	5.2	2.16	8.4	1.90	11.4
18	1.6	0.30	1.73	5.2	2.17	8.6	1.90	11.4
19	1.7	0.70	1.73	5.2	2.03	5.7	1.90	11.4
20	1.7	0.70	1.70	4.9	2.03	5.7	1.90	11.4
21	1.9	1.75	1.70	4.9	2.05	6.9	1.90	11.4
22	1.9	1.75	1.73	5.2	2.07	7.2	1.90	11.4
23	1.9	1.75	1.73	5.2	2.07	7.2	1.90	11.4
24	2.0	2.50	2.01	3.1	2.13	8.0	1.85	10.6
25	2.3	5.55	2.01	3.1	2.13	8.0	1.85	10.6
26	2.3	5.55	0.45	1.9	2.15	8.3	1.85	10.6
27	2.4	6.80	0.45	1.9	2.19	8.9	1.85	10.6
28	2.0	2.50	0.50	1.3	2.19	8.9	1.85	10.6
29	2.0	2.50	1.30	0.5	2.19	8.9	1.70	8.4
30	2.15	3.90	1.30	0.5	2.19	8.9	1.70	8.4
31	2.15	3.90	1.35	0.7	....	....	1.70	8.4

MONTHLY DISCHARGE of Enright & Strong's Ditch, near East End, for 1910.

Month.	Discharge in Second-Feet.			Total Discharge acre-feet.
	Maximum.	Minimum.	Mean.	
April (23-30)	0.65	0.00	0.244	4
May	16.90	0.00	8.011	513
June	17.80	2.70	11.303	672
July	6.80	0.30	1.863	115
August	7.40	0.50	4.739	291
September	8.90	0.70	6.207	369
October	11.80	6.30	9.713	597
The period	....	....	....	2,561

NORTH BRANCH OF FRENCHMAN RIVER, AT CROSS' RANCHE.

This station was established July 25, 1908, by F. T. Fletcher. It is located on Sec. 16, Tp. 7, Rge. 22, W. 3rd Mer., about two and one-half miles from East End post office, and about forty-five miles southeast of Maple Creek, by trail.

The channel is straight for about 200 feet above and 600 feet below the station; the current is smooth and fairly swift. Both banks are high and not liable to overflow. The bed of the stream is sandy and may shift at high stages.

Discharge measurements are made at or near the gauge by wading. The initial point for soundings is a square hardwood plug driven into the ground on the right bank of the stream and marked B. M. with white paint.

A plain staff, graduated to feet and hundredths, is placed vertically at the right bank about one mile downstream from the intake of Mr. Frank Cross' irrigation ditch, and one hundred yards below his house. The gauge is read once each day by Mr. Cross. The gauge is referred to bench marks as follows:—(1) A bolt head in the ground log at the southeast corner of Mr. Cross' house; elevation, 11.10 feet above gauge zero. (2) A bolt-head in the initial point stake on the right bank; elevation, 5.45 feet above gauge zero.

Irrigation ditches owned by F. Cross, H. Cross, and W. F. McNicol take their supply from the North Branch of Frenchman River at points above this station. A small quantity of water was diverted during 1910.

Discharge Measurements of North Fork of Frenchman River, at Cross' Ranche, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 18	H. R. Carscallen	12.8	7.99	1.174	0.82	9.38
May 12	"	12.9	8.53	1.161	0.79	9.90
May 31	"	12.7	7.17	0.946	0.63	6.78
June 17	R. G. Swan	12.8	7.01	0.807	0.64	5.66
July 16	"	13.8	4.92	0.748	0.54	3.68
August 6	"	12.8	5.84	0.897	0.63	5.24
August 29	"	13.0	6.33	0.790	0.66	5.00
September 10	R. J. Burley	13.4	6.67	0.945	0.65	6.32
September 17	H. R. Carscallen	12.6	5.99	0.856	0.61	5.13
October 13	R. G. Swan	13.0	7.89	0.875	0.67	6.91

Daily Gauge Height and Discharge of North Fork of Frenchman River, at Cross' Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.90	12.0	0.80	9.4	0.60	4.9
2	0.90	12.0	0.80	9.4	0.65	5.9
3	0.90	12.0	0.80	9.4	0.65	5.9
4	0.90	12.0	0.80	9.4	0.70	7.0
5	0.90	12.0	0.80	9.4	0.65	5.9
6	0.90	12.0	0.80	9.4	0.65	5.9
7	0.90	12.0	0.80	9.4	0.60	4.9
8	0.90	12.0	0.80	9.4	0.60	4.9
9	0.90	12.0	0.80	9.4	0.60	4.9
10	0.90	12.0	0.80	9.4	0.60	4.9
11	0.90	12.0	0.80	9.4	0.60	4.9
12	0.90	12.0	0.80	9.4	0.60	4.9
13	0.90	12.0	0.80	9.4	0.60	4.9
14	0.90	12.0	0.80	9.4	0.60	4.9
15	0.90	12.0	0.80	9.4	0.60	4.9
16	0.85	10.7	0.80	9.4	0.60	4.9
17	0.85	10.7	0.80	9.4	0.65	5.9
18	0.80	9.4	0.80	9.4	0.60	4.9
19	0.80	9.4	0.80	9.4	0.60	4.9
20	0.80	9.4	0.80	9.4	0.60	4.9
21	0.80	9.4	0.80	9.4	0.60	4.9
22	0.80	9.4	0.80	9.4	0.60	4.9
23	0.80	9.4	0.80	9.4	0.60	4.9
24	0.80	9.4	0.80	9.4	0.60	4.9
25	0.80	9.4	0.75	8.2	0.60	4.9
26	0.80	9.4	0.75	8.2	0.55	3.9
27	0.80	9.4	0.70	7.0	0.55	3.9
28	0.80	9.4	0.70	7.0	0.50	2.95
29	0.80	9.4	0.65	5.9	0.50	2.95
30	0.80	9.4	0.65	5.9	0.50	2.95
31			0.60	4.9		

DAILY GAUGE HEIGHT AND DISCHARGE of North Fork of Frenchman River, at Cross' Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.50	2.95	0.50	2.95	0.65	5.9	0.70	7.0
2	0.55	3.90	0.50	2.95	0.65	5.9	0.70	7.0
3	0.55	3.90	0.50	2.95	0.65	5.9	0.70	7.0
4	0.60	4.90	0.55	3.9	0.70	7.0	0.70	7.0
5	0.60	4.90	0.55	3.9	0.70	7.0	0.70	7.0
6	0.60	4.90	0.60	4.9	0.70	7.0	0.70	7.0
7	0.60	4.90	0.60	4.9	0.70	7.0	0.70	7.0
8	0.60	4.90	0.60	4.9	0.70	7.0	0.70	7.0
9	0.60	4.90	0.60	4.9	0.70	7.0	0.70	7.0
10	0.60	4.90	0.60	4.9	0.65	5.9	0.70	7.0
11	0.60	4.90	0.60	4.9	0.65	5.9	0.70	7.0
12	0.60	4.90	0.60	4.9	0.65	5.9	0.70	7.0
13	0.60	4.90	0.60	4.9	0.65	5.9	0.70	7.0
14	0.55	3.90	0.60	4.9	0.65	5.9	0.70	7.0
15	0.55	3.90	0.60	4.9	0.65	5.9	0.70	7.0
16	0.50	2.95	0.60	4.9	0.65	5.9	0.70	7.0
17	0.45	2.15	0.60	4.9	0.60	4.9	0.70	7.0
18	0.40	1.50	0.60	4.9	0.60	4.9	0.70	7.0
19	0.40	1.50	0.60	4.9	0.60	4.9	0.70	7.0
20	0.40	1.50	0.60	4.9	0.65	5.9	0.70	7.0
21	0.40	1.50	0.60	4.9	0.65	5.9	0.70	7.0
22	0.45	2.15	0.60	4.9	0.65	5.9	0.70	7.0
23	0.50	2.95	0.60	4.9	0.65	5.9	0.70	7.0
24	0.50	2.95	0.60	4.9	0.65	5.9	0.75	8.2
25	0.50	2.95	0.60	4.9	0.70	7.0	0.75	8.2
26	0.50	2.95	0.65	5.9	0.70	7.0	0.80	9.4
27	0.50	2.95	0.65	5.9	0.70	7.0	0.80	9.4
28	0.50	2.95	0.65	5.9	0.70	7.0	0.80	9.4
29	0.50	2.95	0.65	5.9	0.70	7.0	0.80	9.4
30	0.50	2.95	0.65	5.9	0.70	7.0	0.80	9.4
31	0.50	2.95	0.65	5.9	....	....	0.80	9.4

MONTHLY DISCHARGE of North Fork of Frenchman River, at Cross' Ranche, for 1910.
Drainage area, 58 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	12.0	9.40	10.79	0.186	0.208	643
May	9.4	4.90	8.80	0.152	0.175	541
June	7.0	2.95	4.88	0.084	0.094	290
July	4.9	1.50	3.46	0.060	0.069	214
August	5.9	2.95	4.84	0.084	0.097	298
September	7.0	4.90	6.24	0.108	0.121	371
October	9.4	7.00	7.54	0.130	0.150	464
The period						2,821

FAIRWELL CREEK, AT BOLTON'S RANCHE.

This station was established June 10, 1909, by H. R. Carscallen. It is located about eleven miles southeast of Belanger P. O., at Bolton's ranche, on Sec. 30, Tp. 6, Rge. 24, W. 3rd Mer.

The channel is straight for 75 feet upstream, but curves slightly to the right for 50 feet downstream. Both banks are comparatively low and will overflow at high stages of the stream. The banks are covered with brush above and below the station. The bed of the stream is composed of sand and coarse gravel. The current is sluggish at the station, but is swift a short distance below.

The gauge, which was read daily during the season of 1910, by J. C. Temple, is a rod graduated to feet and hundredths, attached vertically to a post sunk in the bed of the stream at the left bank and securely stayed. The gauge is referred to bench marks as follows:—(1) The head of a spike driven into the pointed top of a willow stump about 50 feet southeast of the gauge, the stump blazed and marked B. M. with red paint; elevation, 6.25 feet above the datum of the gauge. (2) The head of a spike surrounded by a circle of nail-heads in a notch cut in a large poplar tree 60 feet southeast of the gauge, the tree blazed and marked B. M. with red paint; elevation, 5.08 feet above the datum of the gauge.

Discharge measurements are made a short distance below the gauge by wading. Owing to the low banks, high-water measurements are not obtainable. The initial point for soundings is a square stake driven close to the ground at the left bank and marked J. P. O. O. Beaver dams below the station have given some trouble.

Within a mile upstream from the gauge rod, the stream is often perfectly dry, while at the rod and a few miles below it, there is a continuous flow. This disappearance of the stream flow, which occurs for a distance of three or four miles, is due to the loose gravelly character of the stream bed.

There are a number of proposed irrigation schemes which will take their supply from this stream at points above the gauging station.

DISCHARGE MEASUREMENTS of Fairwell Creek at Bolton's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq.-ft.	Ft. per sec.	Feet.	Sec.-ft.
April 19	H. R. Carscallen	54.0	47.96	0.436	2.14	20.78
May 13	"	52.9	40.51	0.262	1.99	10.63
June 1	"	53.0	46.05	0.200	2.00	9.35
June 18	R. G. Swan	52.0	38.10	0.168		6.35
July 16	"	52.0	33.66	0.084	1.865	2.84
August 8	"	51.0	33.06	0.082	1.850	2.71
August 29	"	51.0	31.53	0.042	1.820	1.31
September 19	"	52.0	30.54	0.022	1.780	0.67
October 17	"				1.750	0.68

DAILY GAUGE HEIGHT AND DISCHARGE of Fairwell Creek, at Bolton's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			2.1	17.0	1.9	4.1
2			2.1	17.0	1.9	4.1
3			2.1	17.0	1.9	4.1
4			2.1	17.0	1.9	4.1
5			2.1	17.0	1.9	4.1
6			2.1	17.0	1.9	4.1
7			2.1	17.0	1.9	4.1
8			2.1	17.0	1.9	4.1
9			2.1	17.0	1.9	4.1
10			2.1	17.0	1.9	4.1
11			2.1	17.0	1.9	4.1
12			2.1	17.0	1.9	4.1
13			2.0	9.2	1.9	4.1
14			2.0	9.2	1.9	4.1
15			2.0	9.2	1.9	4.1
16			2.0	9.2	1.9	4.1
17			2.0	9.2	1.9	4.1
18			2.1	17.0	1.9	4.1
19	2.15	22.0	2.1	17.0	2.0	9.2
20	2.15	22.0	2.1	17.0	2.0	9.2
21	2.15	22.0	2.1	17.0	2.0	9.2
22	2.10	17.0	2.0	9.2	2.0	9.2
23	2.10	17.0	2.0	9.2	2.0	9.2
24	2.10	17.0	2.0	9.2	1.9	4.1
25	2.10	17.0	2.0	9.2	1.9	4.1
26	2.10	17.0	2.0	9.2	1.9	4.1
27	2.10	17.0	2.0	9.2	1.9	4.1
28	2.10	17.0	2.0	9.2	1.9	4.1
29	2.10	17.0	2.0	9.2	1.9	4.1
30	2.10	17.0	2.0	9.2	1.9	4.1
31			1.9	4.1		

Daily Gauge Height and Discharge of Fairwell Creek, at Bolton's Ranche, for 1910.—*Con.*

Day	July		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.9	4.1	1.8	1.3	1.80	1.3	1.77	0.9
2	1.9	4.1	1.8	1.3	1.80	1.3	1.78	1.1
3	1.9	4.1	1.8	1.3	1.80	1.3	1.78	1.1
4	1.9	4.1	1.8	1.3	1.90	4.1	1.78	1.1
5	1.9	4.1	2.0	9.2	1.90	4.1	1.78	1.1
6	1.9	4.1	1.9	4.1	1.90	4.1	1.78	1.1
7	1.9	4.1	1.9	4.1	1.90	4.1	1.79	1.2
8	1.9	4.1	1.9	4.1	1.90	4.1	1.79	1.2
9	1.9	4.1	1.9	4.1	1.80	1.3	1.78	1.1
10	1.9	4.1	1.9	4.1	1.80	1.3	1.78	1.1
11	1.9	4.1	1.9	4.1	1.80	1.3	1.78	1.1
12	1.9	4.1	1.9	4.1	1.80	1.3	1.78	1.1
13	1.9	4.1	1.9	4.1	1.80	1.3	1.77	0.9
14	1.9	4.1	1.9	4.1	1.80	1.3	1.77	0.9
15	1.9	4.1	1.9	4.1	1.70	0.3	1.77	0.9
16	1.9	4.1	1.9	4.1	1.70	0.3	1.76	0.8
17	1.8	1.3	1.9	4.1	1.70	0.3	1.76	0.8
18	1.8	1.3	1.8	1.3	1.80	1.3	1.76	0.8
19	1.8	1.3	1.8	1.3	1.80	1.3	1.76	0.8
20	1.8	1.3	1.8	1.3	1.79	1.2	1.76	0.8
21	1.8	1.3	1.8	1.3	1.79	1.2	1.76	0.8
22	1.8	1.3	1.8	1.3	1.79	1.2	1.76	0.8
23	1.8	1.3	1.8	1.3	1.79	1.2	1.77	0.9
24	1.8	1.3	1.8	1.3	1.79	1.2	1.77	0.9
25	1.8	1.3	1.8	1.3	1.78	1.1	1.77	0.9
26	1.8	1.3	1.8	1.3	1.78	1.1	1.77	0.9
27	1.8	1.3	1.8	1.3	1.78	1.1	1.77	0.9
28	1.8	1.3	1.8	1.3	1.77	0.9	1.77	0.9
29	1.8	1.3	1.8	1.3	1.77	0.9	1.77	0.9
30	1.8	1.3	1.8	1.3	1.77	0.9	1.77	0.9
31	1.8	1.3	1.8	1.3	....	....	1.77	0.9

Monthly Discharge of Fairwell Creek, at Bolton's Ranche, for 1910.

Drainage area, 135 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (19–30)	22.0	17.0	18.26	0.135	0.060	434
May	17.0	4.1	13.03	0.096	0.111	801
June	9.2	4.1	4.95	0.037	0.041	295
July	4.1	1.3	2.74	0.020	0.023	169
August	9.2	1.3	2.64	0.019	0.022	162
September	4.1	0.3	1.59	0.012	0.013	95
October	1.2	0.8	0.96	0.007	0.008	59
The period						2,015

Blacktail Creek, at Garissere's Ranche.

This station was established by H. R. Carscallen on Aug. 3rd, 1909. It is located in S.E. ¼ Sec. 31, Tp. 6, Rge. 23, W. 3rd Mer., forty miles southeast of Maple Creek and ¼ mile upstream from J. Garissere's house. The channel is straight for 75 feet above and 200 feet below the station. Both banks are high and well wooded. The left bank has a gentle slope but the right is quite steep. The bed of the stream is composed of rocks and gravel, allowing a quantity of water to be lost by seepage. The current is swift.

The gauge rod is of the standard type, securely fastened to a poplar post, sunk in the bed of the stream at the left bank and stayed. The datum elevation of the rod is referred to a Bench Mark formed by two spikes driven into a poplar tree on the right bank, 30 feet upstream and marked B. M. elevation, 7.76 feet and to a second Bench Mark on a spike in a stump on the right bank, 15 feet upstream and marked B. M. elevation, 7.61 feet.

Discharge measurements are made during high water with a meter, and in low water a weir is used. The initial point of sounding is a stake driven into the left bank and marked I. P. O OO.

Water is diverted for irrigation purposes by J. Garissere at a point about 150 yards below the station. The gauge was read during 1910 by Mrs. Pete Chourrout.

DISCHARGE MEASUREMENTS of Blacktail Creek, at Garissere's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
April 19	H. R. Carscallen	13.5	9.68	0.047	1.33	0.46
May 12	"	11.8	7.28	0.032	1.20	0.24
May 31	"	10.2	5.98	0.027	1.06	0.16
June 18	R. G. Swan	9.8	4.52	0.018	0.92	0.09
July 16	"					Nil.
August 8	"					Nil.
August 29	"					Nil.
October 15	"				0.85	0.06

Discharges determined by using a 15 inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Blacktail Creek, at Garissere's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			1.2	0.28	1.1	0.19
2			1.2	0.28	1.1	0.19
3			1.2	0.28	1.1	0.19
4			1.2	0.28	1.1	0.19
5			1.2	0.28	1.1	0.19
6			1.2	0.28	1.1	0.19
7			1.2	0.28	1.1	0.19
8			1.2	0.28	1.1	0.19
9			1.2	0.28	1.1	0.19
10			1.2	0.28	1.1	0.19
11			1.2	0.28	1.1	0.19
12			1.2	0.28	1.1	0.19
13			1.2	0.28	1.0	0.12
14			1.2	0.28	1.0	0.12
15			1.2	0.28	1.0	0.12
16			1.3	0.41	1.0	0.12
17			1.3	0.41	1.0	0.12
18			1.3	0.41	0.9	0.07
19	1.3	0.41	1.2	0.28	0.9	0.07
20	1.3	0.41	1.2	0.28	0.9	0.07
21	1.3	0.41	1.2	0.28	0.9	0.07
22	1.3	0.41	1.2	0.28	0.9	0.07
23	1.3	0.41	1.2	0.28	0.9	0.07
24	1.3	0.41	1.2	0.28	0.9	0.07
25	1.2	0.28	1.2	0.28	0.9	0.07
26	1.2	0.28	1.2	0.28	0.9	0.07
27	1.2	0.28	1.3	0.41	0.9	0.07
28	1.2	0.28	1.2	0.28	0.9	0.07
29	1.2	0.28	1.2	0.28	0.9	0.07
30	1.2	0.28	1.1	0.19	0.9	0.07
31			1.1	0.19		

DAILY GAUGE HEIGHT AND DISCHARGE of Blacktail Creek, at Garissere's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.9	0.07	...	...	...	...	0.5	...
2	0.9	0.07	...	...	...	...	0.5	...
3	0.9	0.07	...	...	...	...	0.5	...
4	0.9	0.07	...	...	...	...	0.5	...
5	0.9	0.07	...	...	...	...	0.5	...
6	0.9	0.07	...	...	...	...	0.5	...
7	0.8	0.04	...	...	...	...	0.5	...
8	0.8	0.04	...	...	...	...	0.5	...
9	0.8	0.04	...	...	...	...	0.5	...
10	0.8	0.04	...	...	...	...	0.6	0.01
11	0.8	0.04	...	...	...	...	0.6	0.01
12	0.7	0.02	...	...	...	...	0.7	0.02
13	0.7	0.02	...	...	...	...	0.7	0.02
14	0.7	0.02	...	...	...	...	0.8	0.04
15	0.6	0.01	...	...	...	...	0.8	0.04
16	0.6	0.01	...	...	...	...	0.8	0.04
17	*	...	...	...	...	...	0.9	0.07
18	...	...	...	...	...	...	0.9	0.07
19	...	...	...	...	...	...	0.9	0.07
20	...	...	...	...	...	...	0.9	0.07
21	...	...	...	...	0.3	†	0.9	0.07
22	...	...	...	...	0.3	...	0.9	0.07
23	...	...	...	...	0.3	...	0.9	0.07
24	...	...	...	...	0.4	...	0.9	0.07
25	...	...	...	...	0.4	...	0.9	0.07
26	...	...	...	...	0.4	...	0.9	0.07
27	...	...	...	...	0.4	...	0.9	0.07
28	...	...	...	...	0.4	...	0.9	0.07
29	...	...	...	...	0.4	...	0.9	0.07
30	...	...	...	...	0.4	...	0.9	0.07
31	...	...	...	...	...	...	0.9	0.07

* Creek dry, July 17 to September 20.
† No flow, water standing in pools, September 21 to October 9.

MONTHLY DISCHARGE OF BLACKTAIL CREEK, at Garissere's Ranche, for 1910.

Drainage area, 8 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (19-30)	0.41	0.28	0.345	0.043	0.019	8
May	0.41	0.19	0.291	0.036	0.041	18
June	0.19	0.07	0.126	0.016	0.018	7
July	0.07	0.00	0.022	0.002	0.002	1
August	...	...	...	...	...	...
September	...	...	...	...	...	...
October	0.07	0.00	0.039	0.005	0.006	2
The period	...	...	...	...	...	36

DAVIS CREEK, AT DRURY'S RANCHE.

This station was established May 24, 1909, by H. R. Carscallen. It is located on Sec. 29, Tp. 6, Rge. 25, W. 3rd Mer., about five miles southeast of Belanger P. O., and about one-half mile from the mouth of the creek.

The channel is straight for 150 feet above and 200 feet below the station. The right bank is comparatively high and will not overflow except in cases of extreme flood; the left bank is low and will overflow at high-water stages of the stream. Both banks are covered with brush. The bed of the stream is composed of sand and coarse gravel and there may be a slight sub-surface flow at this point. The current is swift.

The gauge is a plain staff, graduated to feet and hundredths, attached vertically to a post sunk in the bed of the stream at the right bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) The head of a spike in the top of a pointed willow stump about 15 feet below the gauge on the right bank, the stump blazed and marked B. M. with red paint; elevation, 5.05 feet above gauge zero. (2) The head of a spike surrounded by a circle of nail-heads in the top of a log projecting from southeast corner of Mr. Drury's house; elevation. 9.05 feet above gauge zero. The gauge is read once each day by T. A. Drury.

Discharge measurements are made at or near the gauge by wading. Owing to the left bank being low, high-water measurements are not obtainable. Considerable annoyance is experienced by the construction of dams below the gauge by beavers. During 1910, beaver dams changed the conditions at this station so often that daily discharges could not be computed.

DISCHARGE MEASUREMENTS of Davis Creek, at Drury's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	Sq. ft.	Ft. per sec.	Feet.	Sec.-ft.
April 20	H. R. Carscallen	15.0	9.05	1.061	1.13	9.60
June 1	"	13.6	5.04	0.559	0.84	2.82
June 20	R. G. Swan	12.8	4.22	0.460	0.83	1.94
July 18	"				1.04	
August 8	"				1.68	0.28*
August 29	"				1.24	0.13*
September 19	"				0.79	0.01*
October 17	"				1.04	0.026*

* Discharge determined by using a 15 inch weir.

BELANGER CREEK AT GARRISON'S RANCHE.

This station was established June 12, 1909. by H. R. Carscallen. It is located on Sec. 18, Tp. 7, Rge. 25, W. 3rd Mer., one hundred and fifty yards west of Garrison's Ranche (Belanger P. O.), and about twenty-seven miles south of Maple Creek.

The channel is straight for 100 feet above and 125 feet below the station. Both banks are comparatively high but will overflow at times of extreme flood. The ground on the left bank is very rough and broken. Both banks are covered with low underbrush at the station and with large willow brush above and below. The bed of the stream is composed of sand and coarse gravel. The current is moderate at low stages.

The gauge, which is read daily by G. C. Garrison, is a plain staff, graduated to feet and hundredths, attached to a vertical post sunk in the bed of the creek at the left bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) The head of a spike surrounded by a circle of nail-heads in the top of the initial point stake on the left bank, marked B. M. in red paint; elevation, 5.24 feet above the zero of the gauge. (2) The head of a spike driven into the pointed top of a willow stump blazed and marked B.M. in red paint, almost 40 feet north-east of the gauge: Elevation 7.27 ft. above the zero of the gauge.

Discharge measurements are made at the station by wading. No measurements are obtainable at extreme flood stage as the banks overflow and make wading impossible. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. 0. 0.

DISCHARGE MEASUREMENTS of Belanger Creek at Garrison's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	Sq.-ft.	Ft. per sec.	Feet.	Sec.-ft.
April 20	H. R. Carscallen	18.7	13.59	0.393	1.49	5.35
May 13	"	18.4	12.73	0.358	1.45	4.60
June 2	"	17.4	12.10	0.347	1.45	4.96
June 20	R. G. Swan	17.3	11.30	0.279		3.17
July 19	"	17.5	10.38	0.179	1.35	1.86
August 8	"	16.0	10.32	0.166	1.34	1.71
August 20	"	17.5	10.90	0.174	1.31	1.90
September 20	"	16.0	9.54	0.139	1.30	1.33
October 19	"	16.3	8.74	0.116	1.28	1.01

Daily Gauge Height and Discharge of Belanger Creek, at Garrison's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.4	2.8	1.5	5.7	1.5	5.7
2	1.4	2.8	1.5	5.7	1.5	5.7
3	1.5	5.7	1.5	5.7	1.6	9.2
4	1.5	5.7	1.5	5.7	1.55	7.4
5	1.5	5.7	1.5	5.7	1.5	5.7
6	1.6	9.2	1.5	5.7	1.5	5.7
7	1.6	9.2	1.5	5.7	1.5	5.7
8	1.6	9.2	1.5	5.7	1.5	5.7
9	1.5	5.7	1.5	5.7	1.5	5.7
10	1.5	5.7	1.5	5.7	1.5	5.7
11	1.5	5.7	1.5	5.7	1.5	5.7
12	1.5	5.7	1.5	5.7	1.5	5.7
13	1.6	9.2	1.5	5.7	1.5	5.7
14	1.6	9.2	1.5	5.7	1.5	5.7
15	1.6	9.2	1.5	5.7	1.5	5.7
16	1.6	9.2	1.5	5.7	1.5	5.7
17	1.5	5.7	1.5	5.7	1.5	5.7
18	1.5	5.7	1.5	5.7	1.5	5.7
19	1.5	5.7	1.5	5.7	1.5	5.7
20	1.5	5.7	1.5	5.7	1.5	5.7
21	1.5	5.7	1.5	5.7	1.5	5.7
22	1.5	5.7	1.5	5.7	1.5	5.7
23	1.5	5.7	1.5	5.7	1.5	5.7
24	1.5	5.7	1.5	5.7	1.5	5.7
25	1.5	5.7	1.5	5.7	1.5	5.7
26	1.5	5.7	1.5	5.7	1.5	5.7
27	1.5	5.7	1.5	5.7	1.4	2.8
28	1.5	5.7	1.5	5.7	1.4	2.8
29	1.5	5.7	1.5	5.7	1.4	2.8
30	1.5	5.7	1.5	5.7	1.4	2.8
31	....	....	1.5	5.7	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Belanger Creek, at Garrison's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.40	2.80	1.3	1.35	1.3	1.35	1.29	1.27
2	1.40	2.80	1.3	1.35	1.3	1.35	1.29	1.27
3	1.40	2.80	1.3	1.35	1.3	1.35	1.29	1.27
4	1.40	2.80	1.3	1.35	1.3	1.35	1.29	1.27
5	1.40	2.80	1.3	1.35	1.3	1.35	1.29	1.27
6	1.40	2.80	1.5	5.70	1.3	1.35	1.29	1.27
7	1.40	2.80	1.4	2.80	1.3	1.35	1.29	1.27
8	1.40	2.80	1.3	1.35	1.3	1.35	1.28	1.19
9	1.40	2.80	1.3	1.35	1.3	1.35	1.28	1.19
10	1.40	2.80	1.3	1.35	1.3	1.35	1.28	1.19
11	1.40	2.80	1.3	1.35	1.3	1.35	1.28	1.19
12	1.40	2.80	1.3	1.35	1.3	1.35	1.28	1.19
13	1.40	2.80	1.4	2.80	1.3	1.35	1.27	1.11
14	1.40	2.80	1.3	1.35	1.3	1.35	1.27	1.11
15	1.40	2.80	1.3	1.35	1.3	1.35	1.27	1.11
16	1.40	2.80	1.3	1.35	1.3	1.35	1.27	1.11
17	1.35	1.85	1.3	1.35	1.3	1.35	1.27	1.11
18	1.35	1.85	1.3	1.35	1.3	1.35	1.27	1.11
19	1.35	1.85	1.3	1.35	1.3	1.35	1.27	1.11
20	1.35	1.85	1.3	1.35	1.3	1.35	1.27	1.11
21	1.35	1.85	1.3	1.35	1.3	1.35	1.27	1.11
22	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
23	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
24	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
25	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
26	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
27	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
28	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
29	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
30	1.30	1.35	1.3	1.35	1.3	1.35	1.27	1.11
31	1.30	1.35	1.3	1.35	....	....	1.27	1.11

MONTHLY DISCHARGE of Belanger Creek, at Garrison's Ranche, for 1910.

Drainage area, 47 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	9.20	2.80	6.32	0.134	0.150	376
May	5.70	5.70	5.70	0.121	0.140	350
June	9.20	2.80	5.49	0.117	0.130	327
July	2.85	1.35	2.18	0.046	0.053	134
August	5.70	1.35	1.91	0.040	0.046	117
September	1.35	1.35	1.35	0.029	0.032	80
October	1.27	1.11	1.16	0.025	0.029	71
The period						1,455

LONEPINE CREEK AT HEWITT'S RANCHE.

This station was established July 17, 1909, by H. R. Carscallen. It is located on Sec. 27, Tp. 7, Rge. 26, W. 3rd Mer., about two miles west of the surveyed trail from Belanger P. O., to Maple Creek and about four miles west of Belanger P. O.

The channel is straight for 35 feet above and 45 feet below the station. The right bank is high and not liable to overflow: the left bank is comparatively low and will overflow at high stages of the stream. The surface of the ground on the left bank is very rough and broken. The bed of the stream is composed of sand and coarse gravel. The current is smooth and swift.

The gauge, which is read daily by S. W. Hewitt, is a rod, graduated to feet and hundredths, attached to a vertical post sunk in the bed of the stream at the right bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) A spike-head in the top of the final stake driven close to the ground on the right bank, marked B. M. in red paint; elevation, 5.63 feet above gauge zero. (2) The head of a spike in the top of a pointed willow stump blazed and marked B. M., on the left bank, 97 feet north of the gauge; elevation, 4.59 feet above the zero of the gauge.

The discharge measurements are made near the gauge by wading and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. o.o. The station is below ditches constructed by A. P. McDonald and S. W. Hewitt, and in the case of water being used in these ditches the records at the gauge would not give the total discharge of the creek.

DISCHARGE MEASUREMENTS of Lonepine Creek at Hewitt's Ranche, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 20	H. R. Carscallen	4.4	2.28	0.754	1.35	1.72
May 13	"	4.4	1.92	0.640	1.29	1.23
June 2	"	4.1	1.32	0.387	1.05	0.51
July 19	R. G. Swan	3.5	0.89	0.381	1.03	0.34
August 30	"	2.5	0.76	0.605	1.16	0.46
September 20	"	2.6	0.98	0.459	1.18	0.45
October 19	"	3.5	1.42	0.751	1.28	1.07

DAILY GAUGE HEIGHT AND DISCHARGE of Lonepine Creek at Hewitt's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.30	1.30	1.30	1.30	0.95	0.24
2	1.30	1.30	1.30	1.30	1.05	0.37
3	1.30	1.30	1.30	1.30	1.45	2.80
4	1.30	1.30	1.30	1.30	1.45	2.80
5	1.30	1.30	1.30	1.30	1.45	2.80
6	1.30	1.30	1.25	1.00	1.30	1.30
7	1.30	1.30	1.25	1.00	1.35	1.72
8	1.35	1.72	1.25	1.00	1.35	1.72
9	1.40	2.24	1.25	1.00	1.35	1.72
10	1.40	2.24	1.25	1.00	*0.95	0.24
11	1.40	2.24	1.30	1.30	*1.15	0.59
12	1.35	1.72	1.30	1.30	*1.15	0.59
13	1.45	2.80	1.28	1.18	*0.95	0.24
14	1.45	2.80	1.25	1.00	*0.95	0.24
15	1.35	1.72	1.45	2.80	*0.95	0.24
16	1.35	1.72	1.45	2.80	*0.95	0.24
17	1.35	1.72	1.40	2.24	1.05	0.37
18	1.35	1.72	1.40	2.24	1.05	0.37
19	1.35	1.72	1.40	2.24	1.05	0.37
20	1.35	1.72	1.40	2.24	1.05	0.37
21	1.35	1.72	1.30	1.30	1.05	0.37
22	1.35	1.72	1.30	1.30	1.05	0.37
23	1.35	1.72	1.30	1.30	1.05	0.37
24	1.30	1.30	1.25	1.00	1.05	0.37
25	1.30	1.30	*0.95	0.24	1.05	0.37
26	1.30	1.30	*0.95	0.24	1.05	0.37
27	1.30	1.30	*0.95	0.24	*0.95	0.24
28	1.30	1.30	1.05	0.37	*0.95	0.24
29	1.30	1.30	1.05	0.37	1.00	0.30
30	1.30	1.30	0.95	0.24	1.05	0.37
31	....	....	0.95	0.24	....	....

* Water being used for irrigation above gauge rod.

DAILY GAUGE HEIGHT AND DISCHARGE of Lonepine Creek at Hewitt's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis. charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.10	0.46	1.15	0.59	1.15	0.59	1.19	0.73
2	1.05	0.37	1.15	0.59	1.15	0.59	1.19	0.73
3	1.05	0.37	1.05	0.37	1.15	0.59	1.19	0.73
4	1.05	0.37	1.05	0.37	1.35	1.72	1.20	0.77
5	1.05	0.37	1.15	0.59	1.35	1.72	1.20	0.77
6	1.05	0.37	1.15	0.59	1.35	1.72	1.20	0.77
7	1.05	0.37	1.15	0.59	1.35	1.72	1.20	0.77
8	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
9	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
10	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
11	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
12	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
13	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
14	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
15	1.05	0.37	1.15	0.59	1.25	1.00	1.20	0.77
16	1.05	0.37	1.15	0.59	1.15	0.59	1.20	0.77
17	1.05	0.37	1.15	0.59	1.15	0.59	1.20	0.77
18	1.05	0.37	1.15	0.59	1.15	0.59	1.30	1.30
19	1.05	0.37	1.15	0.59	1.15	0.59	1.27	1.12
20	1.05	0.37	1.15	0.59	1.18	0.70	1.27	1.12
21	1.05	0.37	1.15	0.59	1.19	0.73	1.27	1.12
22	1.05	0.37	1.15	0.59	1.18	0.70	1.25	1.00
23	1.15	0.59	1.15	0.59	1.18	0.70	1.24	0.95
24	1.15	0.59	1.15	0.59	1.19	0.73	1.23	0.91
25	1.15	0.59	1.15	0.59	1.19	0.73	1.24	0.95
26	1.15	0.59	1.15	0.59	1.19	0.73	1.24	0.95
27	1.15	0.59	1.15	0.59	1.19	0.73	1.24	0.95
28	1.15	0.59	1.15	0.59	1.19	0.73	1.25	1.00
29	1.15	0.59	1.15	0.59	1.19	0.73	1.25	1.00
30	1.15	0.59	1.15	0.59	1.19	0.73	1.24	0.95
31	1.15	0.59	1.15	0.59	....	....	1.24	0.95

MONTHLY DISCHARGE of Lonepine Creek at Hewitt's Ranche, for 1910.

Drainage area, 4 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	2.80	1.30	1.65	0.412	0.460	98
May	2.80	0.24	1.22	0.304	0.351	75
June	2.80	0.24	0.743	0.185	0.206	44
July	0.59	0.37	0.404	0.101	0.116	25
August	0.59	0.37	0.576	0.144	0.166	35
September	1.72	0.59	0.898	0.224	0.258	53
October	1.30	0.73	0.878	0.220	0.254	60
The period						390

SUCKER CREEK AT WITCOMB AND ZEIGLER'S RANCHE.

This station was established May 26, 1909, by H. R. Carscallen. It is located on the north boundary of Sec. 24, Tp. 6, Rge. 26, W. 3rd Mer., about five miles south of Belanger Post Office and about thirty-two miles south of Maple Creek.

The channel is straight for 25 feet above and 45 feet below the station. The right bank is comparatively low and will overflow at high stages; the left bank is high and not liable to overflow. The right bank is sparsely covered with brush; the left bank is free from brush at the station. The bed of the stream is composed of sand and coarse gravel. The current is sluggish at the station but swift immediately below.

The gauge, which is read once each day by Mrs. P. A. Zeigler, is a plain staff, graduated to feet and hundredths attached to a vertical post sunk in the bed of the stream at the left bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) A circle of nail-heads in a log near the ground at the northeast corner of a stable; elevation, 12.27 feet above the zero of the gauge. (2) A spike-head in the top of the initial point stake on the left bank, marked B. M.; elevation, 5.30 feet above the zero of the gauge.

Discharge measurements are made at or near the gauge by wading and at very low stages a weir is used. High water measurements cannot be made as the right bank overflows. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. o.o.

DISCHARGE MEASUREMENTS of Sucker Creek at Witcomb and Zeigler's Ranche, in 1910.

DATE	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 20	H. R. Carscallen	12.0	6.05	0.692	0.72	4.19
May 13	"	10.7	4.40	0.700	0.64	3.04
June 2	"	9.2	3.72	0.632	0.59	2.35
June 20	R. G. Swan	10.5	4.61	0.254	0.51	1.17
July 18	"	7.0	1.61	0.143	0.36	0.23
August 8	"	8.9	3.22	0.521	0.55	1.68
August 29	"	7.0	2.52	0.698	0.54	1.76
September 20	"	7.1	2.48	0.694	0.57	1.72
October 17	"	7.0	3.06	0.716	0.60	2.19

Daily Gauge Height and Discharge of Sucker Creek at Witcomb & Zeigler's Ranche, for 1910

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.90	7.25	0.65	3.00	0.58	2.06
2	0.90	7.25	0.65	3.00	0.60	2.30
3	0.85	6.35	0.65	3.00	0.62	2.58
4	0.85	6.35	0.64	2.86	0.61	2.44
5	0.80	5.45	0.63	2.72	0.60	2.30
6	0.90	7.25	0.62	2.58	0.58	2.06
7	0.85	6.35	0.61	2.44	0.58	2.06
8	0.85	6.35	0.60	2.30	0.57	1.94
9	0.90	7.25	0.60	2.30	0.57	1.94
10	C.90	7.25	0.60	2.30	0.55	1.70
11	0.87	6.71	0.60	2.30	0.53	1.48
12	0.85	6.35	0.65	3.00	0.52	1.37
13	0.90	7.25	0.64	2.86	0.52	1.37
14	0.85	6.35	0.62	2.58	0.51	1.26
15	0.83	5.99	0.70	3.80	0.51	1.26
16	0.80	5.45	0.65	3.00	0.50	1.15
17	0.75	4.60	0.62	2.58	0.55	1.70
18	0.74	4.44	0.62	2.58	0.50	1.15
19	0.73	4.28	0.61	2.44	0.50	1.15
20	0.72	4.12	0.61	2.44	0.45	0.70
21	0.70	3.80	0.61	2.44	0.48	0.97
22	0.70	3.80	0.60	2.30	0.50	1.15
23	0.69	3.64	0.60	2.30	0.52	1.37
24	0.67	3.32	0.60	2.30	0.50	1.15
25	0.65	3.00	0.60	2.30	0.45	0.70
26	0.65	3.00	0.59	2.18	0.42	0.52
27	0.65	3.00	0.59	2.18	0.41	0.46
28	0.65	3.00	0.59	2.18	0.40	0.40
29	0.65	3.00	0.59	2.18	0.40	0.40
30	0.65	3.00	0.58	2.06	0.55	1.70
31	....	....	0.58	2.06	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Sucker Creek at Witcomb & Zeigler's Ranche, for 1910. *Concluded.*

Day.	July		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.51	1.26	0.40	0.40	0.59	2.18	0.57	1.94
2	0.50	1.15	0.40	0.40	0.56	1.82	0.57	1.94
3	0.48	0.97	0.40	0.40	0.55	1.70	0.57	1.94
4	0.55	1.70	0.40	0.40	0.60	2.30	0.59	2.18
5	0.50	1.15	0.80	5.45	0.62	2.58	0.60	2.30
6	0.45	0.70	0.60	2.30	0.60	2.30	0.60	2.30
7	0.48	0.97	0.55	1.70	0.63	2.72	0.60	2.30
8	0.47	0.88	0.53	1.48	0.62	2.58	0.60	2.30
9	0.50	1.15	0.51	1.26	0.60	2.30	0.60	2.30
10	0.50	1.15	0.50	1.15	0.60	2.30	0.60	2.30
11	0.50	1.15	0.49	1.06	0.58	2.06	0.60	2.30
12	0.45	0.70	0.49	1.06	0.56	1.82	0.60	2.30
13	0.43	0.58	0.65	3.00	0.56	1.82	0.60	2.30
14	0.40	0.40	0.60	2.30	0.55	1.70	0.60	2.30
15	0.35	0.20	0.59	2.18	0.55	1.70	0.60	2.30
16	0.35	0.20	0.57	1.94	0.55	1.70	0.60	2.30
17	0.35	0.20	0.55	1.70	0.55	1.70	0.59	2.18
18	0.33	0.10	0.53	1.48	0.55	1.70	0.59	2.18
19	0.33	0.10	0.52	1.37	0.55	1.70	0.59	2.18
20	0.33	0.10	0.51	1.26	0.55	1.70	0.60	2.30
21	0.35	0.20	0.51	1.26	0.55	1.70	0.61	2.44
22	0.45	0.70	0.52	1.37	0.60	2.30	0.61	2.44
23	0.55	1.70	0.55	1.70	0.60	2.30	0.60	2.30
24	0.50	1.15	0.57	1.94	0.60	2.30	0.60	2.30
25	0.45	0.70	0.55	1.70	0.60	2.30	0.60	2.30
26	0.45	0.70	0.52	1.37	0.60	2.30	0.60	2.30
27	0.45	0.70	0.52	1.37	0.60	2.30	0.60	2.30
28	0.43	0.58	0.52	1.37	0.60	2.30	0.60	2.30
29	0.43	0.58	0.54	1.59	0.59	2.18	0.60	2.30
20	0.40	0.40	0.53	1.48	0.58	2.06	0.60	2.30
31	0.40	0.40	0.53	1.48	....	....	0.60	2.30

MONTHLY DISCHARGE of Sucker Creek at Witcomb & Zeigler's Ranche, for 1910.

Drainage area, 36 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	7.25	3.00	5.173	0.144	0.161	308
May	3.80	2.06	2.534	0.070	0.081	156
June	2.58	0.40	1.426	0.040	0.044	85
July	1.70	0.10	0.730	0.020	0.023	45
August	5.45	0.40	1.578	0.044	0.051	97
September	2.72	1.70	2.081	0.058	0.065	124
October	2.44	1.94	2.259	0.063	0.073	139
The period						954

OXARART CREEK AT WYLIE'S RANCHE.

This station was established June 15, 1909, by H. R. Carscallen. It is located on Sec. 20, Tp. 6, Rge. 27, W. 3rd Mer., near the mouth of the creek and about thirty-five miles south of Maple Creek.

The channel is straight for 10 feet upstream and then divides into four small courses; the channel is straight for about 20 feet downstream then strikes an earth dam used in diverting water into Mr. Joseph Wylie's irrigation ditch. Here it makes a right-angled turn to the left, a small amount seeping through the dam and flowing down the natural course of the stream. The stream has a considerable fall and is subject to sudden and extreme floods, necessitating the replacing of the dam below the station after every flood. This brings the records of gauge height observations under new sets of conditions and a different rating curve must be constructed for each change of conditions. The creek has several channels during high stages and the station, although unsatisfactory, is the only section to be found, within reach of an observer, where the total flow is contained in one channel during the low water period. The bed of the stream is composed of sand and coarse gravel. The current is sluggish at the station during low water.

The gauge, which is read once each day by Mrs. Rachel Wylie, is a plain staff, graduated to feet and hundredths, attached to a vertical post sunk in the bed of the stream at the left bank and securely stayed to the bank. The gauge is referred to bench marks as follows:—(1) A spike-head in the top of the final point stake driven close to the ground on the right bank, marked B. M.; elevation, 4.71 feet above the zero of the gauge. (2) The top of three nails driven horizontally into a large willow tree, blazed and marked B. M., and about 20 feet from the gauge; elevation, 4.45 feet above the zero of the gauge.

Discharge measurements are made a short distance above the station by wading. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. o.o.

DISCHARGE MEASUREMENTS of Oxarart Creek at Wylie's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 21	H. R. Carscallen	22.8	16.41	0.147	0.97	2.44
May 14	"	23.3	15.03	0.144	0.96	2.17
June 9	"	22.3	14.23	0.106	0.89	1.51
June 30	"	21.8	12.11	0.082	0.85	0.99
July 22	"	22.2	12.45	0.057	0.84	0.71
August 9	"	21.7	11.61	0.058	0.79	0.67
September 2	"	22.0	11.93	0.054	0.79	0.65
September 26	R. G. Swan	21.0	11.18	0.047	0.80	0.54
October 20	"	21.7	10.85	0.043	0.78	0.47

DAILY GAUGE HEIGHT AND DISCHARGE of Oxarart Creek, at Wylie's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.4	12.0	1.0	2.8	0.9	1.5
2	1.4	12.0	1.0	2.8	0.9	1.5
3	1.4	12.0	1.0	2.8	0.9	1.5
4	1.4	12.0	1.0	2.8	0.9	1.5
5	1.4	12.0	1.0	2.8	0.9	1.5
6	1.3	9.3	1.0	2.8	0.9	1.5
7	1.3	9.3	1.0	2.8	0.9	1.5
8	1.3	9.3	1.0	2.8	0.9	1.5
9	1.3	9.3	1.0	2.8	0.9	1.5
10	1.2	6.8	1.0	2.8	0.9	1.5
11	1.1	4.6	1.0	2.8	0.9	1.5
12	1.1	4.6	1.0	2.8	0.9	1.5
13	1.0	2.8	1.0	2.8	0.9	1.5
14	1.0	2.8	1.0	2.8	0.9	1.5
15	1.0	2.8	1.0	2.8	0.9	1.5
16	1.0	2.8	1.0	2.8	0.9	1.5
17	1.0	2.8	1.0	2.8	0.9	1.5
18	1.0	2.8	1.0	2.8	0.9	1.5
19	1.0	2.8	1.0	2.8	0.9	1.5
20	1.0	2.8	1.0	2.8	0.9	1.5
21	1.0	2.8	1.0	2.8	0.9	1.5
22	1.0	2.8	1.0	2.8	0.9	1.5
23	1.0	2.8	1.0	2.8	0.9	1.5
24	1.0	2.8	1.0	2.8	0.9	1.5
25	1.0	2.8	0.9	1.5	0.9	1.5
26	1.0	2.8	0.9	1.5	0.9	1.5
27	1.0	2.8	0.9	1.5	0.9	1.5
28	1.0	2.8	0.9	1.5	0.9	1.5
29	1.0	2.8	0.9	1.5	0.9	1.5
30	1.0	2.8	0.9	1.5	0.9	1.5
31	....	....	0.9	1.5	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Oxarart Creek at Wylie's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.9	1.50	0.80	0.65	0.81	0.72	0.8	0.65
2	0.9	1.50	0.80	0.65	0.81	0.72	0.8	0.65
3	0.9	1.50	0.80	0.65	0.81	0.72	0.8	0.65
4	0.9	1.50	0.80	0.65	0.81	0.72	0.8	0.65
5	0.9	1.50	0.82	0.79	0.81	0.72	0.8	0.65
6	0.9	1.50	0.82	0.79	0.81	0.72	0.8	0.65
7	0.9	1.50	0.82	0.79	0.81	0.72	0.8	0.65
8	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
8	0.8	0.65	0.80	0.65	0.81	0.72	0.8	0.65
10	0.8	0.65	0.80	0.65	0.81	0.72	0.8	0.65
11	0.8	0.65	0.80	0.65	0.81	0.72	0.8	0.65
12	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
13	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
14	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
15	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
16	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
17	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
18	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
19	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
20	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
21	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
22	0.8	0.65	0.81	0.72	0.81	0.72	0.8	0.65
23	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
24	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
25	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
26	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
27	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
28	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
29	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
30	0.8	0.65	0.81	0.72	0.80	0.65	0.8	0.65
31	0.8	0.65	0.81	0.72	....	....	0.8	0.65

MONTHLY DISCHARGE of Oxarart Creek at Wylie's Ranche, for 1910.

Drainage area, 73 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	12.00	2.80	5.450	0.074	0.083	324
May	2.80	1.50	2.510	0.034	0.039	154
June	1.50	1.50	1.500	0.021	0.023	89
July	1.50	0.65	0.841	0.012	0.014	52
August	0.79	0.65	0.710	0.010	0.012	44
September	0.72	0.65	0.700	0.010	0.011	42
October	0.65	0.65	0.680	0.009	0.010	40
The period						745

MISCELLANEOUS DISCHARGE MEASUREMENTS of Frenchman River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.	*Sq. ft.*	*Sec.-ft.*
June 7	Creek (Spring)	20-6-27-3	F. T. Fletcher	*		0.18
May 25	Frenchman River	S.E. 5-1-10-3	F. H. Peters	31.00	26.25	42.48
August 2	"	N.E. 20-6-22-3	R. J. Burley	14.5	5.31	4.21
August 3	"	"	"	16.4	6.80	2.50
August 6	"	"	"	17.4	7.77	5.13
August 10	"	"	"	15.5	7.84	8.08
August 3	"	S.E. 28-6-21-3	"	4.5	1.21	0.40
August 6	"	"	"	5.0	1.37	0.60
August 8	"	"	"	5.1	1.38	0.54
August 11	"	"	"	5.1	1.20	0.50
August 16	"	"	"	7.3	2.28	1.17
July 14	Morrison Bros.' Ditch	S.W. 26-6-21-3	R. G. Swan	6.6	1.56	0.66
June 29	War Lodge Creek	14-7-27-3	H. R. Carscallen	*		0.10

* Weir measurement.

SWIFTCURRENT CREEK DRAINAGE BASIN.

General Description.

Swiftcurrent Creek rises in the eastern slope of the Cypress Hills and follows a northeasterly course for 75 miles and then northward for about 25 miles and finally empties into the South Saskatchewan River in Tp. 20, Rge. 13, W. 3rd Mer.

The only important tributary is Bone Creek, which rises in the Cypress Hills and joins the Swiftcurrent in Tp. 10, Rge. 19, W. 3rd Mer.

The main stream flows through a valley, two to three hundred feet deep and a mile wide, to within a few miles of its mouth, where it enters a deep sandstone gorge, about five hundred feet deep.

The bench land above the creek is of rolling prairie broken by innumerable coulees. The soil is a sandy loam. There is very little tree growth along the stream.

The mean annual rainfall at the town of Swiftcurrent is about 15 inches. This increases slightly at the stream's headwaters. The greatest precipitation occurs during the months of May, June and July. From November to April the stream is frozen over.

There are a number of small irrigation ditches in this drainage basin, and the town of Swiftcurrent takes water for domestic and industrial purposes from the creek.

SWIFTCURRENT CREEK AT POLLOCK'S RANCHE.

This station was established May 18, 1909, by H. R. Carscallen. It is located on Sec. 22, Tp. 7, Rge. 21, W. 3rd Mer., about 4 miles southwest of Southfork P. O.

The channel is straight for 50 feet above and 15 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of sand and gravel. The current is moderate at ordinary stages, becoming sluggish at very low stages of the stream.

The gauge, which is read daily by D. Pollock, is a plain staff, graduated to feet and hundredths, attached to a vertical post sunk in the bed of the stream at the right bank and firmly stayed. It is referred to bench marks as follows:—(1) The top of a hardwood plug driven close to the ground on the left bank beside the corner post of Mr. Pollock's fence, the post blazed and marked B. M.; elevation, 10.16 feet above the zero of the gauge. (2) A hardwood plug driven close to the ground beside a post in the line of fence running east from the corner post and about 100 feet from it, the post blazed and marked B. M.; elevation. 9.24 feet above the zero of the gauge. (3) The top of the ground log at the southeast corner of Mr. Pollock's house, marked with three nail-heads; elevation, 21.28 feet above the zero of the gauge.

Discharge measurements are made at or near the gauge by wading at ordinary stages and at very low stages a weir is used. Mr. Pollock diverts water from the creek into an irrigation ditch about one-half mile above the gauge and when he is using water in his ditch the gauge does not record the total flow of the creek.

DISCHARGE MEASUREMENTS of Swiftcurrent Creek at Pollock's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 15	H. R. Carscallen	4.5	2.44	0.814	0.94	1.97
May 9	"	4.2	1.22	0.548	0.71	0.67*
May 30	"				0.73	0.68*
June 16	R. G. Swan	3.9	1.19	0.386	0.71	0.46*
July 9	"	4.3	1.34	0.309	0.77	0.41*
August 3	"	4.5	1.77	0.429	0.86	0.76
August 8	R. J. Burley				0.90	0.98*
August 10	"				0.86	0.86*
August 11	"				0.83	0.84*
August 13	"				0.93	1.17*
August 16	"				0.86	0.88*
August 26	R. G. Swan				0.82	0.92*
September 16	"	4.0	1.31	0.700	0.79	0.92*
October 12	"	3.8	1.52	0.815	0.83	1.24
November 8	"				0.92	1.83

* Discharge determined by using a 15 inch weir.

PLATE No. 24.

Steam Shovel on Southern Alberta Land Co's Canal, near Gleichen, Alta.

PLATE No. 25.

Steam Shovel on Southern Alberta Land Co's Canal, near Gleichen, Alta.

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Pollock's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	1.10	3.20	0.75	0.75	0.85	1.35
2	1.10	3.20	0.75	0.75	0.90	1.70
3	1.10	3.20	0.75	0.75	0.90	1.70
4	1.10	3.20	0.70	0.55	0.90	1.70
5	1.10	3.20	0.70	0.55	0.85	1.35
6	1.10	3.20	0.70	0.55	0.80	1.05
7	1.10	3.20	0.70	0.55	0.75	0.75
8	1.10	3.20	0.70	0.55	0.75	0.75
9	1.10	3.20	0.70	0.55	0.75	0.75
10	1.10	3.20	0.70	0.55	0.75	0.75
11	1.10	3.20	0.70	0.55	0.75	0.75
12	0.95	2.05	0.70	0.55	0.75	0.75
13	0.95	2.05	0.70	0.55	0.75	*0.75
14	0.95	2.05	0.70	0.55	0.95	*1.90
15	0,95	2.05	0.80	1.05	0.95	*1.85
16	0.95	2.05	0.80	1.05	0.75	*0.60
17	0.95	2.05	0.80	1.05	0.95	*1.75
18	0.95	2.05	0.70	0.55	0.85	*1.10
19	0.95	2.05	0.70	0.55	0.75	*0.55
20	0.95	2.05	0.70	0.55	0.75	*0.50
21	0.95	2.05	0.70	0.55	0.75	*0.50
22	0.95	2.05	0.70	0.55	0.75	*0.45
23	0.85	1.35	0.70	0.55	0.95	*1.45
24	0.85	1.35	0.70	0.55	0.85	*0.80
25	0.85	1.35	0.70	0.55	0.80	*0.55
26	0.85	1.35	0.65	0.40	0.75	*0.30
27	0.85	1.35	0.65	0.40	0.70	0.15
28	0.85	1.35	0.70	0.55	0.70	0.15
29	0.82	1.17	0.70	0.55	0.70	0.15
30	0.82	1.17	0.70	0.55	0.80	0.50
31	....	....	0.75	0.75	....	....

* Changing conditions, June 13-26.

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Pollock's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.75	0.30	0.85	0.75	0.87	*0.90	0.80	1.05
2	0.70	0.15	0.85	0.75	0.87	*0.90	0.80	1.05
3	0.70	0.15	0.85	0.75	0.87	*0.95	0.80	1.05
4	0.70	0.15	0.80	0.50	0.87	*1.00	0.80	1.05
5	0.70	0.15	0.80	0.50	0.87	*1.00	0.80	1.05
6	0.70	0.15	0.85	0.75	0.87	*1.05	0.80	1.05
7	0.70	0.15	0.85	0.75	0.90	*1.30	0.80	1.05
8	0.75	0.30	0.85	0.75	0.92	*1.45	0.80	1.05
9	0.75	0.30	0.85	0.75	0.92	*1.50	0.77	0.87
10	0.75	0.30	0.85	0.75	0.90	*1.45	0.77	0.87
11	0.75	0.30	0.85	0.75	0.90	*1.50	0.78	0.93
12	0.75	0.30	0.85	0.75	0.90	*1.55	0.78	0.93
13	0.90	1.00	0.85	0.75	0.85	*1.25	0.79	0.99
14	0.90	1.00	0.85	0.75	0.85	*1.30	0.79	0.99
15	0.90	1.00	0.85	0.75	0.80	*1.05	0.79	0.99
16	0.85	0.75	0.85	0.75	0.80	1.05	0.79	0.99
17	0.85	0.75	0.85	0.75	0.80	1.05	0.79	0.99
18	0.85	0.75	0.85	0.75	0.90	1.70	0.80	1.05
19	0.85	0.75	0.85	0.75	0.85	1.35	0.80	1.05
20	0.85	0.75	0.85	0.75	0.85	1.35	0.94	1.98
21	0.85	0.75	0.85	0.75	0.85	1.35	0.94	1.98
22	0.85	0.75	0.85	0.75	0.85	1.35	0.94	1.98
23	0.85	9.75	0.85	0.75	0.75	0.75	0.94	1.98
24	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
25	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
26	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
27	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
28	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
29	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
30	0.85	0.75	0.85	0.75	0.75	0.75	0.94	1.98
31	0.85	0.75	0.85	*0.75	....	....	0.94	1.98

* Changing conditions, Aug. 31-Sept. 15.

MONTHLY DISCHARGE of Swiftcurrent Creek at Pollock's Ranche, for 1910.

Drainage area, 12 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	3.20	1.17	2.270	0.189	0.021	135
May	1.05	0.40	0.615	0.051	0.059	38
June	1.90	0.30	0.895	0.075	0.084	53
July	1.00	0.30	0.571	0.048	0.055	35
August	0.75	0.50	0.734	0.061	0.070	45
September	1.70	0.75	1.110	0.093	0.104	66
October	1.98	0.87	1.380	0.115	0.133	85
The period						457

JONES COULEE AT READ'S RANCHE.

This station was established September 23, 1909, by H. R. Carscallen. It is located on Sec. 5, Tp. 8, Rge. 20, W. 3rd Mer., about 300 yards from the surveyed trail to Gul lLake and about 42 miles south of Gull Lake. It is about 2½ miles northeast of South Fork P. O., and near the mouth of the stream.

The channel is straight for 75 feet above and 50 feet below the station. Both banks are high and not liable to overflow. The banks are free from brush, except for a little undergrowth on the left bank. The bed of the stream is composed of soft clay with sand underneath. The current is very sluggish and the water comparatively deep at the station, giving rise to a small amount of vegetation.

The gauge, which is read by W. F. Read, is a plain staff, graduated to feet and hundredths, attached vertically to a post sunk in the bed of the creek at the left bank and securely stayed. It is referred to bench marks as follows:—(1) A spike-head in the top of the final stake driven close to the ground on the right bank and marked B. M.; elevation, 8.25 feet above gauge zero. (2) The top of two spikes driven horizontally into the end of a log at the northwest corner of Mr. Read's stable, the log marked B. M.; elevation 11.46 feet above gauge zero.

Discharge measurements are made a short distance upstream from the gauge by wading and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. o.o.

DISCHARGE MEASUREMENTS of Jones Coulee at Read's Ranche, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 16	H. R. Carscallen	5.7	4.48	0.839	2.48	3.75
May 10	"	7.3	8.67	0.114	2.09	0.99*
May .7	"	7.5	6.91	0.090	1.82	0.62*
June 213	R. G. Swan				1.52	0.13*
July 7	"				1.84	0.37*
August 3	"					Nil.†
August 21	"					Nil.†
September 15	"	8.2	8.70	0.040	1.76	0.31*
October 8	"	8.3	8.36	0.083	1.82	0.70
November 8	"	8.3	9.40	0.126	1.95	1.21

* Discharge determined by using a 15-inch weir.
† Coulee dry from July 30 to August 16.

DAILY GAUGE HEIGHT AND DISCHARGE of Jones Coulee at Read's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	....	....	2.20	1.45	1.75	0.30
2	....	....	2.20	1.45	1.70	0.25
3	2.65	5.58	2.20	1.45	1.70	0.25
4	2.65	5.58	2.20	1.45	1.65	0.21
5	2.60	5.04	2.20	1.45	1.60	0.17
6	2.70	6.12	2.20	1.45	1.65	0.21
7	2.75	6.66	2.20	1.45	1.65	0.21
8	2.70	6.12	2.10	1.02	1.65	0.21
9	2.70	6.12	2.10	1.02	1.60	0.17
10	2.75	6.66	2.10	1.02	1.60	0.17
11	2.65	5.58	2.10	1.02	1.60	0.17
12	2.80	7.20	2.10	1.02	1.65	0.21
13	2.75	6.66	2.10	1.02	1.60	0.17
14	2.60	5.04	2.10	1.02	2.20	1.45
15	2.50	3.96	2.20	1.22	2.10	1.02
16	2.45	3.42	2.20	1.22	2.00	0.72
17	2.40	2.91	2.20	1.22	1.80	0.36
18	2.40	2.91	2.10	1.02	1.80	0.36
19	2.40	2.91	2.25	1.72	1.75	0.30
20	2.40	2.91	2.20	1.45	1.85	0.43
21	2.40	2.91	2.20	1.45	1.65	0.21
22	2.40	2.91	2.25	1.72	1.60	0.17
23	2.45	3.42	2.10	1.02	1.80	0.36
24	2.45	3.42	2.10	1.02	1.85	0.43
25	2.40	2.91	1.85	0.43	1.80	0.36
26	2.35	2.46	1.80	0.36	1.80	0.36
27	2.35	2.46	1.80	0.36	1.80	0.36
28	2.30	2.06	1.80	0.36	1.75	0.30
29	2.35	2.46	1.75	0.30	1.80	0.36
30	2.30	2.06	1.75	0.30	1.80	0.36
31	....	....	1.75	0.30	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Jones Coulee at Read's Ranche, for 1910.—*Continued*.

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.00	0.72			1.60	0.17	1.80	0.36
2	2.60	5.04			1.60	0.17	1.80	0.36
3	2.10	1.02			1.60	0.17	1.80	0.36
4	2.20	1.45			†		1.80	0.36
5	2.10	1.02					1.95	0.60
6	2.00	0.72					1.90	0.51
7	1.85	0.43					1.90	0.51
8	1.85	0.43					1.82	0.39
9	1.85	0.43					1.83	0.40
10	1.90	0.51					1.83	0.40
11	2.10	1.02					1.82	0.39
12	2.10	1.02					1.83	0.40
13	2.10	1.02					1.82	0.39
14	2.00	0.72					1.86	0.45
15	1.80	0.36					1.87	0.46
16	1.80	0.36	1.70	0.25			1.87	0.46
17	1.65	0.21	1.70	0.25			1.86	0.45
18	1.65	0.21	1.65	0.21			1.87	0.46
19	1.60	0.17	1.65	0.21			1.88	0.48
20	1.55	0.14	1.65	0.21			1.88	0.48
21	1.55	0.14	1.60	0.17			1.85	0.43
22	1.60	0.17	1.60	0.17			1.85	0.43
23	1.60	0.17	1.70	0.25	1.85	0.43	1.85	0.43
24	1.65	0.21	1.65	0.21	1.85	0.43	1.86	0.45
25	1.65	0.21	1.65	0.21	1.80	0.36	1.90	0.51
26	1.55	0.14	1.65	0.21	1.80	0.36	1.92	0.55
27	1.50	0.12	1.65	0.21	1.80	0.36	1.90	0.51
28	1.65	0.21	1.65	0.21	1.80	0.36	1.86	0.45
29	1.20	0.01	1.65	0.21	1.80	0.36	1.87	0.46
30	1.10	0.00	1.65	0.21	1.80	0.36	1.90	0.51
31	*		1.65	0.21			1.92	0.55

* Coulee dry from July 30 to August 16.
† No gauge height observations taken from September 3 to September 23.

MONTHLY DISCHARGE of Jones Coulee at Read's Ranche, for 1910.

Drainage area, 43 square miles.

Month.	Discharge in Second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (3-30)	6.66	2.06	4.23	0.098	1.020	235
May	1.45	0.30	1.06	0.024	0.027	65
June	1.45	0.17	0.35	0.008	0.009	21
July	5.04	0.00	0.59	0.014	0.016	36
August	0.25	0.00	0.11	0.003	0.004	7
September (11 days)	0.43	0.17	0.32	0.007	0.003	6
October	0.60	0.36	0.45	0.011	0.012	28
The period						398

SWIFTCURRENT CREEK AT SINCLAIR'S RANCHE (Upper Station.)

This station was established June 15, 1910, by R. G. Swan. It is located on the S.E. ¼ Sec. 18, Tp. 10, Rge. 19, W. 3rd Mer., about 200 feet upstream from the mouth of Bone Creek, and is about 200 yards above the lower station, which is located on the highway bridge on the surveyed trail to Gull Lake, below the mouth of Bone Creek.

The channel is straight for about 200 feet above and below the station. Both banks are fairly high, covered with a growth of willow brush, and not liable to overflow. The bed of the stream is sandy and may shift at high stages.

The gauge is a plain staff, graduated to feet and hundredths, spiked to a vertical post sunk in the bed of the stream at the right bank and stayed.

Discharge measurements are made at the station by wading. The station is close to the mouth of Bone Creek and it will be affected at high stages by backwater from the large stream.

The gauge was read once each day by Geo. A. Mackintosh, who worked at Mr. Sinclair's ranche, about a mile distant from the station.

DISCHARGE MEASUREMENTS of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq. ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 28	H. R. Carscallen	9.5	4.05	0.849	....	3.44
June 15	R. G. Swan	9.8	5.55	0.829	0.75	4.60
July 8	"	6.7	1.77	0.571	0.47	1.01
August 2	"	....	....	....	0.14	Nil.*
August 20	"	5.0	0.98	0.316	0.33	0.31
September 14	"	7.1	3.10	0.606	0.54	1.88
October 7	"	7.0	2.84	0.754	0.57	2.14

* No flow, water standing in pools from July 30 to August 6.

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), for 1910.

Day.	June.		July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1			0.54	1.85	0.15	0.00	0.37	0.52	0.50	1.45
2			0.54	1.85	0.14	0.00	0.40	0.70	0.50	1.45
3			0.51	1.55	0.14	0.00	0.39	0.64	0.49	1.37
4			0.64	3.02	0.13	0.00	0.45	1.05	0.51	1.55
5			0.59	2.39	0.15	0.00	0.55	1.95	0.55	1.95
6			0.54	1.85	0.25	0.08	0.57	2.17	0.54	1.85
7			0.49	1.37	0.39	0.64	0.65	3.15	0.52	1.65
8			0.47	1.21	0.45	1.05	0.63	2.89	0.52	1.65
9			0.45	1.05	0.41	0.77	0.60	2.50	0.51	1.55
10			0.54	1.85	0.34	0.36	0.58	2.28	0.51	1.55
11			0.59	2.39	0.30	0.20	0.57	2.17	0.51	1.55
12			0.53	1.75	0.30	0.20	0.55	1.95	0.51	1.55
13			0.51	1.55	0.31	0.24	0.54	1.85	0.51	1.55
14			0.49	1.37	0.34	0.36	0.54	1.85	0.52	1.65
15	0.75	4.60	0.46	1.13	0.38	0.58	0.53	1.75	0.52	1.65
16	0.7	3.85	0.41	0.77	0.40	0.70	0.52	1.65	0.52	1.65
17	0.7	3.85	0.41	0.77	0.40	0.70	0.51	1.55	0.52	1.65
18	0.64	3.02	0.39	0.64	0.39	0.64	0.50	1.45	0.53	1.75
19	0.58	2.28	0.38	0.58	0.36	0.46	0.50	1.45	0.54	1.85
20	0.54	1.85	0.28	0.15	0.29	0.17	0.49	1.37	0.54	1.85
21	0.54	1.85	0.35	0.40	0.27	0.13	0.49	1.37	0.54	1.85
22	0.53	1.75	0.33	0.32	0.23	0.06	0.50	1.45	0.54	1.85
23	0.58	2.28	0.31	0.24	0.29	0.17	0.50	1.45	0.54	1.85
24	0.64	3.02	0.29	0.17	0.34	0.36	0.51	1.55	0.55	1.95
25	0.54	1.85	0.26	0.10	0.40	0.70	0.53	1.75	0.55	1.95
26	0.47	1.21	0.25	0.08	0.38	0.58	0.53	1.75	0.56	2.06
27	0.46	1.13	0.24	0.07	0.35	0.40	0.52	1.65	0.56	2.06
28	0.43	0.91	0.21	0.03	0.34	0.36	0.52	1.65	0.57	2.17
29	0.45	1.05	0.19	0.02	0.32	0.28	0.52	1.65	0.59	2.39
30	0.51	1.55	0.19	0.02	0.30	0.20	0.51	1.55	0.60	2.50
31			0.15	*0.00	0.34	0.36			0.61	2.63

* No flow, water standing in pools from July 30 to August 6.

MONTHLY DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Upper Station), for 1910.

Drainage area, 162 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
June (15-30)	4.60	0.91	2.253	0.014	0.008	72
July	3.02	0.00	0.985	0.006	0.0007	61
August	1.05	0.00	0.347	0.002	0.0024	21
September	3.15	0.52	1.690	0.010	0.011	101
October	2.63	1.37	1.806	0.011	0.013	111
The period						366

BONE CREEK AT LEWIS' RANCHE.

This station was established July 2, 1908, by F. T. Fletcher. It is located at the highway bridge on Sec. 34, Tp. 8, Rge. 22, W. 3rd Mer. It is on the surveyed trail from Skull Creek P.O. to East End P. O. and about fifteen miles south of Skull Creek P. O., by trail. The bridge is a small wooden structure, built in the form of a culvert with a rectangular cross-section.

The channel is straight for 50 feet above the station; below the station it curves gradually to the left after emerging from the downstream side of the bridge. The right bank is high and will not overflow; the left bank is comparatively low, but no indication of the water overflowing the bank can be found. Both banks are free from brush at the station. The bed of the stream is sandy with some large stones scattered along the cross-section. The current is moderate, becoming very swift below the station.

The gauge, which is read daily by C. L. Lewis, is a plain staff, graduated to feet and hundredths, attached vertically to the left abutment on the upstream side of the bridge. The gauge is referred to bench marks as follows:—(1) The head of a spike surrounded by a circle of nail-heads in the top of the stringer on the left abutment at the upstream side of the bridge, marked B. M. with white paint; elevation, 4.17 feet above the zero of the gauge. (2) The top of the iron pin in the road mound 754 feet north of the bridge on the left bank of the creek; elevation, 5.92 feet above the zero of the gauge.

Discharge measurements are made from the upstream side of the bridge during high water. The initial point for soundings is the inner face of the left abutment. Low-water measurements are made near the station by wading.

Discharge Measurements of Bone Creek at Lewis' Ranche, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 14	H. R. Carscallen	7.5	3.23	0.796	0.40	2.57
May 9	"	7.5	2.81	0.676	0.34	1.90
May 26	"	7.5	3.07	0.496	0.34	1.53
June 13	R. G. Swan	7.4	2.83	0.537	0.35	1.52
July 7	"	7.5	2.64	0.553	0.25	1.46
August 7	"	7.2	2.47	0.393	0.21	0.97
August 27	"	7.0	2.44	0.594	0.31	1.45
September 17	"	6.7	2.42	0.591	0.34	1.43
October 14	"	6.8	2.54	0.604	0.32	1.53

Daily Gauge Height and Discharge of Bone Creek at Lewis' Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.4	2.5	0.40	2.5	0.35	1.9
2	0.4	2.5	0.40	2.5	0.35	1.9
3	0.4	2.5	0.40	2.5	0.40	2.5
4	0.4	2.5	0.40	2.5	0.40	2.5
5	0.4	2.5	0.40	2.5	0.40	2.5
6	0.4	2.5	0.40	2.5	0.40	2.5
7	0.4	2.5	0.40	2.5	0.40	2.5
8	0.4	2.5	0.40	2.5	0.40	2.5
9	0.4	2.5	0.35	1.9	0.35	1.9
10	0.4	2.5	0.35	1.9	0.35	1.9
11	0.4	2.5	0.40	2.5	0.35	1.9
12	0.4	2.5	0.40	2.5	0.35	1.9
13	0.4	2.5	0.40	2.5	0.35	1.9
14	0.4	2.5	0.40	2.5	0.35	1.9
15	0.4	2.5	0.50	4.8	0.40	2.5
16	0.4	2.5	0.40	2.5	0.40	2.5
17	0.4	2.5	0.40	2.5	0.50	4.8
18	0.4	2.5	0.40	2.5	0.45	3.5
19	0.4	2.5	0.40	2.5	0.45	3.5
20	0.4	2.5	0.40	2.5	0.40	2.5
21	0.4	2.5	0.40	2.5	0.35	1.9
22	0.4	2.5	0.40	2.5	0.35	1.9
23	0.4	2.5	0.40	2.5	0.35	1.9
24	0.4	2.5	0.40	2.5	0.35	1.9
25	0.4	2.5	0.30	1.4	0.35	1.9
26	0.4	2.5	0.30	1.4	0.30	1.4
27	0.4	2.5	0.30	1.4	0.30	1.4
28	0.4	2.5	0.40	2.5	0.30	1.4
29	0.4	2.5	0.40	2.5	0.25	1.1
30	0.4	2.5	0.40	2.5	0.25	1.1
31			0.40	2.5		

DAILY GAUGE HEIGHT AND DISCHARGE of Bone Creek at Lewis' Ranche, for 1910.—*Continued*.

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.30	1.4	0.25	1.1	0.30	1.4	0.30	1.4
2	0.30	1.4	0.25	1.1	0.30	1.4	0.30	1.4
3	0.30	1.4	0.25	1.1	0.30	1.4	0.30	1.4
4	0.30	1.4	0.25	1.1	0.30	1.4	0.35	1.9
5	0.30	1.4	0.20	0.9	0.30	1.4	0.32	1.6
6	0.30	1.4	0.25	1.1	0.30	1.4	0.31	1.5
7	0.30	1.4	0.20	0.9	0.30	1.4	0.30	1.4
8	0.30	1.4	0.20	0.9	0.30	1.4	0.30	1.4
9	0.30	1.4	0.20	0.9	0.30	1.4	0.30	1.4
10	0.30	1.4	0.20	0.9	0.30	1.4	0.30	1.4
11	0.30	1.4	0.20	0.9	0.30	1.4	0.30	1.4
12	0.30	1.4	0.20	0.9	0.30	1.4	0.30	1.4
13	0.30	1.4	0.40	2.5	0.30	1.4	0.30	1.4
14	0.30	1.4	0.30	1.4	0.30	1.4	0.32	1.6
15	0.20	0.9	0.30	1.4	0.30	1.4	0.32	1.6
16	0.20	0.9	0.35	1.9	0.30	1.4	0.32	1.6
17	0.20	0.9	0.30	1.4	0.34	1.8	0.32	1.6
18	0.20	0.9	0.30	1.4	0.34	1.8	0.32	1.6
19	0.20	0.9	0.30	1.4	0.36	2.0	0.32	1.6
20	0.20	0.9	0.30	1.4	0.3	2.0	0.32	1.6
21	0.20	0.9	0.30	1.4	0.36	2.0	0.32	1.6
22	0.20	0.9	0.35	1.9	0.30	1.4	0.31	1.5
23	0.20	0.9	0.35	1.9	0.30	1.4	0.32	1.6
24	0.20	0.9	0.35	1.9	0.31	1.5	0.32	1.6
25	0.20	0.9	0.30	1.4	0.31	1.5	0.32	1.6
26	0.20	0.9	0.30	1.4	0.31	1.5	0.21	0.9
27	0.20	0.9	0.30	1.4	0.30	1.4	0.21	0.9
28	0.25	1.1	0.30	1.4	0.30	1.4	0.32	1.6
29	0.25	1.1	0.30	1.4	0.30	1.4	0.32	1.6
30	0.25	1.1	0.30	1.4	0.30	1.4	0.32	1.6
31	0.25	1.1	0.30	1.4	....	....	0.21	0.9

MONTHLY DISCHARGE of Bone Creek at Lewis' Ranche, for 1910.

Drainage area, 8 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	2.5	2.5	2.50	0.312	0.348	149
May	4.8	1.4	2.43	0.304	0.350	149
June	4.8	1.1	2.18	0.272	0.304	130
July	1.4	0.9	1.15	0.144	0.166	71
August	2.5	0.9	1.34	0.167	0.193	82
September	2.0	1.4	1.50	0.187	0.209	89
October	1.9	0.9	1.47	0.184	0.212	90
The period						760

SWIFTCURRENT CREEK AT SINCLAIR'S RANCHE (Lower Station.)

This station was established on May 27, 1910, by H. R. Carscallen. It is located in Sec. 17, Tp. 10, Rge. 19, W. 3rd Mer., at the highway bridge on the surveyed trail from East End to Gull Lake, and just below the mouth of Bone Creek.

The channel is straight for 75 feet above and 20 feet below the station. The left bank has a gradual slope, is high and well wooded. The right bank rises abruptly. It is also high and well wooded. The stream bed is sandy in character, free from vegetation and liable to shift at high water. The current at this point is sluggish.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the left abutment. Low water measurements are made by wading, 100 feet upstream.

The gauge is of the standard chain type. The box is nailed securely to the floor of the bridge on the downstream side. The length of chain from bottom of weight to marker is 21.2 feet. The elevation of the gauge is referred to two bench marks, as follows:—(1) A spike-head in the cap of the left abutment of the bridge on the downstream side and marked B. M.; elevation, 16.96 above the datum of the gauge, and (2) two spikes driven in the first pile of the left wing wall on the downstream side of the bridge and marked B. M.; elevation, 12.09 above the zero of the gauge.

This gauge was also read by Geo. A. Mackintosh.

DISCHARGE MEASUREMENTS of Swiftcurrent Creek at Sinclair's Ranche (Lower Station), in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 28	H. R. Carscallen	16.5	32.74	0.454	3.05	14.88
June 15	R. G. Swan	18.5	35.30	0.614	3.36	21.69
July 8	"	17.0	26.20	0.362	2.75	9.49
August 2	"	14.5	17.27	0.111	2.27	1.92
August 20	"	15.5	25.47	0.258	2.73	6.57
September 14	"	17.3	28.94	0.383	2.86	11.09
October 7	"	15.0	30.06	0.452	2.99	13.59
November 7	"	25.0	35.75	0.498	3.22	17.56*

* Measurement taken at wading station.

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Lower Station), for 1910.

Day.	May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			3.02	14.30	2.97	13.30
2			3.05	14.90	2.82	10.30
3			3.43	23.16	2.81	10.10
4			3.38	22.06	2.92	12.30
5			3.27	19.64	2.85	10.90
6			3.19	17.88	2.82	10.30
7			3.10	15.90	2.78	9.50
8			3.07	15.30	2.75	8.90
9			2.98	13.50	2.74	8.72
10			2.95	12.90	2.88	11.50
11			2.88	11.50	3.01	14.10
12			2.87	11.30	2.88	11.50
13			2.86	11.10	2.75	8 90
14			3.08	15.50	2.70	8.00
15			3.33	20.96	2.61	6.38
16			3.12	16.34	2.52	4.98
17			3.34	21.18	2.50	4.70
18			3.17	17.44	2.46	4.14
19			2.86	11.10	2.43	3.72
20			2.86	11.10	2.37	2.94
21			2.84	10.70	2.41	3.44
22			2.83	10.50	2.59	6.04
23			3.00	13.90	2.57	5.72
24			3.11	16.12	2.56	5.56
25			3.10	15.90	2.55	5.40
26			2.79	9.70	2.51	4.84
27	3.02	14.30	2.73	8.54	2.49	4.56
28	3.05	14.90	2.68	7.64	2.42	3.58
29	3.08	15.50	2.64	6.92	2.42	3.58
30	3.06	15.10	2.93	12.50	2.39	3.18
31	3.05	14.90			2.36	2.82

DAILY GAUGE HEIGHT AND DISCHARGE of Swiftcurrent Creek, at Sinclair's Ranche, (Lower Station), for 1910.—*Continued.*

Day.	August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.29	2.12	2.75	8.90	2.95	12.90
2	2.31	2.30	2.75	8.90	2.95	12.90
3	2.35	2.70	2.74	8.72	2.94	12.70
4	2.35	2.70	2.87	11.30	2.96	13.10
5	2.41	3.44	3.05	14.90	3.04	14.70
6	2.52	4.98	3.07	15.30	3.04	14.70
7	2.74	8.72	3.10	15.90	2.97	13.30
8	2.70	8.00	3.10	15.90	2.96	13.10
9	2.69	7.82	2.99	13.70	2.96	13.10
10	2.61	6.38	2.96	13.10	2.95	12.90
11	2.55	5.40	2.95	12.90	2.95	12.90
12	2.53	5.12	2.93	12.50	2.95	12.90
13	2.55	5.40	2.91	12.10	2.95	12.90
14	2.59	6.04	2.89	11.70	2.96	13.10
15	2.74	8.72	2.88	11.50	2.96	13.10
16	2.85	10.90	2.87	11.30	2.96	13.10
17	2.83	10.50	2.87	11.30	2.98	13.50
18	2.79	9.70	2.85	10.90	2.99	13.70
19	2.74	8.72	2.85	10.90	3.01	14.10
20	2.69	7.82	2.86	11.10	3.02	14.30
21	2.69	7.82	2.86	11.10	3.02	14.30
22	2.66	7.28	2.87	11.30	3.02	14.30
23	2.70	8.00	2.89	11.70	3.02	14.30
24	2.73	8.54	2.94	12.70	3.03	14.50
25	2.83	10.50	3.05	14.90	3.03	14.50
26	2.80	9.90	3.10	15.90	3.03	14.50
27	2.76	9.10	3.15	17.00	3.04	14.70
28	2.74	8.72	3.11	16.12	3.04	14.70
29	2.73	8.54	3.05	14.90	3.04	14.70
30	2.72	8.36	2.99	13.70	3.05	14.90
31	2.73	8.54	....	....	3.06	15.10

MONTHLY DISCHARGE of Swiftcurrent Creek at Sinclair's Ranche (Lower Station), for 1910.

Drainage area, 336 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
May (27-31)	15.50	14.30	14.940	0.045	0.008	148
June	23.16	6.92	14.316	0.043	0.048	852
July	14.10	2.82	7.223	0.022	0.025	444
August	10.90	2.12	7.186	0.021	0.024	442
September	17.00	8.72	12.738	0.038	0.042	758
October	15.10	12.70	13.790	0.041	0.047	848
The period						3,492

SWIFTCURRENT CREEK AT SWIFT CURRENT.

This station was established April 30, 1910, by H. R. Carscallen. It is located at the traffic bridge on the north side of the C. P. R. tracks in the town of Swiftcurrent on Sec. 30, Tp. 15, Rge. 13, W. 3rd Mer.

The channel curves slightly but is almost straight for about 300 feet above the station, and is straight for about 300 feet below. The right bank is rather low with a gradual slope; the left bank is high. Both banks are clear of brush and undergrowth and are not liable to overflow. The bed of the stream is sandy with a few large stones and is liable to shift at high stages. Stones in the cross-section affect the regularity of the current to some extent. The current is sluggish at low stages.

The gauge is a plain staff, graduated to feet and hundredths, spiked vertically to the inside face of the left abutment of the bridge. It is referred to two bench marks:—(1) Top of two spikes in the opposite face of abutment to which the gauge is attached; elevation, 7.11. (2) Top of bolt-head in the top of the right abutment; elevation, 13.49.

During ordinary stages, discharge measurements are made from the downstream side of the bridge, but at low stages, they are made by wading near the bridge. The initial point for soundings is the inner face of the row of piles at end of the south approach.

The gauge was read once each day by C. E. Wesley, a teamster living within 200 yards of the bridge.

The survey did not obtain sufficient data during 1910, to plot a gauge height discharge curve and the records for 1910 are therefore not published in this report, but will be included in the next annual report.

Miscellaneous Discharge Measurements of Swiftcurrent Creek Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of section.	Discharge.
				Feet.	Sq.-ft.	Sec-ft.
May 9	D. Pollock's Ditch		H. R. Carscallen	2.3	0.55	0.63
May 30	"		"	3.0	0.88	0.77
June 16	"		R. G. Swan	3.1	1.15	0.91
July 9	"		"	2.8	0.81	0.60
August 3	"		"			Dry.

ANTELOPE LAKE DRAINAGE BASIN.

General Description.

Antelope Lake is a small body of saline water, 6 miles long, and from 1 to 1½ miles wide. Its elevation is 2,304 feet above sea level. It lies in a deep depression north of the main line of the Canadian Pacific Railway, in Tp. 15, Rge. 18, W. 3rd Mer., and drains an area of about 350 sq. miles.

The lake receives its supply from Bridge Creek which rises in the Cypress Hills. The altitude of the source of this creek is 2,800 feet, and it has an average fall of 15 feet per mile.

The valley traversed by Bridge Creek is narrow and quite shallow, rarely exceeding 100 feet in depth. The land lying along the creek bottom is very flat and liable to become inundated during periods of flood. The bench land is rolling prairie cut up by innumerable coulees which drain the surrounding country into the main valley.

The mean annual rainfall amounts to about 14 inches, most of which occurs during May, June and July. The creek has only a small flow, and is dry for some months.

A number of irrigation schemes receive their supply from this basin. The largest of these is Moorehead and Fearon's works which diverts water from Bridge Creek in Sec. 33, Tp. 10, Rge. 22, W. 3rd Mer.

Bridge Creek, near Skull Creek,

This station was established July 29, 1909, by H. R. Carscallen. It is located at the highway bridge on the surveyed trail running eastward from Maple Creek on Sec. 11, Tp. 11, Rge. 22, W. 3rd Mer. It is about 4 miles from Skull Creek P. O., and 27 miles from Maple Creek.

The channel is straight for 100 feet above and 30 feet below the station. Both banks are high and not liable to overflow. The stream is entirely devoid of tree growth. The bed of the creek is composed of clay and may shift somewhat at high stages. There is a small amount of vegetation at the station. The current is sluggish.

The gauge, which is read once each day by James Mann, is a plain staff, graduated to feet and hundredths, attached vertically to the centre pile on the downstream side of the bridge. The gauge is referred to bench marks as follows:—(1) The head of a spike surrounded by a circle of nail-heads in the top of the stringer at the right or east abutment on the downstream side of the bridge; elevation, 9.83 feet above gauge zero. (2) The head of a spike in the top of a pointed 6 inch wooden post firmly sunk into the ground on the left bank about 60 feet northwest of the gauge, the post blazed and marked B. M.; elevation, 6.26 feet above gauge zero.

During high water discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the left or west abutment. Low-water measurements are made near the bridge by wading, and at very low stages a weir is used.

DISCHARGE MEASUREMENTS at Bridge Creek, near Skull Creek, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq.-ft.	Ft. per sec.	Feet.	Sec.-ft.
April 13	H. R. Carscallen	6.5	3.21	0.296	1.57	0.95
May 7	"				1.13	0.08*
May 25	"	3.5	0.60	0.066	1.08	0.04*
June 10	R. G. Swan				0.83	Nil.
July 6	G. H. Whyte					Nil.
July 30	"					Nil.
August 19	R. G. Swan					Nil.

* Discharge determined by using a 15 -inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Bridge Creek, near Skull Creek, for 1910.

Day.	April.		May.		June.	
	Gauge Height	Discharge.	Gauge Height.	Discharge.	Gauge Height	Discharge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	1.7	1.35	1.3	0.32	1.1	0.06
2	1.7	1.35	1.3	0.32	1.0	0.01
3	1.7	1.35	1.3	0.32	0.9	* 0.00
4	1.7	1.35	1.3	0.32	0.9	0.00
5	1.7	1.35	1.3	0.32	0.9	0.00
6	1.7	1.35	1.2	0.17	0.9	0.00
7	1.7	1.35	1.1	0.06	0.9	0.00
8	1.7	1.35	1.1	0.06	0.9	0.00
9	1.7	1.35	1.1	0.06	0.9	0.00
10	1.6	1.03	1.1	0.06	0.8	0.00
11	1.6	1.03	1.1	0.06	0.7	0.00
12	1.6	1.03	1.1	0.06	0.7	0.00
13	1.6	1.03	1.1	0.06	0.7	0.00
14	1.6	1.03	1.1	0.06	0.7	0.00
15	1.6	1.03	1.2	0.17	0.7	0.00
16	1.5	0.75	1.2	0.17	0.7	0.00
17	1.4	0.51	1.2	0.17	0.7	0.00
18	1.4	0.51	1.2	0.17	0.5	0.00
19	1.4	0.51	1.2	0.17	†	
20	1.4	0.51	1.2	0.17		
21	1.4	0.51	1.2	0.17		
22	1.4	0.51	1.2	0.17		
23	1.3	0.32	1.1	0.06		
24	1.3	0.32	1.1	0.06		
25	1.3	0.32	1.1	0.06		
26	1.2	0.17	1.1	0.06		
27	1.2	0.17	1.1	0.06		
28	1.2	0.17	1.1	0.06		
29	1.3	0.32	1.1	0.06		
30	1.3	0.32	1.1	0.06		
31			1.1	0.06		

* No flow, water standing in pools from June 2 to June 19.
† Creek dry from June 18 to end of year.

MONTHLY DISCHARGE of Bridge Creek, near Skull Creek, for 1910.

Drainage area, 15 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches Drainage area.	Total in acre-feet.
April	1.35	0.17	0.81	0.054	0.06	48
May	0.32	0.06	0.13	0.009	0.01	8
The period						56

MISCELLANEOUS DISCHARGE MEASUREMENTS of Antelope Lake Drainage Basin, in 1910.

DATE.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		Sec.-ft.
June 18	Bridge Creek	33-10-22-3	R. J. Burley	*		0.16
June 24	"	"	"	*		0.22
June 24	"	"	"	*		0.18

* Weir measurements.

LAKE OF THE NARROWS DRAINAGE BASIN.

General Description.

Lake of the Narrows is a small lake, 3 miles long and 1½ miles wide, in Township 3, Range 23. West of the 3rd Meridian. It has a drainage area of about 200 square miles.

The principal stream in the basin is Skull Creek, which rises in the eastern slope of Cypress Hills. It flows through a small valley for the greater part of its course, and as it nears the lake, the valley widens out into large meadows. The surrounding country is rolling prairie.

In very dry years, such as 1910, Skull Creek goes dry for a short time. The mean annual precipitation in the drainage basin is about 13 inches.

There are several small irrigation ditches in this drainage basin, the largest of which is Moorhead and Fearon's ditch, which diverts water from Skull Creek.

SKULL CREEK, NEAR SKULL CREEK.

This station was established June 29, 1908, by F. T. Fletcher. It is located on Sec. 10, Tp. 11, Rge. 22, W. 3rd Mer., at the highway bridge on the surveyed trail running east from Maple Creek. It is about two miles north of Skull Creek P. O., and about twenty-five miles east of Maple Creek, by trail.

The channel is straight for 100 feet above and 150 feet below the station. Both banks are high and not liable to overflow. The banks are clear of brush for about 50 feet above and below the station, and then become densely wooded. The bed of the stream is composed of sand and may shift somewhat at high stages. The current is moderate.

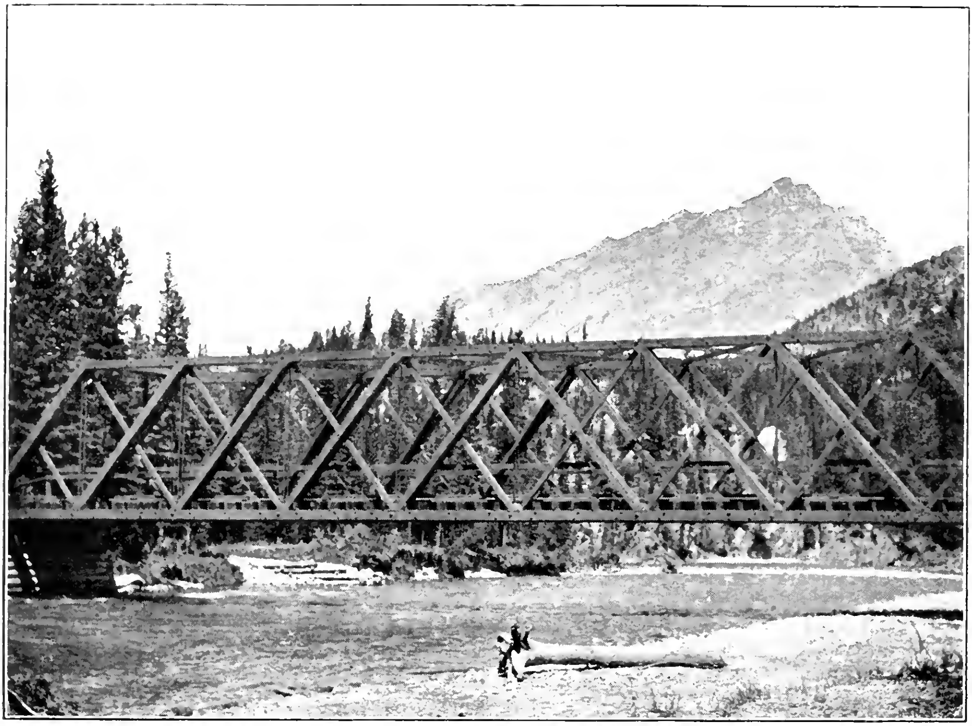
The gauge, which is read once each day by James Mann, is a plain staff, graduated to feet and hundredths, attached vertically to the centre pile on the upstream or south side of the bridge. The gauge is referred to bench marks as follows:—(1) A bolt-head surrounded by a circle of nails in the top of the stringer at the right or east abutment on the upstream side of the bridge; elevation, 11.96 feet above the zero of the gauge. (2) The top of the iron pin in the road mound about 50 feet southeast of the bridge on the right or east bank; elevation, 14.19 feet above the zero of the gauge.

Discharge measurements are made from the upstream side of the bridge. The initial point for soundings is the inner face of the right abutment of the bridge. There is only one channel at low stages, but owing to the centre row of piles supporting the bridge there are two channels at high stages of the stream. Low-water measurements are made at or near the gauge by wading, and at very low stages a weir is used.

DISCHARGE MEASUREMENTS of Skull Creek, near Skull Creek, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	Sq.-ft.	Ft. per sec.	Feet.	Sec.-ft.
April 13	H. R. Carscallen	7.8	5.24	0.948	1.04	4.97
May 7	"	6.9	2.95	0.820	0.82	2.42
May 25	"	6.6	2.74	0.701	0.72	1.92
June 10	R. G. Swan	6.4	2.29	0.629	0.73	1.44
July 6	G. H. Whyte	4.0	0.87	0.552	0.41	0.48
July 30	"					*Nil.
August 19	R. G. Swan	4.0	0.78	0.449	0.41	0.35
September 14	H. R. Carscallen	6.8	2.04	0.594	0.63	1.22
October 7	R. G. Swan	5.6	2.15	0.761	0.67	1.64
November 5	"	6.4	2.74	0.687	0.71	1.88

* Creek dry from July 14 to August 10, and from August 12 to August 16.



Spray River, near Banff, Alta.; in Summer.

Spray River, near Banff, Alta.; in Winter.

DAILY GAUGE HEIGHT AND DISCHARGE of Skull Creek, near Skull Creek, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.04	5.0	0.9	3.5	0.7	1.8
2	1.0	4.5	0.9	3.5	0.7	1.8
3	1.0	4.5	0.9	3.5	0.8	2.6
4	0.9	3.5	0.9	3.5	0.8	2.6
5	1.0	4.5	0.9	3.5	0.8	2.6
6	1.0	4.5	0.9	3.5	0.8	2.6
7	1.0	4.5	0.8	2.6	0.7	1.8
8	0.9	3.5	0.8	2.6	0.7	1.8
9	1.0	4.5	0.8	2.6	0.7	1.8
10	1.0	4.5	0.8	2.6	0.7	1.8
11	1.0	4.5	0.8	2.6	0.6	1.1
12	1.0	4.5	0.8	2.6	0.6	1.1
13	1.0	4.5	0.8	2.6	0.5	0.6
14	1.0	4.5	0.8	2.6	0.5	0.6
15	1.0	4.5	0.9	3.5	0.5	0.6
16	1.0	4.5	1.1	5.7	0.6	1.1
17	1.0	4.5	1.1	5.7	0.8	2.6
18	1.0	4.5	1.0	4.5	0.7	1.8
19	1.0	4.5	1.0	4.5	0.6	1.1
20	1.0	4.5	1.0	4.5	0.5	0.6
21	1.0	4.5	0.9	3.5	0.3	*0.1
22	1.0	4.5	0.9	3.5	0.5	0.6
23	1.0	4.5	0.8	2.6	0.6	1.1
24	1.0	4.5	0.8	2.6	0.5	0.6
25	1.0	4.5	0.7	1.8	0.5	0.6
26	1.0	4.5	0.7	1.8	0.4	0.3
27	1.0	4.5	0.7	1.8	0.3	0.1
28	0.9	3.5	0.7	1.8	0.2	*0.05
29	0.9	3.5	0.7	1.8	0.1	*0.0
30	0.9	3.5	0.7	1.8	0.0	*0.0
31	....	....	0.7	1.8	....	....

* Stream was diverted above gauge.

DAILY GAUGE HEIGHT AND DISCHARGE of Skull Creek, near Skull Creek, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.0	*0.0			0.50	0.6	0.65	1.40
2	0.2	0.05			0.60	1.1	0.65	1.40
3	0.3	0.1			0.70	1.8	0.66	1.52
4	0.4	0.3			0.80	2.6	0.66	1.52
5	0.5	0.6			0.70	1.8	0.72	1.96
6	0.4	0.3			0.70	1.8	0.75	2.20
7	0.3	0.1			0.90	3.5	0.68	1.66
8	0.3	0.1			1.00	4.5	0.70	1.80
9	0.3	0.1			0.80	2.6	0.70	1.80
10	0.5	0.6	0.2	0.05	0.70	1.8	0.70	1.80
11	0.7	1.8	0.1	0.0	0.70	1.8	0.78	2.44
12	0.5	0.6			0.70	1.8	0.78	2.44
13	0.3	0.1			0.70	1.8	0.78	2.44
14	0.2	0.05			0.63	1.31	0.79	2.52
15	0.0	†			0.56	0.90	0.79	2.52
16			0.5	0.6	0.55	0.85	0.79	2.52
17			0.6	1.1	0.55	0.85	0.80	2.60
18			0.5	0.6	0.56	0.90	0.80	2.60
19			0.4	0.3	0.56	0.90	0.82	2.78
20			0.4	0.3	0.56	0.90	0.85	3.05
21			0.4	0.3	0.56	0.90	0.82	2.78
22			0.4	0.3	0.58	1.00	0.82	2.78
23			0.4	0.3	0.59	1.05	0.82	2.78
24			0.4	0.3	0.66	1.52	0.82	2.78
25			0.6	1.1	0.70	1.80	0.85	3.05
26			0.5	0.6	0.72	1.96	0.87	3.23
27			0.5	0.6	0.65	1.10	0.86	3.14
28			0.5	0.6	0.64	1.38	0.84	2.96
29			0.5	0.6	0.62	1.24	0.82	2.78
30			0.5	0.6	0.62	1.24	0.81	2.69
31			0.5	0.6			0.80	2.60

* Stream was diverted above gauge.
† Creek dry July 15, Aug. 9 and Aug. 11-15.

MONTHLY DISCHARGE of Skull Creek, near Skull Creek P. O., for 1910.
Drainage area, 43 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	5.00	3.50	4.35	0.101	0.113	259
May	5.70	1.80	3.06	0.071	0.082	188
June	2.60	0.00	1.20	0.028	0.031	71
July	1.80	0.00	0.16	0.004	0.004	9
August	1.10	0.00	0.28	0.007	0.008	17
September	4.50	0.60	1.58	0.037	0.041	94
October	3.23	1.40	2.40	0.056	0.065	148
The period						786

MISCELLANEOUS DISCHARGE MEASUREMENTS of Lake of the Narrows Drainage Basin, in 1910.

Date	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge
				Feet.		*Sec.-ft.*
June 18	Skull Creek	S.E. 32-10-22-3	R. J. Burley	7.6	2.51	1.62
June 18	"	"	"	7	1.74	1.44
June 23	"	"	"	7.1	2.46	1.33
June 24	"	"	"	9	4.55	2.16
June 5	"	"	"	8.4	3.34	0.95

CRANE LAKE DRAINAGE BASIN.

General Description.

Crane Lake is one of the largest of the many lakes which receive their supply from the drainage on the northern slope of the Cypress Hills. It is situated in Tp. 13, Rge. 23, W. 3rd Mer., and covers an area of 25 square miles.

The lake which has no outlet is shallow and the water saline in character.

There are only two streams of importance in this basin, namely: Piapot and Bear Creeks, which rise in the Cypress Hills and join in Sec. 7, Tp. 12, Rge. 23, W. 3rd Mer.

To the north of the lake the Sand Hills extend northwestward for forty miles. South of the lake and along the course of Piapot and Bear Creeks the country is rolling prairie.

The mean annual rainfall which occurs chiefly during the spring months amounts to about 12 inches.

During the winter season, from November to March, the streams are frozen over.

East Branch of Bear Creek at Johnson's Ranche.

This station was established August 18, 1909, by H. R. Carscallen. It is located on Sec. 21, Tp. 10, Rge. 23, W. 3rd Mer., about a mile and a half southeast of Skibereen P. O.

The channel is straight for 50 feet above and 40 feet below the station. Both banks are high and not liable to overflow, unless in cases of extreme floods. The banks are free from brush at the station, but are wooded above and below. The bed of the stream is composed of coarse gravel and stones. The large stones in the bed of the stream make accurate soundings at the station rather difficult to obtain. The current is moderate.

The gauge, which is read once each day by Ralph Johnson, is a plain staff, graduated to feet and hundredths, attached to a vertical post sunk in the bed of the stream at the right bank and securely stayed. The gauge is referred to bench marks as follows:—(1) A spike-head in the top of a pointed black-birch stump on the high bank about 40 feet southeast of the gauge, the stump blazed and marked B. M.; elevation, 8.99 feet above the zero of the gauge. (2) A spike-head in the top of a pointed black-birch stump, on the right bank about 30 feet northeast of the gauge the stump blazed and marked B. M.; elevation, 6.89 feet above the zero of the gauge.

Discharge measurements are made at or near the gauge by wading. The initial point for soundings is a square stake driven close to the ground on the left bank and marked I. P. o.o.

Discharge Measurements of East Branch of Bear Creek at Johnson's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 12	H. R. Carscallen	15.0	7.82	0.697	1.39	5.45
May 6	"	13.5	6.86	0.461	1.33	3.16
May 25	"	13.3	6.24	0.473	1.30	2.95
June 10	R. G. Swan	13.5	5.60	0.352	1.28	1.97
July 6	"	11.5	4.15	0.137	1.16	0.57
July 30	"	11.0	3.70	0.108	1.10	0.40
August 18	"	13.0	4.77	0.193	1.19	0.92
September 13	H. R. Carscallen	12.8	5.13	0.381	1.25	1.96
October 6	R. G. Swan	13.0	5.48	0.474	1.32	2.59
November 4	"	10.8	4.97	0.470	1.31	2.34

DAILY GAUGE HEIGHT AND DISCHARGE of East Branch of Bear Creek at Johnson's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	1.5	9.0	1.40	5.80	1.28	2.51
2	1.5	9.0	1.40	5.80	1.31	3.22
3	1.45	7.35	1.40	5.80	1.33	3.76
4	1.4	5.8	1.40	5.80	1.31	3.22
5	1.4	5.8	1.33	3.76	1.31	3.22
6	1.4	5.8	1.33	3.76	1.28	2.51
7	1.4	5.8	1.33	3.76	1.28	2.51
8	1.4	5.8	1.33	3.76	1.28	2.51
9	1.4	5.8	1.33	3.76	1.28	2.51
10	1.4	5.8	1.33	3.76	1.28	2.51
11	1.4	5.8	1.33	3.76	1.24	1.69
12	1.4	5.8	1.33	3.76	1.24	1.69
13	1.4	5.8	1.33	3.76	1.24	1.69
14	1.4	5.8	1.33	3.76	1.24	1.69
15	1.4	5.8	1.33	3.76	1.24	1.69
16	1.4	5.8	1.36	4.60	1.24	1.69
17	1.4	5.8	1.33	3.76	1.24	1.69
18	1.4	5.8	1.33	3.76	1.24	1.69
19	1.4	5.8	1.40	5.80	1.24	1.69
20	1.4	5.8	1.36	4.60	1.24	1.69
21	1.4	5.8	1.33	3.76	1.21	1.21
22	1.4	5.8	1.33	3.76	1.21	1.21
23	1.4	5.8	1.33	3.76	1.23	1.53
24	1.4	5.8	1.33	3.76	1.21	1.21
25	1.4	5.8	1.31	3.22	1.18	0.87
26	1.4	5.8	1.28	2.51	1.21	1.21
27	1.4	5.8	1.28	2.51	1.23	1.53
28	1.4	5.8	1.28	2.51	1.16	0.69
29	1.4	5.8	1.28	2.51	1.18	0.87
30	1.4	5.8	1.28	2.51	1.16	0.69
31	....	....	1.28	2.51	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of East Branch of Bear Creek, at Johnson's Ranche, for 1910.—*Concluded.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.16	0.69	1.17	0.78	1.23	1.53	1.28	2.51
2	1.18	0.87	1.11	0.44	1.21	1.21	1.28	2.51
3	1.18	0.87	1.06	0.28	1.20	1.05	1.28	2.51
4	1.18	0.87	1.06	0.28	1.20	1.05	1.32	3.49
5	1.18	0.87	1.08	0.34	1.29	2.73	1.33	3.76
6	1.17	0.78	1.20	1.05	1.38	5.20	1.34	4.03
7	1.15	0.60	1.18	0.87	1.38	5.20	1.34	4.03
8	1.17	0.78	1.18	0.87	1.36	4.60	1.33	3.76
9	1.18	0.87	1.16	0.69	1.34	4.03	1.30	2.95
10	1.20	1.05	1.13	0.52	1.28	2.51	1.24	1.69
11	1.25	1.85	1.13	0.52	1.26	2.07	1.26	2.07
12	1.19	0.96	1.13	0.52	1.25	1.85	1.26	2.07
13	1.15	0.60	1.17	0.78	1.25	1.85	1.27	2.29
14	1.10	0.40	1.18	0.87	1.25	1.85	1.29	2.73
15	1.10	0.40	1.19	0.96	1.25	1.85	1.29	2.73
16	1.10	0.40	1.17	0.78	1.25	1.85	1.27	2.29
17	1.10	0.40	1.16	0.69	1.24	1.69	1.26	2.07
18	1.10	0.40	1.16	0.69	1.24	1.69	1.30	2.95
19	1.10	0.40	1.15	0.60	1.25	1.85	1.31	3.22
20	1.10	0.40	1.11	0.44	1.25	1.85	1.31	3.22
21	1.10	0.40	1.09	0.37	1.25	1.85	1.31	3.22
22	1.15	0.60	1.08	0.34	1.25	1.85	1.30	2.95
23	1.21	1.21	1.13	0.52	1.25	1.85	1.30	2.95
24	1.15	0.60	1.18	0.87	1.30	2.95	1.30	2.95
25	1.10	0.40	1.23	1.53	1.30	2.95	1.34	4.03
26	1.10	0.40	1.21	1.21	1.30	2.95	1.31	3.22
27	1.10	0.40	1.20	1.05	1.28	2.51	1.30	2.95
28	1.15	0.60	1.20	1.05	1.28	2.51	1.30	2.95
29	1.21	1.21	1.20	1.05	1.28	2.51	1.30	2.95
30	1.10	0.40	1.21	1.21	1.28	2.51	1.30	2.95
31	1.10	0.40	1.22	1.37	....	....	1.30	2.95

MONTHLY DISCHARGE of East Branch of Bear Creek at Johnson's Ranche, for 1910.

Drainage area, 27 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	9.00	5.80	6.07	0.235	0.262	361
May	5.80	2.51	3.56	0.132	0.152	220
June	3.76	0.69	1.88	0.070	0.078	112
July	1.85	0.40	0.68	0.025	0.029	42
August	1.53	0.28	0.76	0.028	0.032	47
September	5.20	1.05	2.40	0.088	0.098	143
October	4.03	1.69	2.93	0.109	0.126	180
The period						1,105

WEST BRANCH OF BEAR CREEK AT BERTRAM'S RANCHE.

This station was established September 16, 1909, by H. R. Carscallen. It is located on Sec. 32, Tp. 10, Rge. 23, W. 3rd Mer., about a mile and a half north of Skibereen P. O. The station is about three hundred yards above the junction of this branch with the East branch of Bear Creek.

This channel is straight for 25 feet above and 15 feet below the station. Both banks are comparatively high and will overflow only in cases of extreme floods. The banks are free from brush at the station, but are heavily wooded immediately above and twenty feet below. The bed of the creek is composed of sand and coarse gravel. The current is moderate at the station, but becomes very swift twenty feet downstream.

The gauge, which is read once each day by Charles Bertram, is a plain staff, graduated to feet and hundredths, attached vertically to a post sunk in the bed of the stream at the left bank and firmly stayed to the bank. The gauge is referred to bench marks as follows:—(1) A spike-head in the top of the initial point stake on the left bank, marked B. M.; elevation 8.00 above the zero of the gauge. (2) A spike-head in the top of a pointed poplar stump just below the bank on the left side of the stream, and about 50 feet downstream from the gauge, the stump blazed and marked B. M.; elevation, 8.41 feet abcve the zero of the gauge.

Discharge measurements are made at, or a short distance below, the gauge by wading. High-water measurements are made at the government bridge. situated about three-quarters of a mile upstream. The initial point for soundings at the station is a square stake driven close to the ground on the left bank and marked I. P. o.o.

DISCHARGE MEASUREMENTS of West Branch of Bear Creek at Bertram's Ranche, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 13	H. R. Carscallen	15.0	11.67	0.922	1.54	10.77
May 6	"	17.4	10.26	0.521	1.42	5.35
May 25	"	15.8	9.25	0.495	1.39	4.58
June 9	R. G. Swan	14.5	8.59	0.452	1.38	3.88
July 5	"	14.6	7.39	0.273	1.32	2.02
July 29	"	2.0	0.70	0.200	1.10	0.14
August 18	"	12.4	6.01	0.361	1.31	2.17
September 13	H. R. Carscallen	14.3	8.25	0.321	1.37	2.65
October 6	R. G. Swan	14.5	8.72	0.556	1.42	4.85
November 4	"		8.99	0.430	1.41	3.86

DAILY GAUGE HEIGHT AND DISCHARGE of West Branch of Bear Creek at Bertram's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.6	15.2	1.4	4.2	1.4	4.2
2	1.6	15.2	1.4	4.2	1.4	4.2
3	1.6	15.2	1.4	4.2	1.45	6.0
4	1.6	15.2	1.4	4.2	1.45	6.0
5	1.6	15.2	1.4	4.2	1.4	4.2
6	1.6	15.2	1.4	4.2	1.4	4.2
7	1.6	15.2	1.4	4.2	1.4	4.2
8	1.5	8.4	1.4	4.2	1.4	4.2
9	1.5	8.4	1.4	4.2	1.4	4.2
10	1.5	8.4	1.4	4.2	1.3	1.8
11	1.5	8.4	1.4	4.2	1.3	1.8
12	1.5	8.4	1.4	4.2	1.2	0.8
13	1.5	8.4	1.4	4.2	1.2	0.8
14	1.5	8.4	1.4	4.2	1.2	0.8
15	1.5	8.4	1.4	4.2	1.3	1.8
16	1.5	8.4	1.4	4.2	1.3	1.8
17	1.5	8.4	1.4	4.2	1.4	4.2
18	1.5	8.4	1.4	4.2	1.4	4.2
19	1.5	8.4	1.45	6.0	1.4	4.2
20	1.5	8.4	1.45	6.0	1.4	4.2
21	1.5	8.4	1.45	6.0	1.3	1.8
22	1.4	4.2	1.4	4.2	1.2	0.8
23	1.4	4.2	1.4	4.2	1.2	0.8
24	1.4	4.2	1.4	4.2	1.2	0.8
25	1.4	4.2	1.4	4.2	1.2	0.8
26	1.4	4.2	1.4	4.2	1.1	0.3
27	1.4	4.2	1.4	4.2	1.1	0.3
28	1.4	4.2	1.4	4.2	1.1	0.3
39	1.4	4.2	1.4	4.2	1.2	0.8
30	1.4	4.2	1.4	4.2	1.3	1.8
21	....	....	1.4	4.2	....	....

Daily Gauge Height and Discharge of West Branch of Bear Creek at Bertram's Ranche, for 1910.—*Concluded.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.3	1.8	1.07	0.2	1.37	3.2	1.44	5.6
2	1.3	1.8	1.07	0.2	1.37	3.2	1.45	6.0
3	1.3	1.8	1.07	0.2	1.37	3.2	1.45	6.0
4	1.3	1.8	1.07	0.2	1.37	3.2	1.45	6.0
5	1.3	1.8	1.07	0.2	1.47	7.0	1.45	6.0
6	1.3	1.8	1.07	0.2	1.47	7.0	1.45	6.0
7	1.3	1.8	1.07	0.2	1.50	8.4	1.45	6.0
8	1.3	1.8	1.07	0.2	1.50	8.4	1.45	6.0
9	1.3	1.8	1.07	0.2	1.50	8.4	1.45	6.0
10	1.3	1.8	1.07	0.2	1.47	7.0	1.45	6.0
11	1.3	1.8	1.07	0.2	1.42	4.9	1.45	6.0
12	1.3	1.8	1.07	0.2	1.42	4.9	1.44	5.6
13	1.2	0.8	1.07	0.2	1.37	3.2	1.44	5.6
14	1.1	0.3	1.07	0.2	1.37	3.2	1.44	5.6
15	1.05	0.1	1.17	0.65	1.37	3.2	1.45	6.0
16	1.05	0.1	1.27	1.4	1.37	3.2	1.45	6.0
17	1.1	0.3	1.32	2.2	1.37	3.2	1.45	6.0
18	1.2	0.8	1.32	2.2	1.37	3.2	1.45	6.0
19	1.2	0.8	1.32	2.2	1.37	3.2	1.45	6.0
20	1.2	0.8	1.32	2.2	1.37	3.2	1.45	6.0
21	1.3	1.8	1.32	2.2	1.37	3.2	1.45	6.0
22	1.3	1.8	1.32	2.2	1.37	3.2	1.45	6.0
23	1.2	0.8	1.32	2.2	1.42	4.9	1.46	6.5
24	1.1	0.3	1.32	2.2	1.42	4.9	1.47	7.0
25	1.1	0.3	1.32	2.2	1.43	5.3	1.52	9.6
26	1.1	0.3	1.32	2.2	1.43	5.3	1.52	9.6
27	1.1	0.3	1.32	2.2	1.44	5.6	1.52	9.6
28	1.1	0.3	1.32	2.2	1.44	5.6	1.47	7.0
29	1.1	0.3	1.32	2.2	1.44	5.6	1.47	7.0
30	1.1	0.3	1.32	2.2	1.44	5.6	1.47	7.0
31	1.1	0.3	1.32	2.2	....	....	1.47	7.0

MONTHLY DISCHARGE of West Branch of Bear Creek at Bertram's Ranche, for 1910.

Drainage area, 44.5 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	15.2	4.2	8.73	0.196	0.219	519
May	6.0	4.2	4.37	0.098	0.113	269
June	6.0	0.3	2.54	0.057	0.064	151
July	1.8	0.3	1.05	0.023	0.026	64
August	2.2	0.2	1.22	0.027	0.031	75
September	8.4	3.2	4.79	0.108	0.120	285
October	9.6	5.6	6.47	0.146	0.168	398
The period						1,761

BEAR CREEK, NEAR UNSWORTH'S RANCHE.

This station was established June 22, 1908, by F. T. Fletcher. It is located on Sec. 18, Tp. 11, Rge. 23, W. 3rd Mer., at the highway bridge on the surveyed trail running east from Maple Creek. It is about one-half mile south of S. Unsworth's ranche, and fifteen miles east of Maple Creek.

The channel is straight for 100 feet above and below the station. Both banks are high and not liable to overflow. The station is kept clear of underbrush, but both banks are covered with small trees above and below the bridge. The bed of the stream is sandy and is liable to change at high stages of the creek. The current is moderate, becoming sluggish at very low stages.

The gauge, which is read once each day by Mr. Unsworth, is a plain staff, graduated to feet and hundredths, attached vertically to the centre pile on the downstream side of the bridge. It is referred to bench marks as follows:—(1) A circle of nail-heads in the top of the stringer at the left abutment on the downstream side of the bridge; elevation, 14.05 feet above the zero of the gauge. (2) The top of the iron pin in the road mound southeast of the bridge on the left bank; elevation, 18.97 feet above the zero of the gauge.

Discharge measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the left abutment of the bridge. Low-water measurements are made at a wading section about one-half mile downstream from the gauge. There is only one channel at low stages, but at high stages the centre row of piles supporting the bridge divides the stream into two channels.

DISCHARGE MEASUREMENTS of Bear Creek at Unsworth's Ranche, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 12	H. R. Carscallen	9.0	21.10	0.852	1.79	17.98
May 6	"	9.0	17.15	0.588	1.23	10.09
May 24	"	9.0	17.27	0.511	1.15	8.83
June 9	R. G. Swan	7.9	13.66	0.476	1.01	6.50
June 11	R. J. Burley	8.0	7.75	0.584	0.86	4.53
June 16	"	7.8	6.55	0.474	0.75	3.10
July 5	R. G. Swan	7.4	9.50	0.202	0.58	1.92
July 29	"	8.0	7.82	0.004	0.14	0.01*
August 18	"	8.0	7.68	0.202	0.45	1.55
September 13	"	8.5	11.71	0.263	0.72	3.08
October 6	"	9.5	17.70	0.382	1.06	6.75
November 4	"	9.5	17.80	0.348	1.07	6.20

*Discharge determined by using a 15-inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Bear Creek, near Unsworth's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge. Height	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.9	19.1	1.4	11.0	1.1	7.1
2	1.9	19.1	1.4	11.0	1.1	7.1
3	1.9	19.1	1.3	9.6	1.1	7.1
4	1.8	17.4	1.3	9.6	1.2	8.3
5	1.8	17.4	1.3	9.6	1.2	8.3
6	1.9	19.1	1.2	8.3	1.1	7.1
7	1.9	19.1	1.2	8.3	1.1	7.1
8	1.9	19.1	1.2	8.3	1.0	6.0
9	1.9	19.1	1.2	8.3	1.0	6.0
10	1.9	19.1	1.2	8.3	0.9	5.0
11	1.9	19.1	1.2	8.3	0.9	5.0
12	1.8	17.4	1.2	8.3	0.9	5.0
13	1.8	17.4	1.2	8.3	0.8	4.0
14	1.8	17.4	1.2	8.3	0.8	4.0
15	1.8	17.4	1.2	8.3	0.7	3.1
16	1.8	17.4	1.3	9.6	0.7	3.1
17	1.8	17.4	1.3	9.6	0.8	4.0
18	1.8	17.4	1.3	9.6	1.0	6.0
19	1.8	17.4	1.3	9.6	0.9	5.0
20	1.7	15.7	1.3	9.6	0.9	5.0
21	1.7	15.7	1.2	8.3	0.8	4.0
22	1.7	15.7	1.2	8.3	0.8	4.0
23	1.6	14.1	1.2	8.3	0.7	3.1
24	1.6	14.1	1.1	7.1	0.7	3.1
25	1.6	14.1	1.1	7.1	0.7	3.1
26	1.5	12.5	1.1	7.1	0.7	3.1
27	1.5	12.5	1.1	7.1	0.6	2.3
28	1.5	12.5	1.1	7.1	0.6	2.3
29	1.5	12.5	1.1	7.1	0.6	2.3
30	1.5	12.5	1.1	7.1	0.6	2.3
31	....	....	1.1	7.1	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Bear Creek, near Unsworth's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.6	2.3	0.3	0.5	0.47	1.4	1.05	6.55
2	0.6	2.3	0.3	0.5	0.47	1.4	1.05	6.55
3	0.7	3.1	0.27	0.4	0.47	1.4	1.08	6.90
4	0.7	3.1	0.27	0.4	0.47	1.4	1.1	7.10
5	0.7	3.1	0.25	0.35	0.5	1.6	1.08	6.90
6	0.7	3.1	0.30	0.50	0.6	2.3	1.05	6.55
7	0.6	2.3	0.30	0.50	0.85	4.5	1.05	6.55
8	0.6	2.3	0.32	0.60	0.85	4.5	1.05	6.55
9	0.6	2.3	0.32	0.60	0.85	4.5	1.03	6.30
10	0.6	2.3	0.32	0.60	0.8	4.0	1.03	6.30
11	0.7	3.1	0.32	0.60	0.8	4.0	1.02	6.20
12	0.7	3.1	0.35	0.75	0.78	3.8	1.0	6.00
13	0.6	2.3	0.35	0.75	0.78	3.8	1.0	6.00
14	0.6	2.3	0.37	0.85	0.75	3.5	1.0	6.00
15	0.6	2.3	0.40	1.00	0.75	3.5	1.0	6.00
16	0.5	1.6	0.45	1.30	0.75	3.5	1.0	6.00
17	0.4	1.0	0.50	1.60	0.75	3.5	1.0	6.00
18	0.4	1.0	0.50	1.60	0.75	3.5	1.0	6.00
19	0.3	0.5	0.47	1.40	0.77	3.7	1.0	6.00
20	0.3	0.5	0.45	1.30	0.8	4.0	1.03	6.30
21	0.2	0.2	0.45	1.30	0.8	4.0	1.03	6.30
22	0.2	0.2	0.45	1.30	0.8	4.0	1.05	6.55
23	0.2	0.2	0.45	1.30	0.8	4.0	1.05	6.55
24	0.2	0.2	0.47	1.40	0.82	4.2	1.05	6.55
25	0.3	0.5	0.50	1.60	0.85	4.5	1.07	6.80
26	0.3	0.5	0.50	1.60	0.87	4.7	1.07	6.80
27	0.3	0.5	0.50	1.60	0.90	5.0	1.08	6.90
28	0.2	0.2	0.50	1.60	0.95	5.5	1.1	7.10
29	0.15	0.1	0.50	1.60	1.00	6.0	1.1	7.10
30	0.15	0.1	0.50	1.60	1.02	6.2	1.1	7.10
31	0.12	0.04	0.50	1.60	....	....	1.1	7.10

MONTHLY DISCHARGE of West Branch of Bear Creek at Unsworth's Ranche, for 1910.

Drainage area, 95 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in incheson Drainage area.	Total in acre-feet.
April	19.1	12.50	16.59	0.175	0.195	985
May	11.0	7.10	8.50	0.089	0.103	522
June	8.3	2.30	4.76	0.050	0.056	283
July	3.1	0.04	1.50	0.015	0.017	92
August	1.6	0.35	1.05	0.011	0.013	65
September	6.2	1.40	3.73	0.039	0.044	222
October	7.1	6.00	6.50	0.068	0.078	400
The period						2,569

PIAPOT CREEK AT CUMBERLAND'S RANCHE.

This station was established June 17, 1908, by F. T. Fletcher. It was located on Sec. 17, Tp. 11, Rge. 24, W. 3rd Mer., at the highway bridge on the surveyed trail running east of Maple Creek and about nine miles from Maple Creek. This station, on account of the difficulty of obtaining an observer, was abandoned May 13, 1909, and re-established by H. R. Carscallen at a wading section near A. Cumberland's house. It is located about a mile north of the old station on Sec. 18, Tp. 11, Rge. 24, W. 3rd Mer.

The channel is straight for 50 feet above and 100 feet below the station. The right bank is high and not liable to overflow; the left bank is comparatively low and will overflow at flood stages of the stream. The bed of the stream is composed of sand and may shift during high stages. The current is sluggish.

The gauge, which is read by Mr. Cumberland, is a plain staff graduated to feet and hundredths, attached vertically to a post sunk in the bed of the stream at the left bank and securely stayed to the bank. It is referred to bench marks as follows:—(1) The top of two spikes driven horizontally into the end of a log at the southwest corner of Mr. Cumberland's old house; elevation, 12.72 above the zero of the gauge. (2) A spike-head surrounded by a circle of nail-heads in the tcp of a log at the north-west corner of the out-building south of Mr. Cumberland's house; elevation, 11.70 feet above the zero of the gauge.

Discharge measurements are made at or near the gauge by wading. High-water measurements are made at the first established station, from the downstream side of the bridge. The initial point for soundings is the inner face of left abutment of the bridge. Owing to a centre row of piles, there are two channels at high water.

DISCHARGE MEASUREMENTS of Piapot Creek at Cumberland's Ranche. in 1910.

DATE	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Sec-ft.*	*Feet.*
April 11	H. R. Carscallen	11.6	11.12	0.777	1.48	8.64
May 6	"	11.3	6.16	0.364	1.07	2.24
May 24	"	11.6	6.15	0.328	1.07	2.02
June 9	R. G. Swan	11.4	6.13	0.212	1.03	1.30
July 4	"	11.7	6.70	0.148	1.01	0.99
July 28	"	11.7	5.40	0.053	0.92	0.28*
August 17	"	11.8	5.51	0.102	1.05	0.56*
September 12	H. R. Carscallen	11.5	6.46	0.084	1.06	0.54*
October 5	R. G. Swan	11.1	6.42	0.140	1.05	0.90
November 3	"	11.3	6.40	0.176	1.05	1.13

* Discharge determined by using a 15-inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Piapot Creek at Cumberland's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.43	7.31	1.13	1.64	0.98	0.49
2	1.43	7.31	1.13	1.64	1.03	0.77
3	1.43	7.31	1.13	1.64	1.08	1.15
4	1.43	7.31	1.08	1.15	1.13	1.64
5	1.43	7.31	1.08	1.15	0.93	0.29
6	1.43	7.31	1.08	1.15	1.03	0.77
7	1.43	7.31	1.03	0.77	1.03	0.77
8	1.43	7.31	1.03	0.77	1.03	0.77
9	1.43	7.31	1.03	0.77	1.03	0.77
10	1.43	7.31	1.03	0.77	1.03	0.77
11	1.43	7.31	0.98	0.49	0.93	0.29
12	1.43	7.31	0.98	0.49	0.93	0.29
13	1.43	7.31	0.98	0.49	0.83	0.07
14	1.23	2.97	0.98	0.49	0.83	0.07
15	1.23	2.97	1.13	1.64	1.03	0.77
16	1.23	2.97	1.13	1.64	1.03	0.77
17	1.18	2.24	1.08	1.15	1.13	1.64
18	1.13	1.64	1.03	0.77	1.13	1.64
19	1.13	1.64	1.08	1.15	1.13	1.64
20	1.13	1.64	1.13	1.64	1.03	0.77
21	1.13	1.64	1.13	1.64	1.03	0.77
22	1.13	1.64	1.13	1.64	1.03	0.77
23	1.13	1.64	1.08	1.15	1.03	0.77
24	1.13	1.64	1.08	1.15	1.03	0.77
25	1.13	1.64	1.03	0.77	1.03	0.77
26	1.13	1.64	1.03	0.77	1.03	0.77
27	1.13	1.64	1.03	0.77	1.03	0.77
28	1.13	1.64	1.03	0.77	1.03	0.77
29	1.13	1.64	1.03	0.77	0.98	0.49
30	1.13	1.64	1.03	0.77	1.03	0.77
31	....	....	1.03	0.77	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Piapot Creek, at Cumberland's Ranche, for 1910.—*Con.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.03	0.77	0.93	0.29	1.01	0.64	1.05	0.90
2	1.03	0.77	0.93	0.29	1.02	0.71	1.03	0.77
3	1.03	0.77	0.93	0.29	1.02	0.71	1.04	0.84
4	1.03	0.77	0.94	0.32	1.07	1.07	1.06	0.98
5	1.03	0.77	1.03	0.77	1.08	1.15	1.06	0.98
6	1.03	0.77	1.01	0.64	1.06	0.98	1.05	0.90
7	1.03	0.77	1.01	0.64	1.18	2.24	1.04	0.84
8	1.03	0.77	1.00	0.58	1.13	1.64	1.04	0.84
9	1.03	0.77	0.99	0.53	1.12	1.53	1.03	0.77
10	1.13	1.64	1.01	0.64	1.06	0.98	1.03	0.77
11	1.13	1.64	1.00	0.58	1.05	0.90	1.04	0.84
12	1.03	0.77	0.99	0.53	1.06	0.98	1.05	0.90
13	1.03	0.77	1.02	0.71	1.06	0.98	1.04	0.84
14	0.98	0.49	1.04	0.84	1.05	0.90	1.03	0.77
15	0.93	0.29	1.08	1.15	1.05	0.90	1.03	0.77
16	1.03	0.77	1.08	1.15	1.03	0.77	1.03	0.77
17	1.03	0.77	1.05	0.90	1.03	0.77	1.03	0.77
18	1.03	0.77	1.05	0.90	1.03	0.77	1.06	0.98
19	1.03	0.77	1.04	0.84	1.03	0.77	1.04	0.84
20	0.93	0.29	1.03	0.77	1.02	0.71	1.03	0.77
21	0.93	0.29	1.02	0.71	1.02	0.71	1.03	0.77
22	0.93	0.29	1.01	0.64	1.03	0.77	1.03	0.77
23	1.03	0.77	1.06	0.98	1.03	0.77	1.04	0.84
24	1.03	0.77	1.08	1.15	1.04	0.84	1.04	0.84
25	0.93	0.29	1.08	1.15	1.07	1.07	1.12	1.53
26	0.93	0.29	1.07	1.07	1.08	1.15	1.07	1.07
27	0.93	0.29	1.05	0.90	1.06	0.98	1.08	1.15
28	0.88	0.16	1.03	0.77	1.05	0.90	1.06	0.98
29	0.93	0.29	1.03	0.77	1.04	0.84	1.05	0.90
30	0.93	0.29	1.07	1.07	1.03	0.77	1.03	0.77
31	0.93	0.29	1.08	1.15	....	....	1.10	1.32

MONTHLY DISCHARGE of Piapot Creek at Cumberland's Ranche, in 1910.

Drainage area, 50 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	7.31	1.64	4.25	0.0850	0.0948	253
May	1.64	0.49	1.04	0.0208	0.0240	64
June	1.64	0.07	0.78	0.0156	0.0174	46
July	1.64	0.16	0.64	0.0128	0.0148	39
August	1.15	0.29	0.77	0.0154	0.0177	47
September	2.24	0.64	0.96	0.0192	0.0214	57
October	1.53	0.77	0.90	0.0180	0.0207	55
The period						561

MISCELLANEOUS DISCHARGE MEASUREMENTS of Crane Lake Drainage Basin, in 1910.

DATE	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
June 4	BearCreek,E.Branch	N.E. 29-10-23-3	R. J. Burley	12.7	7.5	3.97
June 6	"	"	"	11.0	4.46	1.88
June 6	"	"	"	6.0	2.32	2.60
June 14	"	"	"	4.7	1.96	1.31
June 4	Bear C'k.,W.Branch	N.W. 29-10-23-3	"	14.3	11.5	5.65
June 6	"	"	"	12.0	4.84	4.29
June 14	"	"	"	% 6.5	2.48	2.19
June 14	"	"	"	† 7.2	3.7	2.22
June 11	Creek (Spring)	N.W. 5-11-23-3	"			0.38
June 5	Glennie's Creek	S.W. 25-10-24-3	"	*		0.42
June 5	Piapot Creek	N.E. 25-10-25-3	"	9.2	2.9	0.82

% At rapids.
† At slow current.
* Weir measurements.

HAY LAKE DRAINAGE BASIN.

General Description.

Hay Lake is quite small, covering only an approximate area of 3 square miles. It is situated in Tp. 11, Rge. 25, W. 3rd Mer., and like most of the lakes in the surrounding district, it has no surface outlet. Its source of supply is Hay Creek. This creek rises in the Cypress Hills and follows a northerly course to the lake. The basin supplies water to a number of irrigation schemes and also supplies the domestic water supply for the town of Maple Creek.

The annual precipitation, is about 12 inches, falling during May, June and July.

HAY CREEK AT FAUQUIER'S RANCHE.

This station was established April 22, 1909, by F. T. Fletcher. It is located on Sec. 30, Tp. 10, Rge. 25, W. 3rd Mer., about 7 miles southeast of Maple Creek.

The channel is straight for 100 feet above and 200 feet below the station. Both banks are high at the station and not liable to overflow. The bed of the stream is composed of sand and coarse gravel and is liable to shift at high stages. The current is sluggish at the gauge in low water, but is swift at high stages.

Discharge measurements are made near the regular station by wading and at very low stages a weir is used. The initial point for soundings is a square stake driven close to the ground on the left bank, marked I. P. o.o. High-water measurements cannot be obtained owing to the absence of any structure from which to gauge the stream. The gauge was at first located below the intake of the Maple Creek Waterworks and of H. Fauquier's irrigation canal and records of flow obtained at the gauge do not include this diverted water and do not represent the total discharge of the stream. Below the intake of the Waterworks there is a continuous flow for a short distance kept up mainly by the overflow from the Waterworks Reservoir. This flow does not reach the gauge, being partly used up by H. Fauquier's irrigation ditch and the rest disappearing as seepage. As a consequence of this, the creek at the gauge was dry from the 4th April, throughout the whole of the season of 1910.

In the endeavour to obtain records of the flow above the intake of Mr. Fauquier's ditch and below the overflow of the Maple Creek Waterworks Reservoir a gauge was established on July 4th by R. G. Swan, on Sec. 29, Tp. 10, Rge. 25, W. 3rd Mer. It is about 200 yards above the headgate of Mr. Fauquier's irrigation ditch and 300 yards below the overflow of the Maple Creek Waterworks Reservoir.

The gauge, which is a plain staff, graduated to feet and hundredths, is securely fastened to a post sunk in the bed of the stream near the right bank and stayed. It is referred to two bench marks as follows:—(1) A spike driven in the southeast corner of a house, 300 feet west of the gauge and marked B. M.; elevation, 8.32 above the datum of the gauge. (2) A spike in the base of a willow stump, about 75 feet south of the rod and marked B. M.; elevation, 4.96 above the datum of the gauge.

The channel of the creek is slightly curved for about 8 feet above and 50 feet below the rod. The channel bed is sandy, covered with vegetation and liable to shift. The current is sluggish. Both banks are low and liable to overflow.

Discharge measurements are made with meter at ordinary stages and with a weir at low stages. The discharge at this station being dependent upon the overflow from the Maple Creek Waterworks Reservoir varied according to the consumption of water in the town of Maple Creek. Hence, since the gauge was read only once each day accurate results could not be obtained.

The gauge was read during 1910, by H. A. Symonds.

DISCHARGE MEASUREMENTS of Hay Creek at Fauquier's Ranche, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 26	R. J. Burley					0.20*
May 28	"					Nil.
May 30	"					0.29*
August 15	R. G. Swan				0.995	0.01*
September 3	"				0.990	0.04*
September 12	H. R. Carscallen				0.990	0.04*

* Discharge determined by using a 15-inch weir.

DAILY GAUGE HEIGHT of Hay Creek at Fauquier's Ranche, for 1910.

Day.	July.		August.		September.		October.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.		*Feet.*		*Feet.*		*Feet.*	
1			0.0		0.9		0.0	
2			0.0		1.0			
3	0.9		0.0		1.0			
4	1.0		0.0		1.0			
5	0.9		0.9		1.0			
6	0.9		1.0		1.0			
7	0.8		0.9		1.0			
8	0.9		0.9		1.0			
9	1.0		0.9		1.0			
10	1.0		0.9		1.0			
11	0.9		0.9		1.0			
12	0.9		0.9		1.0			
13	1.0		0.9		1.0			
14	0.9		1.0		1.0			
15	0.8		1.0		1.0			
16	0.9		0.9		0.9			
17	0.9		0.9		0.98			
18	1.0		1.0		1.0			
19	1.0		1.0		0.99			
20	0.9		0.9		0.97			
21	1.0		*0.0		0.90			
22	1.0		0.0		0.94			
23	1.0		0.9		0.89			
24	1.0		0.9		0.89			
25	1.0		1.0		0.88			
26	1.0		0.9		0.87			
27	1.0		*0.0		0.87			
28	1.0		0.0		*0.0			
29	0.9		0.0		0.0			
30	1.0		0.0		0.0			
31	*0.0		0.0					

* Creek dry, July 31-Aug. 4, Aug. 21-22, Aug. 27-31, Sept. 28-Oct. 31.

BIGSTICK LAKE DRAINAGE BASIN.

This lake is one of the largest in the northern Cypress Hills district. It is situated in Tp. 15, Rge. 25, W. 3rd Mer., covers an area of 35 square miles, is alkaline in character and has no surface outlet.

Maple Creek, which rises in the Cypress Hills, with its tributary, Gap Creek, is its only source of supply. On the south and east the lake is bounded by the Sand Hills.

The valley of Maple Creek is quite flat and shallow, and the surrounding bench land is gentle rolling prairie.

The annual precipitation is about 12 inches, and falls during May, June and July.

There are several small irrigation ditches in the basin.

Maple Creek at Maple Creek.

This station was established May 9, 1908, by R. J. Burley. It is located at the highway bridge just north of the C. P. Railway tracks in the town of Maple Creek.

The channel is straight for 200 feet above and 100 feet below the station. Both banks are comparatively low and will overflow at high-water stages of the stream. The bed of the stream is composed of sand and may shift during flood stages. The current is moderate at high and sluggish at low stages of the stream. The bridge is not at right angles to the flow and measurements made at the bridge must be corrected.

The gauge is a plain staff, graduated to feet and hundredths, attached vertically to a pile on the upstream side of the bridge, is referred to bench marks as follows:—(1) A spike-head in the top of a small pile on the right bank at the upstream side of the bridge; elevation, 8.04 feet above the zero of the gauge. (2) Nail-heads in the top of the stringer at the right abutment on the upstream side of the bridge; elevation, 8.14 feet above the zero of the gauge. (3) An "arrow-head" painted in black on the top of a long pile in the bed of the creek near the left bank and on the upstream side of the bridge; elevation, 8.64 feet above the zero of the gauge. It was read until Aug. 20, 1910, by C. A. Peterson, and after that by Thos. McMurdo.

Discharge measurements are made from the downstream side of the bridge. The initial point for sounding is the inner face of the right or south abutment of the bridge. Low-water measurements are made at a point about 50 feet upstream from the gauge by wading, and at very low stages a weir is used. The light, sandy soil of the banks gives rise to a great amount of erosion during flood stages, and this fact, coupled with that of the low banks of the stream, makes this station a rather unsatisfactory one for gauging purposes.

Discharge Measurements of Maple Creek at Maple Creek, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 2	H. R. Carscallen	8.5	4.73	0.596	1.16	2.82
April 29	"				0.84	0.17*
May 4	"				0.84	0.15*
May 21	"				0.83	0.18*
June 6	R. G. Swan				0.84	0.21*
June 25	"				0.82	0.18*
July 25	"					Nil. †
September 6	"				0.75	Nil.
August 16	"				0.74	Nil.

* Discharge determined by using a 15-inch weir
† Creek dry July 11-Aug. 11, Aug. 16-Sept. 4, Sept. 8-Oct. 31.

DAILY GAUGE HEIGHT AND DISCHARGE of Maple Creek, at Maple Creek, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.15	2.60	0.85	0.22	0.80	0.09
2	1.15	2.60	0.85	0.22	0.85	0.22
3	1.15	2.60	0.85	0.22	0.85	0.22
4	1.10	1.85	0.85	0.22	0.85	0.22
5	1.10	1.85	0.85	0.22	0.85	0.22
6	1.10	1.85	0.85	0.22	0.85	0.22
7	1.10	1.85	0.85	0.22	0.85	0.22
8	1.05	1.33	0.85	0.22	0.85	0.22
9	1.05	1.33	0.85	0.22	0.85	0.22
10	1.05	1.33	0.85	0.22	0.85	0.22
11	1.00	0.94	0.85	0.22	0.80	0.09
12	1.00	0.94	0.85	0.22	0.80	0.09
13	1.00	0.94	0.85	0.22	0.80	0.09
14	1.00	0.94	0.85	0.22	0.80	0.09
15	1.00	0.94	0.85	0.22	0.80	0.09
16	0.95	0.62	0.85	0.22	0.80	0.09
17	0.95	0.62	0.85	0.22	0.80	0.09
18	0.95	0.62	0.85	0.22	0.80	0.09
19	0.95	0.62	0.85	0.22	0.80	0.09
20	0.95	0.62	0.85	0.22	0.80	0.09
21	0.90	0.38	0.85	0.22	0.80	0.09
22	0.90	0.38	0.80	0.09	0.80	0.09
23	0.90	0.38	0.80	0.09	0.80	0.09
24	0.85	0.22	0.80	0.09	0.80	0.09
25	0.85	0.22	0.80	0.09	0.80	0.09
26	0.85	0.22	0.80	0.09	0.80	0.09
27	0.85	0.22	0.80	0.09	0.80	0.09
28	0.85	0.22	0.80	0.09	0.80	0.09
29	0.85	0.22	0.80	0.09	0.80	0.09
30	0.85	0.22	0.80	0.09	0.80	0.09
31	....	....	0.80	0.09	....	....

DAILY GAUGE HEIGHT AND DISCHARGE of Maple Creek at Maple Creek, for 1910.—*Concluded.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.80	0.09	0.40	....	0.65	....	0.69	....
2	0.80	0.09	0.40	....	0.65	....	0.69	....
3	0.80	0.09	0.40	....	0.65	....	0.69	....
4	0.80	0.09	0.50	....	0.75	....	0.69	....
5	0.80	0.09	0.60	....	0.80	0.09	0.69	....
6	0.80	0.09	0.65	....	0.80	0.09	0.68	....
7	0.80	0.09	0.65	....	0.80	0.09	0.68	....
8	0.80	0.09	0.65	....	0.75	*.........	0.67	....
9	0.80	0.09	0.65	....	0.75	....	0.66	....
10	0.80	0.09	0.65	....	0.75	....	0.65	....
11	0.75	*.........	0.65	....	0.75	....	0.64	....
12	0.75	....	0.80	0.09	0.75	....	0.63	....
13	0.70	....	0.85	0.22	0.75	....	0.63	....
14	0.70	....	0.85	0.22	0.74	....	0.62	....
15	0.70	....	0.80	0.09	0.73	....	0.61	....
16	0.65	....	0.75	*.........	0.73	....	0.60	....
17	0.65	....	0.75	....	0.73	....	0.59	....
18	0.65	....	0.75	....	0.72	....	0.59	....
19	0.65	....	0.70	....	0.71	....	0.59	....
20	0.65	....	0.60	....	0.71	....	0.59	....
21	0.65	....	0.50	....	0.71	....	0.59	....
22	0.65	....	0.40	....	0.71	....	0.59	....
23	0.65	....	0.70	....	0.71	....	0.59	....
24	0.65	....	0.65	....	0.71	....	0.64	....
25	0.65	....	0.65	....	0.70	....	0.64	....
26	0.60	....	0.60	....	0.70	....	0.63	....
27	0.55	....	0.60	....	0.70	....	0.63	....
28	0.55	....	0.65	....	0.70	....	0.63	....
29	0.50	....	0.65	....	0.70	....	0.62	....
30	0.45	....	0.65	....	0.70	....	0.62	....
31	0.45	....	0.70	....	....	....	0.68	....

* Creek dry July 11-Aug. 11, Aug. 16-Sept. 4, Sept. 8-Oct. 31.

MONTHLY DISCHARGE of Maple Creek at Maple Creek, for 1910.

Drainage area, 91 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	2.60	0.22	0.99	0.011	0.012	59
May	0.22	0.09	0.18	0.002	0.002	11
June	0.22	0.09	0.13	0.001	0.001	8
July	0.09	0.00	0.03	0.0003	0.0003	2
August	0.22	0.00	0.02	0.0002	0.0002	1
September	0.09	0.00	0.01	0.0001	0.0001	0.5
The period						81.5

MAPLE CREEK, NEAR MAPLE CREEK.

This station was established on May 4, 1910, by H. R. Carscallen. It is one mile north of the town of Maple Creek, on the bridge between Secs. 27 and 28, Tp. 11, Rge. 16, W. 3rd Mer.

The channel is straight for a distance of 100 feet upstream and 10 feet downstream. The right bank is high and sandy. The left is low with a gradual slope and liable to overflow. The stream bed is sandy and liable to shift.

The gauge, which was read daily during 1910 by C. A. Peterson, is a plain staff, graduated to feet and hundredths, securely fastened to the downstream side of the second pile from the right abutment. It is referred to two bench marks:—(1) Two spikes in the downstream side of the plank wing at the right abutment, marked B. M.; elevation, 9.37. (2) A spike-head in a five-inch post on the right bank, 35 feet west of the gauge and marked B.M.; elevation, 9.42.

DISCHARGE MEASUREMENTS of Maple Creek near Maple Creek, in 1910.

DATE	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 4	H. R. Carscallen				2.36	0.31
May 21	"	28.0	41.96	0.005	2.38	0.21
June 7	"	27.0	45.22	0.004	2.35	0.18
June 27	R. G. Swan	25.0	41.90	0.002	2.35	0.08
July 25	"				2.35	0.06
August 16	"				2.51	0.09
September 6	"				2.49	0.11
September 23	"				2.44	0.03
November 1	"				2.50	0.11

Discharges determined by using a 15-inch weir.

DAILY GAUGE HEIGHT of Maple Creek near Maple Creek, for 1910

Day.	May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.		*Feet.*		*Feet.*	
1	....	....	2.35	....	2.40	....
2	....	....	2.35	....	2.35	....
3	....	....	2.35	....	2.35	....
4	2.3	....	2.30	....	2.35	....
5	2.35	....	2.30	....	2.35	....
6	2.35	....	2.30	....	2.35	....
7	2.35	....	2.30	....	2.35	....
8	2.30	....	2.30	....	2.35	....
9	2.30	....	2.30	....	2.35	....
10	2.30	....	2.30	....	2.35	....
11	2.35	....	2.30	....	2.35	....
12	2.35	....	2.30	....	2.35	....
13	2.35	....	2.30	....	2.35	....
14	2.35	....	2.30	....	2.35	....
15	2.35	....	2.30	....	2.35	....
16	2.40	....	2.30	....	2.35	....
17	2.40	....	2.35	....	2.35	....
18	2.40	....	2.35	....	2.35	....
19	2.45	....	2.35	....	2.35	....
20	2.40	....	2.35	....	2.35	....
21	2.40	....	2.35	....	2.35	....
22	2.40	....	2.35	....	2.35	....
23	2.40	....	2.35	....	2.35	....
24	2.40	....	2.35	....	2.40	....
25	2.40	....	2.35	....	2.40	....
26	2.40	....	2.35	....	2.40	....
27	2.40	....	2.35	....	2.40	....
28	2.40	....	2.35	....	2.40	....
29	2.40	....	2.35	....	2.40	....
30	2.40	....	2.35	....	2.40	....
31	2.35	....	....	....	2.40	....

No gauge height observations were made after July 31.

GAP CREEK, NEAR MAPLE CREEK.

This station was established on May 3, 1910, by H. R. Carscallen. It is located at the traffic bridge on the road allowance between Sec. 31 and 32, Tp. 11, Rge. 26, W. 3rd Mer., which is about 4½ miles north of the town of Maple Creek.

The channel is straight for about 60 feet above the station, but is slightly curved for about 100 feet below. The left bank is high and the right low, but not liable to overflow. The bed is sandy and liable to shift.

During high water discharge measurements are made from the bridge. The initial point for soundings is marked on the north end of the bridge in red paint. The bridge is not at right angles to the direction of the current, and a coefficient is applied to the measured discharge to obtain the actual discharge. The discharge is determined in extreme low water by means of a weir.

The gauge, which is a plain staff, graduated to feet and hundredths, was read during 1910, by C. A. Peterson. It is nailed to the downstream end of the south pier of the bridge. It is referred to a point marked B. M. in red paint on the top of the cap of the left abutment; elevation, 13.48 above zero.

DISCHARGE MEASUREMENTS of Gap Creek, near Maple Creek, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
May 4	H. R. Carscallen	....	....	....	1.50	0.51
May 21	"	27.0	8.21	0.018	1.48	0.15
June 7	"	12.5	4.25	0.005	1.39	0.02
June 27	R. G. Swan	....	....	....	....	Nil.
September 6	"	....	....	....	1.38	0.02
September 23	"	....	....	....	1.38	0.02
November 1	"	....	....	....	1.37	0.03

Discharges determined by using a 15-inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Gap Creek, near Maple Creek, for 1910.

Day.	May.		June.		July.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.
1	....	....	1.35	0.01	1.25	....
2	....	....	1.35	0.01	1.25	....
3	....	....	1.40	0.03	1.25	....
4	1.50	0.50	1.40	0.03	1.25	....
5	1.50	0.50	1.40	0.03	1.25	....
6	1.50	0.50	1.40	0.03	1.25	....
7	1.50	0.50	1.40	0.03	1.25	....
8	1.50	0.50	1.40	0.03	1.25	....
9	1.50	0.50	1.35	0.01	1.25	....
10	1.45	0.07	1.35	0.01	1.25	....
11	1.50	0.50	1.35	0.01	1.25	....
12	1.50	0.50	1.30	†	1.25	....
13	1.45	0.07	1.30	....	1.25	....
14	1.45	0.07	1.25	....	1.25	....
15	1.45	0.07	1.25	....	1.25	....
16	1.50	0.50	1.25	....	1.25	....
17	1.50	0.50	1.30	....	1.25	....
18	1.45	0.07	1.25	....	*	....
19	1.50	0.50	1.25	....	....	....
20	1.50	0.50	1.25	....	....	....
21	1.50	0.50	1.25	....	....	....
22	1.50	0.50	1.25	....	....	....
23	1.50	0.50	1.25	....	1.25	†
24	1.45	0.07	1.25	....	1.25	....
25	1.45	0.07	1.25	....	1.25	....
26	1.40	0.03	1.25	....	1.25	....
27	1.40	0.03	1.25	....	*.........	....
28	1.40	0.03	1.25	....	....	....
29	1.40	0.03	1.25	....	....	....
30	1.40	0.03	1.25	....	....	....
31	1.40	0.03	....	....	....	....

† No flow, water standing in pools, June 12-July 17, July 23-26.
* Creek dry, July 18-22, July 27-31.
No gauge height observations were made after July 31.

McSHANE CREEK AT SMALL'S RANCHE.

This station was established April 23, 1909, by F. T. Fletcher. It is located on Sec. 4, Tp. 10, Rge. 27, W. 3rd Mer., at the highway bridge on the surveyed trail from Maple Creek to Ten-mile, about 12 miles south of Maple Creek. It is about 600 feet above the mouth of the creek and about 500 feet from Wm. Small's house. Mr. Small diverts water from the stream for irrigation purposes, and, as the intake of his ditch is above the station, records of daily flow do not represent the full discharge of the creek when water is being used in the ditch.

The channel is straight for 100 feet above and 200 feet below the station. Both banks are high and not liable to overflow. The bed of the stream is composed of coarse gravel and shifts at high stages. The current is swift.

The gauge, which is read daily by Mr. Small, is a plain staff, graduated to feet and hundredths, attached firmly to the right abutment on the downstream side of the bridge. The gauge is referred to bench marks as follows:—(1) Nail-heads in the top of the wooden stringer at the north or right side of the stream and on the downstream side of the bridge, marked B. M. with white paint; elevation, 9.68 feet above the zero of the gauge. (2) The top of the iron pin in the road mound situated 350 feet south of the bridge on the east side of the trail; elevation, 16.96 feet above the zero of the gauge.

Highwater measurements are made from the downstream side of the bridge. The initial point for soundings is the inner face of the right abutment of the bridge. Low-water measurements are made near the gauge by wading and at very low stages a weir is used.

There was no flow at all in this stream, either at the gauging station or above Mr. Small's Ditch during 1910.

DISCHARGE MEASUREMENTS of McShane Creek at Small's Ranche, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per Sec.*	*Feet.*	*Sec.-ft.*
April 23	H. R. Carscallen					Nil.
May 17	"					Nil
June 23	"					Nil
July 16	"					Nil
August 3	"					Nil

No flow, water standing in pools.

GAP CREEK AT SMALL'S RANCHE.

This station was established April 25, 1909, by F. T. Fletcher. It is located on Sec. 3, Tp. 10, Rge. 27, W. 3rd Mer., about 400 yards west of the surveyed trail from Maple Creek to Tenmile and about 12 miles south of Maple Creek.

The channel is straight for 600 feet above and below the station. The right bank is high and will not overflow except at very extreme flood stages; the left bank is much higher than the right and will not overflow at any stage of the stream. The bed of the stream is composed of loose, coarse gravel. The current is sluggish.

The gauge, which is read daily by Wm. Small, is a plain staff, graduated to feet and hundredths, spiked firmly to a vertical post sunk in the bed of the stream at the right bank and securely stayed to the bank. It is referred to bench marks as follows:—(1) The top of the initial point stake on the right bank, marked B. M.; elevation, 8.08 feet above gauge zero. (2) The top of the final point stake, driven close to the ground on the left bank and marked B. M.; elevation, 8.09 feet above the zero of the gauge. (3) Nail-heads on the top of the ground-log at the south-west corner of a cow shed, just below the cross-section and on the right bank; elevation, 9.60 feet above gauge zero.

Discharge measurements are made at the regular station by wading, and at very low stages a weir is used. The regular station is a cross-section taken 250 feet above the gauge and the initial and final point stakes are located on the right and left banks of the stream, respectively, at this cross-section. The initial point for soundings is a square stake driven close to the ground on the right bank and marked B. M.

DISCHARGE MEASUREMENTS of Gap Creek at Small's Ranche, in 1910.

DATE	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 23	H. R. Carscallen				2.04	0.45
May 17	"	20.0	17.47	0.059	1.95	1.02
May 27	"					Nil
June 23	"				1.75	Nil
July 16	"				1.46	Nil
August 3	"				1.45	Nil
August 19	"				1.49	Nil
September 8	"				1.72	Nil
September 30	R. G. Swan				1.69	Nil

DAILY GAUGE HEIGHT AND DISCHARGE of Gap Creek at Small's Ranche, for 1910.

Day.	April.		May.		June.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	2.10	0.700	2.00	0.050	1.90	0.020
2	2.10	0.700	2.00	0.050	1.90	0.020
3	2.10	0.700	2.00	0.050	1.95	0.035
4	2.10	0.700	2.00	0.050	1.95	0.035
5	2.10	0.700	2.00	0.050	1.90	0.020
6	2.10	0.700	2.00	0.050	1.90	0.020
7	2.10	0.700	2.00	0.050	1.90	0.020
8	2.10	0.700	2.00	0.050	1.90	0.020
9	2.10	0.700	2.00	0.050	1.90	0.020
10	2.10	0.700	2.00	0.050	1.90	0.020
11	2.10	0.700	1.95	0.035	1.90	0.020
12	2.10	0.700	1.95	0.035	1.90	0.020
13	2.10	0.700	1.95	0.035	1.85	0.010
14	2.10	0.700	1.95	0.035	1.85	0.010
15	2.10	0.700	1.95	0.035	1.80	*.........
16	2.10	0.700	1.95	0.035	1.80	....
17	2.10	0.700	1.95	0.035	1.80	....
18	2.10	0.700	2.10	0.700	1.80	....
19	2.05	0.375	2.10	0.700	1.75	....
20	2.05	0.375	2.10	0.700	1.75	....
21	2.05	0.375	2.10	0.700	1.75	....
22	2.05	0.375	2.10	0.700	1.75	....
23	2.05	0.375	2.05	0.375	1.75	....
24	2.05	0.375	2.00	0.050	1.75	....
25	2.05	0.375	1.95	0.035	1.70	....
26	2.00	0.050	1.95	0.035	1.70	....
27	2.00	0.050	1.90	0.020	1.65	....
28	2.00	0.050	1.95	0.035	1.65	....
29	2.00	0.050	1.90	0.020	1.65	....
30	2.00	0.050	1.90	0.020	1.65	....
31	....	....	1.90	0.020	....	....

* No flow, water standing in pools from June 14 to Oct 31.

DAILY GAUGE HEIGHT of Gap Creek at Small's Ranche, for 1910.—*Concluded.*

Day.	July.		August.		September.		October.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height	Dis-charge.
	Feet.	*Sec.-ft.* *	*Feet.*	*Sec.-ft*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	1.65	....	1.45	....	1.54	....	1.69	....
2	1.60	....	1.45	....	1.53	....	1.69	....
3	1.60	....	1.45	....	1.52	....	1.67	....
4	1.60	....	1.45	....	1.55	....	1.70	....
5	1.55	....	1.45	....	1.60	....	1.71	....
6	1.55	....	1.45	....	1.60	....	1.71	....
7	1.55	....	1.45	....	1.70	....	1.71	....
8	1.50	....	1.45	....	1.70	....	1.70	....
9	1.50	....	1.45	....	1.70	....	1.70	....
10	1.50	....	1.46	....	1.70	....	1.70	....
11	1.55	....	1.46	....	1.70	....	1.71	....
12	1.55	....	1.46	....	1.70	....	1.72	....
13	1.55	....	1.46	....	1.68	....	1.72	....
14	1.50	....	1.46	....	1.68	....	1.72	....
15	1.50	....	1.48	....	1.67	....	1.72	....
16	1.50	....	1.50	....	1.67	....	1.72	....
17	1.45	....	1.50	....	1.66	....	1.73	....
18	1.45	....	1.48	....	1.65	....	1.74	....
19	1.45	....	1.48	....	1.65	....	1.74	....
20	1.45	....	1.47	....	1.65	....	1.75	....
21	1.45	....	1.47	....	1.63	....	1.75	....
22	1.45	....	1.48	....	1.64	....	1.75	....
23	1.45	....	1.50	....	1.63	....	1.75	....
24	1.45	....	1.51	....	1.70	....	1.75	....
25	1.45	....	1.51	....	1.70	....	1.76	....
26	1.45	....	1.51	....	1.69	....	1.77	....
27	1.45	....	1.50	....	1.69	....	1.79	....
28	1.45	....	1.50	....	1.69	....	1.78	....
29	1.45	....	1.50	....	1.69	....	1.77	....
30	1.45	....	1.51	....	1.69	....	1.78	....
31	1.45	....	1.53	....	....	....	1.79	....

* No flow, water standing in pools June 14 to Oct. 31.

MONTHLY DISCHARGE of Gap Creek, at Small's Ranche, for 1910.

Drainage area, 69.5 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April	0.700	0.05	0.516	0.0070	0.0078	31.0
May	0.700	0.02	0.157	0.0020	0.0023	10.0
June	0.035	0.00	0.010	0.0001	0.0001	0.6
July	....	....	....	....	....	....
August	....	....	....	....	....	....
September	....	....	....	....	....	....
October	....	....	....	....	....	....
The period	....	....	....	....	....	41.6

MISCELLANEOUS DISCHARGE MEASUREMENT of Bigstick Lake Drainage Basin, in 1910.

DATE	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		Sec.-ft.
May 29	Cypress Creek	S.W. 17-9-27-3	F. T. Fletcher	3	0.65	0.28
August 9	"	N.W. 5-9-27-3	H. R. Carscallen	*		0.19
May 20	Maple Creek	17-13-26-3	F. T. Fletcher	*		0.92
May 21	"	"	"	8.4	1.78	0.88
May 22	"	"	"	*		0.57
May 26	Spring Creek	S.E. 10-9-27-3	"	*		0.21
May 31	"	"	"	*		0.12

* Weir measurements.

MANY ISLAND LAKE DRAINAGE BASIN.

General Description.

Many Island Lake is situated on the boundary line between the Provinces of Alberta and Saskatchewan, and ten miles north of the town of Walsh. It is the farthest west of several lakes which receive the drainage from the north slope of the Cypress Hills.

The water is shallow and saline and covers an approximate area of 25 square miles. It is fed by Mackay Creek, and its tributaries Boxelder and Stony Creeks.

The annual precipitation, most of which occurs during May, June and July, is usually about 12 inches.

The streams do not have a very large flow, and during the summer months often go dry.

There are one or two small irrigation schemes in this watershed.

BOXELDER CREEK, NEAR WALSH.

This station was established May 24th, 1909, by P. M. Sauder. It is located at John Young's Farm on Sec. 2, Tp. 12, Rge. 30, W. 3rd Mer., and 2 miles East of Walsh.

The stream flows in one channel, which is crooked both above and below the gauge. The banks are high and not liable to overflow. The bed of the stream is composed of clay.

Discharge measurements are generally made by wading at or near the gauge, but during floods it may be measured from the C. P. R. bridge a few hundred feet below the gauge.

The gauge, which is a plain staff, graduated to feet and hundredths, is attached to a post at the right bank. It is referred to bench marks as follows:—(1) The top of the frame of outside cellar entrance of Mr. Young's house; elevation, 17.36 feet. (2) Two spikes driven near the south east corner of Mr. Young's house; elevation, 16.40 feet above the datum of the gauge.

There was no flow in the creek during 1910, after the gauge was established.

DISCHARGE MEASUREMENTS of Boxelder Creek at Walsh, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 28	H. R. Carscallen					Nil
May 24	P. M. Sauder					Nil
June 14	"					Nil
June 16	R. G. Swan					Nil
July 24	P. M. Sauder					Nil
August 9	F. T. Fletcher					Nil

MACKAY CREEK AT WALSH.

This station was established on July 29, 1909, by F. T. Fletcher. It is located at the traffic bridge ½ mile south of the C. P. R. track at Walsh. The bridge is on the N.W. ¼ Sec. 26, Tp. 11, Rge. 1, W. 4th Mer.

The channel is straight for about 225 feet above and 500 feet below the station. Both banks are clean but liable to overflow at high stages. The bed is clean, composed of clay and not liable to shift. The current is sluggish.

The gauge is a plain staff, graduated to feet and hundredths, nailed to an upright timber on the upstream side of the bridge near the right abutment.

During high water,discharge measurements are made from the downstream side of the bridge. At low stages the discharge is measured by wading, and at extreme low water a weir is used.

The gauge was read once each day by Geo. Sept, General Merchant, Walsh. The flow ceased on the 27th April, and the creek remained dry throughout the remainder of the season.

DISCHARGE MEASUREMENTS of Mackay Creek at Walsh, in 1910.

DATE.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Dis-charge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 28	H. R. Carscallen				0.07	Nil
May 24	P. M. Sauder					Nil
June 14	"					Nil
June 16	F. T. Fletcher					Nil
June 24	R. G. Swan					Nil
August 9	P. M. Sauder					Nil

Daily Gauge Height and Discharge of Mackay Creek at Walsh, for 1910.

Day.	April.		May.		June.		July.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1	0.8	*						
2	0.8							
3	0.7						1.0	*
4	0.6						0.4	
5	0.6						0.2	
6	0.6						†	
7	0.6							
8	0.6							
9	0.7							
10	0.7							
11	0.6							
12	0.6							
13	0.7							
14	0.7							
15	0.6							
16	0.6							
17	0.6							
18	0.6							
19	0.6							
20	0.5							
21	0.4							
22	0.4							
23	0.4							
24	0.3							
25	0.2							
26	0.1							
27	†							
28								
29								
30								
31								

* No flow, water standing in pools April 1-26, July 3-5.
† Creek dry April 27-July 2, July 6 to end of the season.

Miscellaneous Discharge Measurements of Many Island Lake Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		*Sec.-ft.*
April 28	Stoney Creek	25-11-2-4	H. R. Carscallen			Nil
May 24	"	"	P. M. Sauder			Nil
June 14	"	"	"			Nil
June 24	"	"	R. G. Swan			Nil
August 9	"	"	P. M. Sauder			Nil

ROSS CREEK DRAINAGE BASIN.

General Description.

Ross Creek rises in Elkwater Lake, a small body of water covering an area of approximately 2 square miles, situated in Tp. 8, Rge. 3, W. 4th Mer. The creek flows in a northerly direction as far as Irvine and then turns sharply to the westward, and closely parallels the main line of the C. P. R. to Medicine Hat. Here it is joined by Sevenpersons River and the combined flow empties into South Saskatchewan River in Sec. 32, Tp. 12, Rge. 5, W. 4th Mer.

The tributaries of Ross Creek are Bullshead Creek, which joins it in Sec. 21, Tp. 12, Rge. 5, W. 4th Mer., and Gros Ventre Creek which joins it in Sec. 14, Tp. 11, Rge. 3, W. 4th Mer.

The C. P. R. takes its water supply for their tank at Irvine from this stream.

Ross Creek at Irvine.

This station was established July 28, 1909, by F. T. Fletcher. It is located at the traffic bridge in the town of Irvine, on Sec. 31, Tp. 11, Rge. 2, W. 4th Mer., and about 400 yards below the C. P. R. dam.

The stream flows in one channel, which is slightly curved for 75 feet above the station, and almost straight for 600 feet below. The banks are composed of clay, high and not liable to overflow. The bed is composed of sand and gravel and may shift at high stages.

Discharge measurements are made from the downstream side of the bridge during high stages of the stream, and during low water it is waded. In extreme low water a weir is used.

The gauge, which is a plain staff, graduated to feet and hundredths, is spiked to the downstream pile of the first row from the left abutment. It is referred to bench marks as follows:—(1) The top of the downstream pile in the first row from the left abutment; elevation, 15.52 feet above the datum of the gauge. (2) The top of the south rail of C. P. R., south of station; elevation, 23.11. It was read during 1910, by H. G. Price of Irvine.

Discharge Measurements of Ross Creek at Irvine, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 28	H. R. Carscallen	2.8	0.40	0.175	0.73	0.07
May 24	P. M. Sauder	9.0	2.21	0.435	0.90	0.96*
June 14	"					Nil†
June 25	R. G. Swan	4.8	1.00	0.038	0.66	0.04
July 5	F. T. Fletcher					Nil†
July 19	H. R. Carscallen				0.65	0.01*
August 9	P. M. Sauder					Nil

* Discharge determined by using a 15-inch weir.
† Flow too small to gauge.

Daily Gauge Height and Discharge of Ross Creek at Irvine, for 1910.

Day.	May.		June.		July.		August.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.84	0.58	0.66	0.04	0.62	*
2			0.83	0.53	0.66	0.04	0.63	0.01
3			0.82	0.48	0.66	0.04	0.60	*
4			0.81	0.43	0.66	0.04	0.60	
5			0.80	0.38	0.66	0.04	0.60	
6			0.78	0.30	0.66	0.04	0.59	
7			0.74	0.18	0.65	0.03	0.58	
8			0.72	0.13	0.65	0.03	0.55	
9			0.72	0.13	0.64	0.02	0.54	
10			0.70	0.09	0.64	0.02	0.17	
11			0.68	0.06	0.64	0.02	0.12	
12			0.68	0.06	0.64	0.02	0.11	
13			0.68	0.06	0.64	0.02	0.08	
14			0.68	0.06	0.64	0.02	0.07	
15			0.68	0.06	0.64	0.02	0.66	0.04
16			0.68	0.06	0.64	0.02	0.66	0.04
17			0.67	0.05	0.64	0.02	0.59	*
18			0.68	0.06	0.64	0.02	0.54	
19			0.67	0.05	0.64	0.02	0.27	
20			0.67	0.05	0.64	0.02	0.12	
21			0.67	0.05	0.64	0.02	0.05	
22			0.67	0.05	0.64	0.02	0.03	
23			0.67	0.05	0.64	0.02	0.61	
24	0.90	0.96	0.67	0.05	0.64	0.02	0.10	
25	0.90	0.96	0.67	0.05	0.64	0.02	0.02	
26	0.89	0.89	0.67	0.05	0.64	0.02	0.00	
27	0.88	0.82	0.67	0.05	0.64	0.02		
28	0.87	0.75	0.66	0.04	0.64	0.02		
29	0.86	0.69	0.66	0.04	0.64	0.02		
30	0.85	0.63	0.66	0.04	0.64	0.02		
31	0.84	0.58			0.63	0.01		

* No flow, water standing in pools Aug. 1, Aug. 3-14, Aug. 17-26.

SEVENPERSONS RIVER DRAINAGE BASIN.

Bullshead Creek, near Dunmore.

This station was established July 26, 1909, by F. T. Fletcher. It is located at the traffic bridge on the S.W. ¼ Sec. 16, Tp. 12, Rge. 5, W. 4th Mer. It is 4 miles from Medicine Hat, and 1 mile above the junction of Ross and Bullshead Creeks.

The stream flows in one channel, which is straight for about 200 feet above and 450 feet below the station. The banks are high, clean and not liable to overflow. The bed is composed of sand, and shifts.

During high water discharge measurements are made from the downstream side of the bridge, but during low water the discharge is measured by wading, or by means of a weir.

The gauge, which is a plain staff, graduated to feet and hundredths, is spiked to the downstream side of the first row of piles from the right abutment. It is referred to the following bench marks:—(1) A spike driven in the top of the centre row of piles; elevation, 7.39. (2) The top of a wooden plug driven flush with the ground in the road mound on right bank; elevation, 6.34.

As the creek was dry almost all year, no observer was engaged during 1910.

Discharge Measurements of Bullshead Creek at Dunmore, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
March 31	H. R. Carscallen	8.9	1.87	0.631	0.55	1.18
April 27	"	2.5	0.32	0.187	0.46	0.06
May 23	P. M. Sauder	3.0	0.30	0.033	0.44	0.01*
June 14	"					Nil
July 9	F. T. Fletcher					Nil
August 19	P. M. Sauder					Nil

* Discharge determined by using a 15-inch weir.

Sevenpersons River at Medicine Hat.

This station was established on April 27, 1910, by H. R. Carscallen. It is located in Sec. 30, Tp. 12, Rge. 5, W. 4th Mer., at the bridge on the road from Medicine Hat to Dunmore Junction and about 1½ miles east of the C. P. R. station at Medicine Hat.

The channel is straight for about 100 feet above and below the station. Both banks are high and wooded. The stream bed is sandy and liable to change at high water.

During high water stages discharge measurements are made with a current meter. The initial point of soundings is the inner face of the left abutment of the bridge. Low water measurements are made with a weir.

The gauge, which is a plain staff, graduated to feet and hundredths, is attached to the west or left abutment of the bridge. It is referred to two bench marks:—(1) The top of a bolt-head in the cap of the right abutment, elevation, 10.41 feet above the datum of the gauge. (2) The head of a spike driven into a large stump about 100 feet east of the rod, elevation, 11.40 feet above the zero of the gauge.

Discharge Measurementss of Sevenpersons River at Medicine Hat, in 1910.

Date	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
April 27	H. R. Carscallen	2.0	0.26	0.577	0.84	0.15
May 23	P. M. Sauder	11.0	3.23	0.015	0.82	0.05*
June 14	"					Nil
July 6	F. T. Fletcher					Nil.
August 19	P. M. Sauder					Nil

* Discharge determined by using a 15-inch weir.

DAILY GAUGE HEIGHT AND DISCHARGE of Sevenpersons River, at Medicine Hat, for 1910.

Day.	April.		May.	
	Gauge Height.	Discharge.	Gauge Height.	Discharge.
	Feet.	*Sec.-ft.*	*Feet.*	*Sec.-ft.*
1			0.90	0.68
2			0.85	0.22
3			0.85	0.22
4			0.85	0.22
5			0.85	0.22
6			0.85	0.22
7			0.85	0.22
8			0.80	0.02
9			0.80	0.02
10			0.85	0.22
11			0.90	0.68
12			0.87	0.40
13			0.85	0.22
14			0.85	0.22
15			0.85	0.22
16			0.80	0.02
17			0.80	0.02
18			0.85	0.22
19			0.85	0.22
20			0.80	0.02
21			0.80	0.02
22			0.80	0.02
23			0.80	0.02
24			0.75	*
25			0.75	
26			0.70	
27	0.85	0.22	0.60	
28	0.85	0.22	0.50	
29	0.90	0.68		
30	0.90	0.68		
31				

* No flow, water standing in pools May 24-28.

MOOSEJAW CREEK DRAINAGE BASIN.

General Description.

Moosejaw Creek rises in the vicinity of Yellowgrass and flows in a north and westerly direction until it reaches the city of Moosejaw, and thence in an easterly and northerly direction; finally emptying into the Qu'Appelle River near Buffalo Pound Lake. From the headwaters to the city of Moosejaw, the drainage area is estimated at about one thousand eight hundred and thirty square miles. This area is almost entirely devoid of tree growth, except that the valley is lined with brush in the vicinity of Moosejaw.

Throughout its entire length the creek flows in a very crooked but well defined channel. The upper portion of the valley is small, being merely a depression, but it gradually increases in size until at Drinkwater it is about 30 feet deep and at Moosejaw about 80 feet deep. The fall in the creek is very small, and particularly so between Drinkwater and Moosejaw, where the total fall is only 67.5 feet or an average of 2.3 feet per mile of valley.

The lack of timber growth and the clayey surface-cover of the drainage basin tend to the rapid collection and delivery of storm water to the main channel. The flow of the river, is therefore subject to sudden rises during periods of abundant rain-fall or the melting of the snow in the spring, but the high part of the flood quickly passes and the creek soon resumes its normal conditions.

WATER SUPPLY.

It is pretty generally believed that 1910 was a year of exceptional drought and the rain-fall and run-off were much below the average. A study of the precipitation records in the accompanying table covering the period from 1895 to the present does not altogether bear this out. In discussing this table it should be noted that no account seems to have been taken of the snow during the time preceding the fall of 1908. This table indicates that the average precipitation in the vicinity of Moosejaw for the past fifteen years is between thirteen and fourteen inches. The only point in the watershed of Moosejaw Creek at which precipitation records have been obtained is at Moosejaw, but there is no doubt but that these records give a fair average for the whole basin. With the exception of the month of July, the precipitation for each month for the past year has differed but little from the average. The rain-fall in July is usually one of the highest during the year, but this year it was very small. This coupled with high temperatures and high winds appears to be largely responsible for the drought.

With the few records of discharge which have been obtained, it is impossible to determine the relationship of run-off and rain-fall. The precipitation in 1909 was somewhat above the average, and as the total for this year is very little below the average it would hardy be expected that the total discharge of Moosejaw Creek during 1910 should be very much below the average. Residents along the creek, however, claim that it was lower this year than they have ever seen it before.

Two gauging stations were established on the creek; one at the bridge on the N.W. ¼ Sec. 16-16-26-2 near V. J. McCarthy's farm and the other at the bridge on the road allowance between Secs. 14 and 15, Tp. 15, Rge. 25, W. 2nd Mer., near W. F. Bryce's farm. The height of the water was read daily by observers living near the stations and the flow measured at both stations about once every two weeks. With these records the mean daily discharge of the creek at each station was computed, and tables of monthly discharges were compiled. The creek broke up and commenced to flow at Moosejaw on the 17th of March, and continued to flow until the 25th of July, when the flow ceased. The creek did not entirely dry up as there has been a small discharge from springs five and six miles above the city, and water has been standing in pools, in the channel of the stream.

From the table of "Monthly Discharge" at McCarthy's farm, it will be seen that the estimated total discharge of Moosejaw Creek near Moosejaw for the past year is 4,112.6 acre-feet or 1,116,455,747 Imperial gallons.

The Canadian Pacific Railway Company has dams at Milestone, Rouleau, Drinkwater, two at Moosejaw and one at Pasqua. There is also a municipality dam in Sec. 19-15-24-2, which supplies water to the neighbourhood in periods when there is no flow in the creek. No allowance need be made for the dams above the gauging station at McCarthy's farm as they were always full while there was flow in the creek. The Canadian Pacific Railway have, however, been licensed to divert 1.154 cu. ft. per sec. from the creek at Moosejaw and 0.0625 cu. ft. per sec. at Pasqua. Therefore, only that part of the flow in excess of 1.2165 cu. ft. per sec. is available. Deducting this from the discharges at McCarthy's farm, the total available during the past year was 3,823.5 acre-feet=1,037,973,192 Imperial gallons. Allowing the usual estimate of 100 gallons per day per capita, which would be little enough when the loss by evaporation and seepage from a large reservoir is included, this would only be sufficient for a city of 28,438 inhabitants. The supply would, however, be considerably augmented by storing the extra flow during wet years for use during dry years, and in that way a supply for a much larger population can be obtained from the creek.

Topographic Survey.

A careful topographic survey was made of Moosejaw valley from the City of Moosejaw to a point above Rouleau. The stadia method was employed throughout. A traverse line was projected along each bank of the valley using the stadia to measure all distances. The north and south section lines were assumed as true meridians. The traverse lines were tied in to convenient section mounds every few miles and the bearings checked, thus eliminating all errors in location. The creek and the contour lines were established by taking numerous side shots from the traverse stations and sketch topography was taken to assist in plotting the notes. The datum taken for the elevations was mean sea level and the initial elevation was obtained from a Bench Mark of the Canadian Pacific Railway at their station in Moosejaw. Two separate lines of levels were run, one on each bank of the valley to carry the elevation from one traverse station to another. The levels were carefully checked throughout the survey. The datum of the Canadian Pacific Railway Company elevations is 20.63 below the datum of the City of Moosejaw elevations, hence the Bench Mark on the telegraph pole at the south west corner of Main and Hall streets is at elevation 1800.87 referred to C. P. R. datum.

The map prepared from the data obtained by the topographic survey shows the configuration of the surface of the ground by contours of 10 foot intervals. Owing to its size and the expense of lithographing, the map is not published but blue prints of it can be furnished for a small fee.

Reservoir Sites.

While the topographic survey was in progress a careful reconnaissance was made to discover the most inviting places for a location of dams and reservoirs. This inspection revealed very few places where there is the desired combination of suitable dam site and broad valley. The selection of a suitable site is made still more difficult by the very small fall in the creek, and no matter where a dam is constructed the reservoir will have a large flooded area in comparison with its capacity.

Four dam sites "A," "B," "C" and "D," offer the best opportunities for storage and a cross-section of each was taken. The map shows the land which would be flooded by the erection of a dam of any possible height at any of the proposed sites. Tables showing the flooded areas and capacities of the reservoirs, for dams which would raise the water in the reservoir to any given height up to elevation 1,800 feet have been prepared.

Falls on Bow River near Banff, Alta.; in Summer.

Falls on Bow River, near Banff, Alta.; in Winter.

Borings were made at each site to determine the depth of a good foundation. At site "A" blue clay was found at elevation 1,747, but at the other three sites it was impossible to force the small auger at our disposal, through the gravel and boulders. Impervious clay is said to be found at about 18 feet below the bottom level of the valley and appears to underlie the whole valley. Further borings should be made to determine the depth of blue clay with exactitude.

Site "D," which is within the city limits, near the east boundary of the N.W. ¼ Sec. 28, Tp. 16, Rge. 26, W. 2nd Mer., is a very favourable location for a dam, and the valley widens out above it making a fine large basin with steep banks. The land in this basin is, however, considerably improved and highly assessed. Several dwellings, green-houses and other buildings would have to be moved. The elevation of the guard rail on the steel bridge on Main Street is only 1,743, and if water were raised above elevation 1,740 the bridge would have to be raised and approaches constructed. If water were raised above elevation 1,768, a steel bridge on the N. W. ¼ Sec. 16-16-26-2 and a wooden bridge on the S.E. ¼ Sec. 9-16-26-2 would also have to be raised and approaches constructed.

Sites "C" on the N.W. ¼ Sec. 29, Tp. 16, Rge. 26, W. 2nd Mer., and "B" on the S.W. ¼ Sec. 29, Tp. 16, Rge. 26, W. 2nd Mer. are above site "D" and outside the city limits. They would not store nearly as much water as site "D" without a higher dam. The cost of the dam would, however, be less as the valley is much narrower. There is very little difference in the character of the cross-sections, but "C" seems to be a little the better site and is almost half a mile nearer the city. A dam at either of these would not flood nearly as much highly assessed land as one at site "D." If water were raised above elevation 1,768, the steel bridge on the N.W. ¼ Sec. 16-16-26-2 and the wooden bridge on the S.E. ¼ Sec. 9-16-26-2 would have to be raised and approaches constructed.

Site "A" near the south boundary of the N.E. ¼ Sec. 9, Tp. 16, Rge. 26, W. 2nd Mer. would require the least embankment and the flooded lands are only farm or pasture lands. A bridge could be constructed on the dam to replace the wooden one on the S.E. ¼ Sec. 9-16-26-2. This site is, however, five miles from the centre of Moosejaw.

The fact that the valley of Moosejaw Creek is thickly populated and a great deal of improvement made by farmers, increase the cost of the reservoir very much. The land is improved and cultivated, and therefore valuable. Farmers own land on both sides of the stream and in natural conditions, they can ford it at almost any time and the establishment of a reservoir would divide their farms. Bridges have been erected on a number of the roads and as the population increases, more roads will be opened and more bridges built. It is impossible to raise the water more than a few feet without flooding the whole of the bottom of the valley. Bridges would have to be raised and long approaches constructed in order to cross the valley.

The water in Moosejaw Creek is not of very good quality and must be purified by filtration, before it can be used for drinking purposes. As the valley becomes more thickly populated there will be more pollution and the cost of treating the water will increase. A large quantity of vegetable matter must be removed and the shores treated before the valley can be safely used as a storage basin. The reservoir should be fenced to protect it from stock and to prevent them from miring in the mud as the water is drawn down.

POWER.

The water power in a stream depends directly on the fall of the stream within a given distance and the amount of flow which can be uniformly maintained throughout the year. As above mentioned, the total flow of Moosejaw Creek at McCarthy's farm during the past year is estimated at 4112.6 acre-feet, which without allowing for loss by evaporation and seepage, equals a uniform flow of 5.68 cu. ft. per sec. While there are probably seasons when there is a much larger flow, the quantity of power that could be developed from this flow is so small that it does not warrant further investigations.

Table of Flooded Areas and Capacities of Proposed Reservoirs.

Dam Site "A."

Elevation.	Flooded Area.	Capacity of Reservoir.	
C. P. R. Datum.	*Acres.*	*Acre Feet.*	*Imperial Gallons.*
1,800	2,517.5	35,892	9,743,716,460
1,790	1.484.0	15,343	4,165,137,887
1,780	619.0	5,808	1,576,706,661
1,770	305.0	1,613	437,887,621
1,760	36.0	61	16,544,104

Dam Site "B."

Elevation.	Flooded Area.	Capacity of Reservoir.	
C. P. R. Datum.	*Acres.*	*Acre Feet.*	*Imperial Gallons.*
1,800	3,309.6	61,459	16,684,511,666
1,790	2,161.3	33.269	9,031,648,118
1,780	1,219.2	17,737	4,815,003,849
1,770	791.5	7,658	2,078,886,426
1,760	330.3	2,520	684,087,722
1,750	90.7	414	112,487,139

Dam Site "C."

Elevation.	Flooded Area.	Capacity of Reservoir.	
C. P. R. Datum.	*Acres.*	*Acre Feet.*	*Imperial Gallons.*
1,800	3,394.0	64,397	17,481,963,381
1,790	2,231.3	35,658	9,680.113,285
1,780	1,280.6	19,221	5,218,066,471
1,770	846.0	8,812	2,392,338,856
1,760	377.6	2,917	791,775,235
1,750	121.5	655	177,706,142
1,740	5.8	18	4,775,192

Dam Site "D."

Elevation.	Flooded Area.	Capacity of Reservoir.	
C. P. R. Datum.	*Acres.*	*Acre Feet.*	*Imperial Gallons.*
1,800	3,734.0	79,381.0	21,549,716,117
1,790	2,540.2	47,484.0	12,890,541,157
1,780	1,567.0	27,998.0	7,600,664,912
1,770	1,111.0	14,908.0	4,017,017,705
1,760	622.8	6,654.0	1,806,404,550
1,750	290.4	2,035.0	552,388,511
1,740	76.2	452.0	122,805,789
1,730	12.4	9.5	2,565,410

Records of Precipitation at Moosejaw, Sask.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1895..........	1.14	0.28	0.61	0.23	3.82	2.26	2.18	......	0.97	0.19	1.72	0.38	13.78
1896..........	......	......	......	2.23	2.78	2.64	1.24	1.66	0.52	......	......	......	11.07
1897..........	......	......	......	......	0.13	1.35	0.96	0.30	0.49	0.25	......	......	3.48
1898..........	......	......	......	0.38	0.42	2.48	2.26	0.42	1.56	0.50	......	......	8.02
1899..........	......	......	......	0.60	3.76	3.02	1.36	2.44	0.50	0.32	0.30	......	12.30
1900..........	......	......	......	......	1.51	0.19	1.51	2.09	2.41	0.39	......	......	8.10
1901..........	......	......	0.04	0.19	1.78	2.79	5.08	0.39	2.86	0.52	......	......	13.61
1902..........	......	......	0.85	0.46	1.74	4.32	2.17	0.49	0.34	......	......	......	10.37
1903..........	......	......	......	......	1.38	6.92	3.61	3.26	0.80	0.33	......	......	16.30
1904..........	......	......	0.35	0.37	1.51	2.59	1.06	0.48	1.65	0.35	0.02	......	8.38
1905..........	......	......	0.30	0.07	4.30	5.68	4.26	0.78	0.83	0.92	0.15	......	17.29
1906..........	......	0.20	......	1.34	3.24	6.53	1.32	2.27	1.39	0.26	0.22	......	16.77
1907..........	......	......	0.21	0.21	0.91	2.63	1.26	3.12	0.51	0.55	......	......	9.40
1908..........	......	......	......	0.49	......	0.96	0.87	1.41	0.11	1.12	0.21	0.46	5.63
1909..........	0.97	0.17	0.22	0.59	3.23	2.79	6.52	2.05	0.36	0.63	0.70	0.71	18.94
1910..........	0.10	0.21	0.93	0.21	3.20	3.06	0.24	2.47	0.16	0.21	0.53	1.28	12.60
Average......	0.737	0.215	0.439	0.567	2.247	3.137	2.244	1.575	0.966	2.467	0.481	0.707	13.78

Moosejaw Creek at McCarthy's Farm.

This station was established on April 7, 1910, by P. M. Sauder and W. H. Greene. It is located at the traffic bridge in Sec. 16, Tp. 16, Rge. 26, W. 2nd Mer., and is 3 miles south of Moosejaw Post Office.

The stream flows in one channel which is straight for about 100 feet above and 300 feet below the station. The right bank is high, slightly wooded, and not liable to overflow. The left bank is low, slightly wooded and liable to overflow. The bed of the stream is composed of mud at the bridge but a short distance below it is composed of gravel.

During high water discharge measurements are made from the downstream side of the bridge, but in low water they are made by wading about 30 feet downstream. The initial point for soundings is at the west end of the handrail of the bridge.

The gauge, which is a plain staff, graduated to feet and hundredths, is nailed to the inner face of the right abutment. It is referred to the top of a bolt between two notches in the guard rail, just above the gauge; elevation, 23.19 feet above the datum of the gauge.

The gauge was read during 1910 by V. J. McCarthy.

Discharge Measurements of Moosejaw Creek at McCarthy's Farm, in 1910.

Date.	Hydrographer.	Width.	Area of section.	Mean velocity.	Gauge height.	Discharge.
		Feet.	*Sq.-ft.*	*Ft. per sec.*	*Feet.*	*Sec.-ft.*
March 19.........	A. W. Pae......................	16.0	5.46	0.610	....	3.34
April 7..........	P. M. Sauder....................	30.0	21.05	1.309	1.20	27.55
April 7..........	Whyte and Degnan.............	30.0	24.25	1.161	....	28.17
April 9..........	"	29.0	19.05	0.999	....	19.04
April 15..........	W. H. Greene..................	25.0	10.60	0.569	0.82	6.03
April 18..........	"	22.0	9.40	0.254	0.67	2.39
April 26..........	"	20.0	6.80	0.157	0.55	1.07
May 3..........	"	19.0	5.60	0.223	0.55	1.25
May 26..........	"	32.5	74.25	1.409	1.78	104.65
May 26..........	P. M. Sauder..................	31.0	62.42	1.524	1.78	95.16
May 26..........	Whyte & Degnan...............	31.0	62.43	1.525	1.77	95.23
May 30..........	P. M. Sauder..................	32.8	36.27	1.098	1.26	39.83
June 4..........	W. H. Greene..................	32.2	58.01	0.800	1.24	46.41
June 15..........	"	30.0	18.10	1.347	1.06	24.38
June 29..........	"	19.0	7.10	0.900	0.73	6.39
August 12........	P. M. Sauder..................	....	....	....	....	Nil.

DAILY GAUGE HEIGHT AND DISCHARGE of Moosejaw Creek at McCarthy's Farm, for 1910.

Day.	April.		May.		June.		July.		August.	
	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.	Gauge Height.	Dis-charge.
	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Feet.	Sec.-ft.	Fe.	Sec.-ft.	Feet.	Sec.-ft.
1	....	....	0.55	1.10	1.16	31.60	0.65	4.35	†	....
2	....	....	0.55	1.10	1.15	30.75	0.62	3.72	....	....
3	....	....	0.55	1.10	1.15	30.75	0.58	2.96	....	....
4	....	....	0.55	1.10	1.14	29.95	0.56	2.62	....	....
5	....	....	0.55	1.10	1.13	29.15	0.55	2.45	....	....
6	....	....	0.54	1.01	1.13	29.15	0.52	2.03	....	....
7	1.20	27.45	0.53	0.92	1.16	31.60	0.50	1.75	....	....
8	1.14	22.79	0.52	0.83	1.30	43.60	0.50	1.75	....	....
9	1.03	15.68	0.51	0.74	1.30	43.60	0.50	1.75	....	....
10	1.02	15.12	0.50	0.65	1.18	33.30	0.50	1.75	....	....
11	1.05	16.80	0.48	0.51	1.17	32.45	0.49	1.64	....	....
12	0.98	12.96	0.48	0.51	1.21	35.85	0.47	1.42	....	....
13	0.92	10.02	0.48	0.51	1.23	37.55	0.46	1.31	....	....
14	0.87	7.96	0.48	0.51	1.12	28.35	0.45	1.20	....	....
15	0.80	5.60	0.56	1.20	1.11	27.55	0.44	1.11	....	....
16	0.75	4.20	0.65	2.25	1.13	29.15	0.42	0.93	....	....
17	0.70	3.10	0.65	2.25	1.05	23.00	0.40	0.75	....	....
18	0.70	3.10	0.68	2.76	0.97	17.61	0.39	0.68	....	....
19	0.65	2.25	0.78	5.04	0.92	14.64	0.37	0.54	....	....
20	0.65	2.25	1.17	25.08	0.84	10.58	0.36	0.47	....	....
21	0.63	1.99	1.68	*75.00	0.76	7.50	0.35	0.40	....	....
22	0.60	1.60	1.92	*104.10	0.75	7.15	0.34	0.34	....	....
23	0.59	1.50	1.98	*112.15	0.90	13.50	0.33	0.28	....	....
24	0.58	1.40	1.97	*112.80	0.92	14.64	0.32	0.22	....	....
25	0.56	1.20	1.91	*108.75	0.90	13.50	0.31	0.16	....	....
26	0.55	1.10	1.77	94.18	0.85	11.00	0.28	%	....	....
27	0.56	1.20	1.59	74.00	0.75	7.15	0.26	....	....	....
28	0.58	1.40	1.42	55.48	0.71	5.91	0.22	....	....	....
29	0.58	1.40	1.31	44.54	0.74	6.84	0.21	....	....	....
30	0.55	1.10	1.22	36.70	0.69	5.35	0.20	....	....	....
31	....	....	1.23	37.55	....	....	0.17	....	....	....

* Changing conditions.
% No flow, water standing in pools July 26-31.
† Creek dry Aug. 1-Oct. 29.

MONTHLY DISCHARGE of Moosejaw Creek at McCarthy's Farm, for 1910

Drainage area, *1,765 square miles.

Month.	Discharge in Second-Feet.				Run-Off.	
	Maximum.	Minimum.	Mean.	Per square mile.	Depth in inches on Drainage area.	Total in acre-feet.
April (7-30)	27.45	1.10	6.80	0.0039	0.0035	324
May	112.80	0.51	29.21	0.0165	0.0190	1796
June	43.60	5.35	22.77	0.0129	0.0144	1,354
July	4.35	0.00	1.18	0.0007	0.0008	73
August	....	....	....	....	....	....
September	....	....	....	....	....	....
The period	....	....	....	....	....	3,547

* Approximate owing to lack of topography on maps.

SOURIS RIVER DRAINAGE BASIN.

General Description.

The source of Souris River is in marshes near Yellow Grass, Sask. From here it flows in a south-easterly direction almost paralleling the Soo Line of the C. P. R. to Estevan, where it turns south, and crosses the international boundary in Range 34, W. of Principal Mer. After making a loop into North Dakota it re-crosses the boundary line in Range 27, W. 1st Mer., and flows in a north-easterly direction to Souris, Man., where it turns east and finally joins Assiniboine River in Tp. 8, Rge. 16, W. of Principal Mer.

This stream drains a large tract of typical western plains. The rain-fall will probably average very little over 15 inches, and is usually sufficiently divided over the year to prevent excessive run-off, or floods. At times when there is an unusual amount of rain-fall and in the early spring, the water drains into the streams very rapidly and causes a flood of short duration.

There are towns, villages and farms all along the course of this stream and its tributaries, which depend on it for a domestic and industrial water supply. In North Dakota it has been proposed to divert water for irrigation purposes.

MISCELLANEOUS DISCHARGE MEASUREMENTS of Souris River Drainage Basin, in 1910.

Date.	Stream.	Locality.	Hydrographer.	Width.	Area of Section.	Discharge.
				Feet.		*Sec.-ft.*
July 27........	Souris River......	30-2-1-2..........	P. M. Sauder.....	13	7.3	3.79

MISCELLANEOUS MEASUREMENTS.

A LARGE NUMBER OF MISCELLANEOUS DISCHARGE MEASUREMENTS made by the Irrigation Surveys, from the year 1894 to the end of 1909, were not included in the "Report of Progress of Stream Measurements for the Calendar Year, 1909." The records have been carefully examined and all measurements which were not published in that report are given here in lists according to drainage basins.

ANTELOPE LAKE DRAINAGE BASIN.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1896.				*Sec.-ft.*	
September 23...	Bridge Creek.....	Sec. 25-13-29-3....	J. Gibbons.......	92.0	Flood stage.
1909.					
July 21........	"	Sec. 33-10-22-3....	R. J. Burley......	1.7	
August 2.......	" ...	"	"	0.29	

BATTLE CREEK DRAINAGE BASIN.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1897.					
July 19.........	Battle Creek......	Sec. 35-4-27-3.....	R. W. Macintyre.	29.37	
August 14.......	"	Sec. 36-7-30-3.....	"	6.1	
1907.					
September 18...	"	Sec. 30-4-26-3.....	R. J. Burley......	23.57	
1908.					
September 14...	"	S.E. 36-4-26-3.....	"	0.79	
1909.					
June 8........	"	N.W. 3-7-29-3....	F. T. Fletcher....	36.75	
June 16........	"	"	R. J. Burley......	5.65	
June 21........	"	S.W. 23-8-1-4.....	"	122.65	
September 24...	"	Sec. 29-4-26-3.....	F. T. Fletcher....	11.61	
September 27...	"	Sec. 1-6-28-3......	" ...	12.42	
1909.					
June 7........	Gaff Creek.......	S.E. 3-7-29-3......	"	0.44	Weir measurement.
June 17........	Graburn Creek....	N.E. 14-8-1-4.....	"	4.74	
1908.					
October 12......	Sixmile Creek.....	Sec. 32-7-28-3.....	R. J. Burley......	0.59	Flow greater above point of gauging.
1909.					
June 7........	"	Sec. 11-8-29-3.....	F. T. Fletcher....	4.57	
June 4........	Spring Creek.....	Sec. 24-7-29-3.....	"	0.33	
June 8........	Whitemud Coulee.	Sec. 23-7-29-3.....	"	0.14	

Belly River Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1894.				Sec.-ft.	
August 18......	Belly River.......	Sec. 31-5-25-4.....	A. O. Wheeler....	442.1	
August 22......	"	Sec. 1-5-27-4......	"	424.6	
September 3....	"	Sec. 1-3-28-4......	"	423.8	
October 8......	"	Sec. 25-8-23-4.....	" ...	2,423.3	Below confluence of Oldman River.
October 10......	"	Sec. 36-8-22-4.....	" ...	3,980.5	do St. Mary Ri
October 13......	"	Sec. 33-8-22-4.....	"	1,129.2	do Waterton River
1906.					
September 18...	"	Sec. 13-3-28-4.....	J. F. Hamilton...	160.09	
September 20...	"	Sec. 16-1-28-4.....	"	131.45	
September 24...	"	Sec. 13-3-28-4.....	"	180.84	
1907.					
July 26.........	"	Sec. 13-3-28-4.....	I. J. Walmsley...	913.1	
August 13......	"	"	" ...	503.55	
September 18...	"	Sec. 21-6-25-4.....	"	665.7	
July 30.........	Bullhorn Coulee...	Sec. 34-2-27-4.....	"	Nil	Water only in poo
August 12......	"	"	"	....	Only slight flow. ls.
1894.					
September 3...	Mami Creek......	Sec. 5-3-27-4......	A. O. Wheeler....	1.0	
1906.					
September 15...	"	Sec. 19-2-27-4.....	J. F. Hamilton...	2.97	
1907.					
July 30.........	"	Sec. 36-2-28-4.....	I. J. Walmsley...	4.3	
July 27.........	" W. Branch	Sec. 18-2-27-4.....	"	7.5	
August 12......	" "	"	"	4.5	
July 27.........	" E. Branch	"	"	0.2	
August 12.......	" "	"	"	0.3	

Bigstick Lake Drainage Basin.

1896.					
June 4........	Gap Creek.......	Sec. 25-11-27-3....	J. Gibbons.......	7.4	
1908.					
May 19........	"	Sec. 31-9-27-3.....	F. T. Fletcher....	0.94	Weir measurement.
October 13......	"	Sec. 2-9-28-3......	"	0.19	Weir measurement.
1909.					
June 28........	"	N.E.34-10-27-3....	R. J. Burley......	37.93	
1896.					
May 29........	Maple Creek......	Sec. 16-11-26-3....	J. Gibbons.......	8.75	Low water.
1906.					
June 13........	"	Sec. 4-12-26-3.....	R. J. Burley......	254.0	
1907.					
June 3.........	"	.N.E. 4-12-26-3...	"	17.2	
1908.					
May 7........	"	N.E. 9-11-26-3....	"	0.11	

Bow River Drainage Basin.

1894.					
June 25........	Bow River.......	Sec. 34-24-2-5.....	J. S. Dennis......	9,271.8	
August 11......	"	"	"	6,654,7	
eptember 27...	"	"	"	2,784.5	

BOW RIVER DRAINAGE BASIN.—*Continued.*

DATE.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
				Sec.-ft.	
1895.					
October 12......	Bow River........	Sec. 13-24-1-5.....	J. S. Dennis......	2,909.7	Low water.
1906.					
February 3.....	"	Sec. 32-24-8-5.....	J. F. Hamilton...	728.7	"
October 23......	"	Sec. 25-21-28-4....	"	2,507.7	"
November 1....	"	Sec. 13-24-1-5.....	"	2,138.1	"
1907.					
October 22......	"	Sec. 15-24-1-5.....	"	2,800.3	"
1894.					
September 25...	Bighill Creek.....	Sec. 13-26-4-5.....	T. D. Green......	1.70	"
1895.					
July 4.........	Bragg Creek......	N.E. 12-23-5-5....	A. O. Wheeler....	10.56	"
July 25.........	Canon Creek.....	Sec. 15-22-6-5.....	"	17.25	"
July 15.........	Canon Creek, Branch of......	Sec. 30-22-6-5.....	"	7.37	"
1894.					
June 25........	Elbow River......	Sec. 25-23-2-5.....	A. O. Wheeler....	647.4	
June 30........	"	Sec. 13-24-4-5.....	T. D. Green......	412.2	
October 3.......	"	Sec. 34-22-5-5.....	J. S. Dennis......	210.5	
1895.					
June 29........	"	Sec. 13-23-5-5.....	A. O. Wheeler....	761.3	
July 7.........	"	Sec. 11-23-5-5.....	A. O. Wheeler....	972.8	
July 20.........	"	Sec. 23-20-7-5.....	"	148.8	
1896.					
August 3.......	"	Sec. 1-20-8-5......	"	37.5	
1898.					
June 17........	"	Sec. 15-24-1-5.....	"	1,480.8	
1906.					
June 11........	"	N.W. 25-23-2-5...	J. F. Hamilton...	1,619.0	
June 18........	"	" ...	" ...	729.0	
October 29......	"	Sec. 10-24-1-5.....	" ...	275.0	
1907.					
October 21......	"	"	I. J. Walmsley...	349.3	
1908.					
May 7.........	"	N.W. 10-24-3-5...	P. M. Sauder.....	195.3	
1895.					
July 15.........	Elbow, Branch of.	N.W. 30-22-5-5...	A. O. Wheeler....	7.37	
July 20.........	"	N.E. 23-20-7-5....	"	39.12	
July 25.........	"	S.W. 4-22-6-5.....	"	18.58	
1894.					
June 26........	Fish Creek.......	Sec. 1-23-2-5.....	J. S. Dennis......	16.1	Summer flow.
1906.					
June 13........	"	Sec. 3-23-1-5......	J. F. Hamilton...	87.7	
June 14........	"	"	"	72.5	
June 16........	"	Sec. 26-22-3-5.....	P. M. Sauder.....	42.7	
November 7....	"	"	"	14.9	
1894.					
July 10.........	Fish Creek, South Branch.........	Sec. 4-22-3-5......	J. S. Dennis......	3.7	
1895.					
August 14......	"	S.W. 14-22-4-5....	A. O. Wheeler....	11.22	
August 20......	"	S.E. "	"	3.91	

Bow River Drainage Basin.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1906.				*Sec.ft.*	
June 18........	Fish Creek, South Branch.........	Sec. 22-22-3-5.....	P. M. Sauder.....	7.5	
1907.					
May 13........	"	"	I. J. Walmsley...	24.2	
October 17......	"	"	"	11.81	
1894.					
July 7..........	Fish Creek, North Branch.........	Sec. 19-22-3-5.....	J. S. Dennis......	2.7	
1895.					
August 7.......	"	S.W. 6-23-4-5.....	A. O. Wheeler....	1.86	
August 9.......	"	N.W. 25-22-4-5...	"	28.41	
1896.					
June 18........	"	Sec. 22-22-3-5.....	P. M. Sauder.....	29.06	
1907.					
May 13........	"	"	I. J. Walmsley...	16.9	
October 17......	"	"	"	13.3	
1908.					
May 20........	"	"	P. M. Sauder.....	91.07	
1895.					
July 23.........	Fisher Branch....	N.E. 18-21-7-5.....	A. O. Wheeler....	163.44	
1894.					
July 9.........	Highwood River..	Sec. 5-18-1-5......	J. S. Dennis......	893.7	Below Pekisko Creek.
July 9.........	" ..	Sec. 1-18-2-5......	"	907.8	Above "
July 19.........	" ..	Sec. 32-20-28-4....	"	667.9	Below "
1897.					
August 13......	" ..	Sec. 19-18-2-5.....	A. O. Wheeler....	466.4	Above "
September 13...	" ..	Sec. 35-16-5-5.....	"	109.05	
1906.					
July 10.........	" ..	Sec. 1-18-2-5.....	J. F. Hamilton...	841.0	
October 20......	" ..	Sec. 22-21-28-4...	"	334.5	
1907.					
May 23........	" ..	Sec. 1-18-2-5......	I. J. Walmsley...	482.1	Above Pekisko Creek
October 4......	" ..	"	"	706.1	"
1909.					
September 13...	" ..	Sec. 7-19-28-4.....	J. S. Tempest....	246.6	
1894.					
June 26........	Jumpingpound Ck	Sec. 31-24-4-5.....	J. S. Dennis......	85.5	
June 27........	"	"	"	65.0	
October 17......	"	Sec. 3-24-5-5.....	"	24.6	
1895.					
June 13........	"	Sec. 13-24-7-5....	A. O. Wheeler....	67.12	
June 13........	.. Jumpingpound, Branch of......	N.E. 11-24-7-5....	"	6.4	
June 24........	"	S.E. 20-24-7-5.....	"	9.0	
June 25........	"	N.W. 8-24-6-5....	"	17.6	
June 26........	"	N.E. 11-24-6-5....	"	133.26	
1906.					
January 29.....	Kananaskis River.	Sec. 33-24-8-5.....	J. F. Hamilton...	165.0	Low water.
1909.					
June 5........	Little Bow Ditch.	N.E. 1-19-29-4....	J. S. Tempest....	11.7	
June 7.........	"	S.W. 33-18-29-4...	"	6.2	
June 8.........	"	N.W. 30-18-29-4..	"	2.4	
1895.					
September 24...	Macabee Creek...	S.W. 30-19-3-5....	A. O. Wheeler....	1.66	
1907.					
May 27.........	"	Sec. 29-19-3-5.....	P. M. Sauder.....	3.7	
1909.					
June 17........	Meinsinger Creek.	S.E. 14-17-4-5.....	J. S. Tempest....	6.23	
1907.					
May 4.........	Nose Creek.......	N.W. 13-24-1-5...	I. J. Walmsley...	24.6	
October 23......	"	"	"	5.3	
1894:					
September 1....	Nose Ck. W. Br'h.	Sec. 1-26-2-5......	T. D. Green......	0.77	
June 28........	Pine Creek.......	Sec. 1-22-2-5......	I. J. Walmsley...	0.0	
1895.					
July 25.........	Prairie Creek.....	S.E. 17-22-6-5.....	A. O. Wheeler....	21.02	Above junction of streams.
July 25.........	PrairieCk.,Br. of.	"	"	22.07	
1894.					
July 11.........	Pekisko Creek....	Sec. 36-17-2-5.....	"	23.5	
1906.					
July 9.........	"	"	J. F. Hamilton...	48.17	
1907.					
October 5.......	"	Sec. 25-17-2-5.....	I. J. Walmsley....	83.0	
1894.					
June 30........	Spring Creek.....	Sec. 11-24-4-5.....	A. O. Wheeler....	22.3	
June 30........	"	Sec. 13-24-4-5.....	"	1.5	
1909.					
May 29........	"	N.E. 20-19-2-5....	J. S. Tempest....	0.23	Float measurement.
June 22........	"	S.W. 24-17-4-5....	"	1.41	
July 22.........	"	S.W. 13-17-4-5....	"	0.35	
July 25.........	Small Creek......	N.E. 26-13-30-4...	"	0.7	Weir measurement.
1894.					
June 30........	Stream, small.....	Sec. 11-24-4-5.....	T. D. Green......	23.2	From Muskeg to Elbow.

Bow River Drainage Basin.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1894.				Sec.-ft.	
July 3	Sheep River	Sec. 25-20-2-5	J. S. Dennis	257.0	
July 23	"	Sec. 24-20-29-4	"	159.1	
July 12	Sheep River, N.Br.	N.E. 2-21-3-5	"	3.0	
1906.					
June 21	"	Sec. 7-21-2-5	J. F. Hamilton	109.60	
June 23	"	"	"	593.90	
1907.					
May 15	"	S.E. 12-21-3-5	I. J. Walmsley	162.7	
October 16	"	"	"	78.12	
1895.					
August 27	Sheep, N. Branch of N. Fork	N.E. 1-21-5-5	A. O. Wheeler	12.48	
September 16	"	S.E. 33-20-4-5	"	8.52	
September 26	Sheep Riv., S. Br.	Sec. 19-19-3-5	"	171.35	
September 26	"	"	"	168.46	
October 3	"	Sec. 29-19-5-5	"	102.67	
October 6	"	Sec. 15-19-6-5	"	93.33	
1896.					
August 6	"	Sec. 14-19-6-5	"	304.37	
1906.					
June 25	"	Sec. 17-20-2-5	J. F. Hamilton	879.0	
June 25	"	Sec. 6-20-2-5	P. M. Sauder	797.8	
1907.					
May 16	"	Sec. 16-20-2-5	I. J. Walmsley	476.3	
October 15	"	"	"	197.8	
1895.					
August 22	Stream to N. Br. of Sheep River	S.E. 34-21-3-5	A. O. Wheeler	0.74	
September 11	"	S.E. 2-21-6-5	"	1.12	
September 11	"	S.W. 1-21-6-5	"	2.7	
September 24	Stream to S. Br. of Sheep River	N.W. 31-19-3-5	"	0.82	
September 30	"	S.E. 30-19-4-5	"	19.94	
October 3	"	S.W. 32-19-5-5	"	14.66	
October 6	"	S.W. 14-19-6-5	"	4.51	
October 6	"	S.E. 15-19-6-5	"	23.61	
October 8	"	S.W. 34-19-5-5	"	9.37	
October 2	"	S.E. 21-19-4-5	"	2.13	
1894.					
July 13	Stimson Creek	Sec. 4-17-2-5	"	3.9	
1906.					
July 9	"	Sec. 5-17-2-5	J. F. Hamilton	28.81	
1907.					
October 5	"	"	I. J. Walmsley	37.0	
1909.					
September 10	Trap Creek	Sec. 8-18-4-5	J. S. Tempest	24.24	
1906.					
July 6	Tongueflag Creek	Sec. 19-19-28-4	J. F. Hamilton	7.3	
1907.					
May 20	"	"	I. J. Walmsley	14.2	
October 7	"	"	"	6.7	
1895.					
September 22	Ware Creek	Sec. 20-20-4-5	A. O. Wheeler	5.8	
September 22	Ware Creek, Br. of	"	"	0.84	

Crane Lake Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1896.					
September 21	Bear Creek	Sec. 19-11-23-3	James Gibbons	13.09	
1907.					
July 3		S.W. 30-11-23-3	R. J. Burley	32.73	
1907.					
June 12	Bear Creek, E. Br.	N.E. 29-10-23-3	"	10.27	
1908.					
June 19	"	Sec. 29-10-23-3	"	3.05	
October 27	"	"	F. T. Fletcher	4.04	
1909.					
July 8	"	S.E. 29-10-23-3	R. J. Burley	17.73	
1907.					
June 11	Bear Creek, W. Br.	N.W. 29-10-23-3	"	14.85	
1909.					
July 8	"	S.W. "	"	28.44	
1896.					
September 21	Piapot Creek	Sec. 18-11-24-3	James Gibbons	1.74	Low water.
1906.					
June 21	"	Sec. 36-10-25-3	R. J. Burley	9.86	"
1907.					
June 20	"	"	"	14.4	
1908.					
June 17	"	Sec. 19-10-24-3	F. T. Fletcher	0.94	Weir measurement.
October 19	"	Sec. 8-10-24-3	"	2.69	

Crane Lake Drainage Basin.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
				Sec.-ft.	
1908.					
October 24......	Piapot, E. Branch	Sec. 19-10-24-3....	F T. Fletcher.....	1.05	
October 24......	Piapot, W. Branch.	"	"	2.17	
1896.					
September 21...	Skull Creek.......	Sec. 7-12-22-3.....	James Gibbons....	0.5	Low water.
1907.					
July 13.........	"	S.E. 34-10-22-3....	R. J. Burley......	5.27	
1909.					
July 21.........	"	Sec. 32-10-22-3....	"	3.04	
August 2.......	"	"	"	2.49	

Frenchman River Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1897.					
July 22.........	Belanger Creek....	Sec. 25-6-26-3.....	R. W. MacIntyre.	7.29	
1907.					
August 23.......	"	Sec. 6-7-25-3......	R. J. Burley......	4.57	
1909.					
September 14..	"	S.E. 14-8-26-3.....	F. T. Fletcher....	2.51	
August 24......	Blacktail Creek ..	Sec. 30-6-23-3.....	"	0.23	
August 21......	Calf Creek.......	Sec. 5-8-22-3......	"	1.55	
September 13...	Dip Creek........	S.E. 7-8-25-3......	"	0.26	Weir measurement.
August 23......	Doyles Coulee....	N.W. 17-7-22-3...	"	0.22	"
1907.					
August 23......	Davis Creek......	Sec. 27-7-25-3.....	R. J. Burley......	No flow.	
1908.					
June 19........	"	"	F. T. Fletcher....	3.05	
1909.					
September 13...	"	N.E. 21-8-25-3....	"	3.5	
1896.					
September 17...	Frenchman River.	Sec. 29-6-21-3.....	R. W. MacIntyre.	23.2	Low water.
1907.					
July 30.........	"	N.W. 24-6-23-3...	R. J. Burley......	32.5	"
1909.					
August 19......	"	Sec. 31-6-21-3.....	F. T. Fletcher....	13.84	
1907.					
July 31.........	Frenchman River, N. Branch......	Sec. 15-7-22-3.....	R. J. Burley......	6.84	
1909.					
August 23......	"	S.E. 16-7-22-3.....	R. J. Burley......	5.45	
August 23......	"	"	"	5.33	
1908.					
August 7.......	Fairwell Creek....	Sec. 7-8-23-3......	F. T. Fletcher....	Nil	
August 7.......	Fairwell Creek, W. Branch.....	Sec. 9-8-24-3......	"	Nil	
1909.					
September 8....	"	Tp. 8, Rge.23-W.3	"	0.87	
September 8....	" E. Branch	"	"	0.89	
September 8....	" E. Branch	"	"	0.40	
1908.					
August 17......	Lone Pine Creek..	Sec. 27-7-26-3.....	"	0.6	Weir measurement.
August 17......	" ..	"	"	0.63	
1909.					
September 12...	" ..	Sec. 14-7-26-3.....	"	0.38	Weir measurement.
1907.					
August 23......	Sucker Creek.....	Sec. 16-7-26-3.....	"	1.05	
1908.					
August 22......	" ..	Tp. 6, Rge 26-W.3	"	Dry.	
July 20.........	Spring Creek.....	Sec. 18-7-22-3.....	"	0.28	
July 20.........	"	Sec. 17-7-22-3.....	"	0.28	
1909.					
August 23......	"	Sec. 18-7-22-3.....	"	0.12	Weir measurement.
1908.					
August 22......	Warlodge Creek...	Sec. 14-7-27-3......	"	0.12	"
August 22......	" Br. of..	"	"	0.15	"
1909.					
September 8....	" " ..	"	"	0.22	"

Hay Lake Drainage Basin.

1896					
Sept. 19........	Hay Creek........	Sec. 30-10-25-3....	R. W. MacIntyre.	0.73	
1906					
June 30.........	"	Sec. 29-10-25-3....	R. J. Burley......	8.42	
1907					
June 20.........	"	"	"	13.3	
Sept. 6.........	"	"	"	1.2	

HAY LAKE DRAINAGE BASIN.—*Continued.*

Date	Stream	Locality	Hydrographer	Discharge	Remarks.
1908				Sec.-ft.	
May 12	Hay Creek	Sec. 29-10-25-3	R. J. Burley	1.0	Weir measurement.
May 13	"	"	"	0.96	
October 16	"	Between Tps. 11-12 Rge. 25-3	F. T. Fletcher	0.15	Weir measurement.
1909					
July 2	"	S.W. 29-10 25-3	R. J. Burley	1.12	" "
April 26	Saunders Spg. C'k.	S.E. 20-10-25-3	P. M. Sauder	0.32	At intake Maple Ck. W.Wks.
April 29	" "	N.W. 20-10-25-3	"	0.33	At Reservoir Maple. Ck. W. Wks.
1909					
May 15	" "	SE. 20-10-25-3	R. J. Burley	0.63	At intake Maple Ck. W. Works.
June 26	" "	"	"	0.8	" "
July 2	" "	N.W. 20-10-25-3	"	0.7	Below Maple Ck. W. Works overflow. *
July 2	" "	"	"	0.08	Above " " *
July 2	" "	"	"	0.19	Below " " *
July 3	" "	"	"	0.79	Below " " *
July 3	" "	"	"	0.07	Above " " *
July 4	" "	"	"	0.81	Below " " *
July 4	" "	"	"	0.17	Above " " *
July 5	" "	"	"	1.34	Below " " *
July 5	" "	"	"	1.05	Above " " *
September 3	" "	S.E. 20-10-25-3	R. J. Burley & P. M. Sauder	0.8	At Intake Maple Ck. W. Works.*
September 3	" "	N.W. 20-10-25-3	" "	0.47	Below overflow. *
Spetember 3	" "	"	" "	0.03	Above " *
October 1	" "	"	R. J. Burley	0.38	Below " *
October 1	" "	"	"	Nil.	Above Maple Creek overflow too small to measure.*

* Weir measurements.

LITTLE BOW RIVER DRAINAGE BASIN.

Date	Stream	Locality	Hydrographer	Discharge	Remarks
1894					
August 2	Little Bow River	Sec. 1-18-28-4	J. S. Dennis	3.1	Low water
1907					
May 27	" "	Sec. 6-19-28-4	I. J. Walmsley	2.0	Partly supplied by Highwood River.
June 4	" "	Sec. 12-15-26-4	"	14.0	
September 29	" "	Sec. 19-16-26-4	"	11.5	
1909					
June 9	" "	Sec. 29-18-28-4	J. S. Tempest	16.07	
June 9	" "	Sec. 20-19-28-4	"	16.7	
June 28	" "	Sec. 1-14-25-4	"	57.39	
June 29	" "	Sec. 31-13-23-4	"	53.55	
June 29	" "	Sec. 31-16-26-4	"	17.77	
1907					
October 7	Ditch Feeding Little Bow	Sec. 6-19-28-4	I. J. Walmsley	0.9	
1894					
July 20	Mosquito Creek	Sec. 35-16-29-4	A. O. Wheeler	......	Creek not flowing.
July 23	"	Sec. 12-16-28-4	"	......	" "
August 1	"	"	"	......	" "
1906					
July 14	"	Sec. 28-16-28-4	J. F. Hamilton	35.55	
July 25	"	Sec. 11-15-26-4	P. M. Sauder	36.8	
1907					
June 4	"	Sec. 12-15-26-4	I. J. Walmsley	30.2	
June 8	"	Sec. 28-16-28-4	"	13.6	
September 25	"	"	"	14.8	
1896					
October 22	Nanton Creek	Sec. 26-15-29-4	A. C. Talbot	0.82	
1906					
July 14	"	Sec. 21-16-28-4	J. F. Hamilton	21.97	
1907					
June 8	"	"	I. J. Walmsley	6.0	
September 25	"	"	"	4.82	
1909					
July 7	Springhill Creek	Sec. 3-16-29-4	J. S. Tempest	1.06	
July 12	Springhill Ck., Br. of	"	"	0.8	

Lodge Creek Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge	Remarks.
1897				Sec.-ft.	
July 13.........	Lodge Creek......	Sec. 36-4-2-4......	R. W. MacIntyre..	1.63	
1908					
September 19...	"	Sec. 25-2-30-3.....	F. T. Fletcher.....	Nil.	
November 9.....	"	N.W. 29-5-2-4.....	R. J. Burley......	Nil.	Water in pools.
1909					
July 14.........	"	N.W.29-7-3-4.....	F. T. Fletcher.....	0.14	Weir measurement.
July 22.........	"	Sec. 15-6-3-4	"	Dry.	
July 22.........	"	Sec. 27-6-3-4......	"	Dry.	
1897					
July 7..........	Lodge Ck. E. Bran.	Sec. 13-7-3-4......	R. W. MacIntyre..	5.34	
1909					
July 22.........	" "	Sec. 22-6-3-4......	F. T. Fletcher.....	Dry	
1906					
August.........	Middle Creek.....	Sec. 8-4-29-3......	R. J. Burley......	0.63	
1908					
September 19....	"	Sec. 9-4-29-3......	F. T. Fletcher.....	Nil	
September 21....	"	Sec. 17-4-29-3.....	"	Nil	
1909					
July 21.........	" ...	Sec. 36-5-2-4......	"	Dry	
October 26......	"	Sec. 22-5-30-3.....	R. J. Burley......	Dry	
May 31.........	Spring Creek......	Sec. 33-6-2-4......	"	0.818	Weir measurement.
May 31.........	" ...	N.E. 29-6-2-4.....	"	0.08	" "

Many Island Lake Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge	Remarks.
1909					
June 25.........	Boxelder Creek....	N.W. 24-12-30-3...	F. T. Fletcher.....	17.79	
June 24.........	Mackay Creek....	N.W. 26-11-1-4....	F. T. Fletcher.....	48.66	
July 29.........	"	"	"	0.64	

Oldman River Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge	Remarks.
1896					
October 31......	Beaver Creek.....	Tp. 9, Rge. 29-W-4	A. C. Talbot......	4.77	
1906					
July 26.........	"	Near mouth on Peigan Res....	J. F. Hamilton....	24.92	
August 1........	"	S.W. 2-9-29-4.....	P. M. Sauder.....	21.3	
1907					
June 29.........	"	Near Mouth on Peigan Res.....	I. J. Walmsley....	79.2	
1909					
August 22.......	"	N.E. 36-9-30-4....	J. S. Tempest.....	6.34	
1906					
July 19.........	Burton Creek.....	Sec. 14-12-1-5.....	P. M. Sander	15.3	
July 20.........	Burke Creek......	Sec. 36-11-30-4....	"	5.0	
1907					
August 31.......	Byron Creek......	Sec. 17-7-3-5......	I. J. Walmsley....	12.9	
September 2.....	Blairmore Creek...	Tp. 8.;Rge. 4 W-5.	"	21.3	
1896					
November 3.....	Cow Creek........	Sec. 34-8-2-5......	A. C. Talbot......	2.99	
1906					
August 4........	"	Sec. 12-8-2-5......	P. M. Sauder.....	2.4	
1907					
July 7..........	"	Sec. 6-8-1-5.......	I. J. Walmsley....	23.0	
August 29.......	"	"	"	9.3	
1909					
August 24.......	"	Sec. 12-8-2-5......	J. S. Tempest.....	4.2	
1896					
November 4.....	Connelly Creek....	Sec. 34-7-2-5......	A. C. Talbot......	1.15	
1906					
August 4........	" ...	Sec. 36-7-2-5......	P. M. Sauder.....	1.0	
1907					
July 7..........	" ...	"	I. J. Walmsley....	11.7	
August 29.......	" ...	"	"	3.5	
1906					
August 9........	Crowsnest River...	Sec. 29-7-1-5......	J. F. Hamilton....	161.7	
1907					
July 3..........	" ...	"	I. J. Walmsley....	957.2	
September 3.....	" ...	"	"	503.7	
1906					
August 7........	Callum Creek.....	Sec. 31-10-1-5.....	P. M. Sauder.....	10.5	
1907					
August 21.......	"	"	I. J. Walmsley...	6.5	
1909					
August 16.......	"	Sec. 36-11-2-5.....	J. S. Tempest.....	1.33	
August 18.......	"	Sec. 31-10-1-5.....	"	4.33	

OLDMAN RIVER DRAINAGE BASIN.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1909				Sec.-ft.	
August 16.......	Callum Creek, Br. of.............	S.W. 6-12-1-5.....	J. S. Tempest.....	0.57	
August 16.......	" "	S.E. 7-12-1-5......	"	0.63	
1906					
August 6........	Cabin Creek......	Sec. 3-9-1-5.......	P. M. Sauder.....	Dry.	
1907					
August 19......	"	"	I. J. Walmsley....	0.7	
August 28.......	Canyon Creek.....	Sec. 14-6-2-5......	"	14.6	
1906					
August 8........	Damon Creek.....	N.E. 18-11-2-5....	P. M. Sauder......	1.0	
1907					
August 21.......	"	"	I. J. Walmsley....	0.7	
1906					
July 31.........	Five Mile Creek...	Sec. 22-9-29-4.....	P. M. Sauder.....	7.8	
1909					
August 22.......	"	S. W. 15-9-29-4....	J. S. Tempest.....	1.0	Weir measurement.
1907					
August 31.......	Gold Creek.......	Sec. 31-8-3-5......	I. J. Walmsley....	45.3	
1896					
November 2.....	Heath Creek......	Sec. 33-9-1-5......	A. C. Talbot......	3.86	
1906					
August 6........	"	Sec. 4-10-1-5......	P. M. Sauder.....	5.8	
1907					
August 20.......	"	Sec. 3-10-1-5......	I. J. Walmsley....	5.6	
1909					
August 19.......	"	N.E. 32-9-1-5.....	J. S. Tempest.....	4.05	
1896					
October 23......	Kuntz Creek......	Sec. 14-14-30-4....	A. C. Talbot......	0.69	
1907					
June 6..........	"	Sec. 18-14-29-4....	I. J. Walmsley....	0.3	Below G. Lane's int'e.
June 6..........	"	"	"	2.7	Above " "
1909					
July 24.........	"	Sec. 20-14-29-4....	J. S. Tempest.....	1.93	
July 27.........	"	N.W. 11-14-30-4...	"	1.93	
1906					
July 30.........	Kyiskap Creek....	Sec. 2-10-27-4.....	J. F. Hamilton....	2.3	
1907					
June 20.........	"	"	I. J. Walmsley....	1.9	
September 2.....	Lyon Creek.......	Sec. 35-7-4-5......	"	27.7	
1906					
July 21.........	Lyndon Creek.....	Sec. 11-12-29-4....	P. M. Sauder......	17.7	
1907					
June 14.........	"	"	I. J. Walmsley....	26.6	
September 23....	"	"	"	6.6	
1906					
August 6........	Meadow Creek....	Sec. 7-10-1-5......	P. M. Sauder.....	Dry.	
1907					
August 20.......	"	"	I. J. Walmsley....	0.4	
1896.					
October 28......	Muddypound Ck..	Sec. 14-11-28-4....	A. C. Talbot.....	2.82	S. Br. of Muddypound
1906.					
July 19.........	"	Sec. 25-11-28-4...	J. F. Hamilton...	9.2	
1907.					
June 11.........	"	"	I. J. Walmsley...	8.3	Below intake.
June 15.........	"	Sec. 27-11-28-4....	"	10.4	
1906.					
August 8........	Mill Creek.......	Sec. 19-6-1-5......	J. F. Hamilton...	46.4	
1907.					
July 8..........	"	Sec. 18-6-1-5......	I. J. Walmsley...	271.7	
August 17.......	"	"	"	48.9	
1906.					
August 6.......	Mead Creek......	Sec. 7-10-1-5......	P. M. Sauder.....	Dry	
1907.					
August 20......	"	"	I. J. Walmsley...	0.3	
September 2....	McGillivary Ck...	Sec. 8-8-4-5.......	"	17.9	
1906.					
August 1.......	Nine mile Creek..	Sec. 1-9-29-4......	P. M. Sauder....	1.2	
1909.					
August 22......	" ..	"	J. S. Tempest....	0.25	Weir measurement.
1907.					
September 2....	Nez. Percee Ck...	Sec. 17-8-4-5......	I. J. Walmsley...	7.1	
1894.					
August 9.......	Oldman River....	Sec. 20-9-25-4.....	A. O. Wheeler....	1,078.0	Mean.
1895.					
August 28......	"	Sec. 36-7-1-5......	T. D. Green......	70.27	North fork.
1906.					
July 25.........	"	Sec. 10-9-26-4.....	J. F. Hamilton...	1,229.6	High water.
July 31.........	"	"	" ...	1,013.9	"
August 10......	"	Sec. 34-7-1-5......	" ...	258.8	Low water.
October 2.......	"	Sec. 10-9-26-4.....	" ...	528.4	
1907.					
June 25........	"	"	P. M. Sauder & I. J. Walmsley....	10,722.4	
September 14...	"	"	I. J. Walmsley....	1,569.2	
September 20 .	"	"	" ...	2,994.0	

OLDMAN RIVER DRAINAGE BASIN.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
				Sec.-ft.	
July 4..........	Oldman River.....	Sec. 34-7-1-5......	I. J. Walmsley....	3,124.7	North fork.
August 23......	"	"	" ...	486.8	"
1909.					
August 19......	"	Sec. 6-10-1-5......	J. S. Tempest....	352.5	
August 25......	"	S.W. 32-7-1-5.....	" ...	278.78	
1906.					
August 6......	Olin Creek.......	Sec. 22-9-1-5......	P. M. Sauder.....	1.4	
1907.					
August 20......	"	Sec. 16-9-1-5......	I. J. Walmsley....	1.1	
1909.					
August 19......	"	S.E. 15-9-1-5......	J. S. Tempest....	0.6	
1906.					
July 30.........	Olson Creek......	Sec. 2-9-28-4......	P. M. Sauder.....	1.1	
1907.					
June 29..	"	On Peigan Reserve	I. J. Walmsley....	1.6	
1906.					
July 7.........	Oxley Creek......	S.W. 25-14-29-4...	P. M. Sauder.....	13.9	
1907.					
June 5........	"	Sec. 26-14-29-4....	I. J. Walmsley....	3.4	
1909.					
July 22.........	"	S.W. 7-14-28-4....	J. S. Tempest....	3.86	
1906.					
July 20.........	Patterson Creek...	Sec. 36-11-30-4....	P. M. Sauder.....	4.3	
1894.					
October 22......	Pincher Creek....	Sec. 12-7-29-4.....	A. O. Wheeler....	19.8	
1895.					
August 29......	"	N.E. 4-7-29-4.....	T. D. Green......	4.99	
1906.					
August 8......	Playle Creek......	Sec. 30-11-1-5.....	P. M. Sauder.....	1.1	
1907.					
August 21......	"	"	I. J. Walmsley....	0.6	
June 5.........	Pine Coulee......	Sec. 10-15-28-4....	"	0.7	
September 29...	"	"	"	0.4	
August 29......	Rock Creek.......	Sec. 29-7-2-5......	"	5.4	
1906.					
July 20.........	Stewart Creek....	Sec. 36-11-30-4....	P. M. Sauder.....	7.1	
August 7......	Sharples Creek....	N.E. 31-10-1-5....	"	3.8	
1907.					
August 21......	"	"	I. J. Walmsley....	3.0	
1909.					
August 18......	"	"	J. S. Tempest....	5.3	Weir measurement.
1895.					
August 29......	South Fork River.	Sec. 25-7-1-5......	T. D. Green......	303.35	
1906.					
Aug. 11........	" ..	Sec. 2-7-1-5.......	J. F. Hamilton...	270.1	
1907.					
July 2..........	" ..	"	I. J. Walmsley....	3,240.1	
August 26......	" ..	"	"	653.1	
1909.					
August 28......	" ..	S.E. 34-6-1-5......	J. S. Tempest....	315.98	
July 25.........	Spring Creek.....	S.E. 35-13-30-4....	"	0.15	Weir measurement.
July 27.........	"	S.W. 2-14-1-5.....	"	0.09	"
July 27.........	Small Creek......	N.E. 27-13-1-5....	"	0.83	"
July 28.........	Two Springs......	N.W. 35-13-1-5...	"	0.18	"
1896.					
October 28......	Trout Creek......	Sec. 12-12-28-4....	A. C. Talbot.....	17.19	Low water.
1906.					
July 21.........	"	Sec. 2-12-29-4......	P. M. Sauder.....	40.4	High water.
July 19.........	"	Sec. 2-12-28-4.....	J. F. Hamilton ...	81.59	"
1907.					
June 11........	"	"	I. J. Walmsley....	56.1	Below ditches.
June 13........	"	Sec. 2-12-29-4.....	"	121.9	Above ditches.
June 14........	"	"	"	38.3	Above Lyndon Creek.
September 23...	"	"	"	14.0	"
September 24...	"	Sec. 12-12-28-4....	"	21.3	Below ditches.
1909.					
August 6.......	"	"	J. S. Tempest....	27.86	
1896.					
October 26......	Trout Ck., S. Br.	Sec. 2-12-29-4.....	A. C. Talbot.....	12.12	Low water.
1906.					
July 20.........	"	Sec. 6-12-29-4.....	P. M. Sauder.....	16.8	
1909.					
August 11......	"	S.E. 11-12-29-4....	J. S. Tempest....	16.76	
1896.					
October 24......	Trout Ck., N. Br.	Sec. 26-12-29-4....	A. C. Talbot.....	8.82	
1909.					
August 5.......	"	S.W. 34-12-29-4...	J. S. Tempest....	6.44	
August 11......	"	S.E. 11-12-29-4....	"	5.83	
August 11......	Trout Ck., Br. of..	N.W. 1-12-28-4...	"	0.94	Weir measurement.
November 3....	Todd Creek......	Sec. 5-9-2-5.......	A. C. Talbot.....	4.25	
1906.					
August 4.......	"	Sec. 7-8-1-5.......	P. M. Sauder.....	11.7	Low water.
1907.					
July 7.........	"	"	I. J. Walmsley....	45.8	
August 29......	"	"	"	44.4	

OLDMAN RIVER DRAINAGE BASIN.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1909.				*Sec.-ft.*	
July 28	"	Sec. 36-8-2-5	J. S. Tempest	11.4	
August 24	"	N.W. 30-8-1-5	"	4.98	
1906.					
August 2	Tennessee Creek	Sec. 23-8-30-4	P. M. Sauder	2.7	
1907.					
August 19	"	"	I. J. Walmsley	2.0	
1894.					
July 25	Willow Creek	Sec. 23-13-28-4	A. O. Wheeler	25.8	
August 10	"	Sec. 24-9-26-4	"	39.6	
1906.					
July 16	"	Sec. 7-12-27-4	P. M. Sauder	208.1	
July 18	"	"	"	255.2	
July 18	"	"	J. F. Hamilton	258.0	
July 20	"	Sec. 31-9-26-4	"	169.6	
July 22	"	"	"	262.3	
July 31	"	"	"	283.4	
October 3	"	"	"	70.9	
1907.					
June 12	"	Sec. 7-12-27-4.	I. J. Walmsley	385.3	
June 13	"	"	"	389.7	
June 27	"	Sec. 31-9-26-4	"	1,318.8	
September 24	"	Sec. 7-12-27-4	"	290.2	
1909.					
July 29	"	S.E. 2-14-30-4	J. S. Tempest	208.7	
August 6	"	N.E. 7-12-28-4	"	107.1	
1907.					
September 2	York Creek	Sec. 34-7-4-5	I. J. Walmsley	46.5	

PAKOWKI LAKE DRAINAGE BASIN.

1909.					
July 7	Canal Creek		F. T. Fletcher	Dry.	
July 9	Manyberries Ck.		"	0.33	Weir measurement.

RED DEER RIVER DRAINAGE BASIN.

1894.					
September 14	Beaverdam Creek.	Sec. 36-28-3-5	T. D. Green	2.7	
1896.					
June 3	"	Sec. 35-29-3-5	A. C. Talbot	7.94	
1909.					
	Berry Creek	Sec. 27-23-13-4	J. Stewart	6.31	
1894.					
September 19	Dogpound Creek	Sec. 33-28-4-5	T. D. Green	2.4	
1896.					
June 2	"	Sec. 33-29-3-5	A. C. Talbot	13.9	
June 9	"	Sec. 34-30-3-5	"	16.0	
June 16	"	Sec. 34-31-3-5	"	13.6	
June 23	"	Sec. 33-32-3-5	"	7.5	
June 29	"	Sec. 13-29-4-5	"	13.6	
1894.					
October 13	Little Red Deer River	Sec. 18-34-2-5	T. D. Green	30.1	
1896.					
June 27	"	Sec. 4-33-2-5	A. C. Talbot	51.36	
1894.					
October 16	Red Deer River	Sec. 27-35-3-5	T. D. Green	539.9	Low water.
1896.					
August 18	"	Sec. 26-33-5-5	A. St. Cyr	1,001.4	"

ROSS CREEK DRAINAGE BASIN.

1907.					
May 24	Bullshead Creek	Sec. 16-11-5-4	R. J. Burley	10.09	
1909.					
June 29	"	N.E. 3-12-5-4	F. T. Fletcher	3.86	
July 1	"	S.E. 16-9-5-4	"	1.81	
July 26	"	"	"	0.22	
1909.					
July 14	Gros. Ventre Creek	N.E. 30-8-3-4	"	1.32	
July 29	"	Sec. 14-11-3-4	"	2.25	
June 28	Ross Creek	N.W. 31-11-2-4	F. T. Fletcher	20.38	
June 30	"	S.W. 28-12-5-4	"	21.12	
July 15	"	At Elkwater Lake	"	Dry.	
July 15	"	N.E. 1-9-3-4	"	4.98	
July 28	"	N.W. 31-11-2-4	"	1.27	

Sevenpersons River Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1909.				Sec.-ft.	
July 5	Peigan Creek	Sec. 23-7-7-4	F. T. Fletcher	0.1	
June 30	Sevenpersons River	N.W. 29-12-5-4	"	10.29	
July 5	"	S.E. 9-8-8-4	"	0.25	
July 15	Spring Creek	N.W. 29-12-5-4	"	1.35	

St. Mary River Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1907.					
August 5	Alberta Railway & Irrigation Co's. Canal	Sec. 21-2-24-4	I. J. Walmsley	357.5	
1906.					
September 14	Boundary Creek	S.W. 20-1-26-4	P. M. Sauder	3.1	
1907.					
July 29	"	"	"	18.5	
August 6	"	Sec. 1-1-26-4	I. J. Walmsley	14.95	
1906.					
September 15	Lee Creek	Sec. 12-2-27-4	P. M. Sauder	27.1	
September 21	"	N.E. 9-3-25-4	J. F. Hamilton	19.22	
1907.					
July 29	"	Sec. 12-2-27-4	I. J. Walmsley	80.4	
August 1	"	N.E. 9-3-25-4	"	53.0	
August 10	"	"	"	73.5	
1909.					
September 28	"	N.W. 10-3-25-4	J. S. Tempest	42.57	
1906.					
September 11	Rolph Creek	Sec. 22-1-24-4	P. M. Sauder	Dry.	
1907.					
August 5	"	Sec. 21-2-24-4	I. J. Walmsley	0.86	
1895.					
July 19	St. Mary River	N.E. 18-2-24-4	J. S. Dennis	2,202.3	
1907.					
August 6	Snake Creek	Sec. 30-2-21-4	P. M. Sauder	0.0	Water in pools.

Swiftcurrent Creek Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1909.					
August 17	Jones Coulee	Sec. 17-8-20-3	R. J. Burley	0.53	
August 4	McNicolls Creek	N.E. 21-7-21-3	"	0.19	Weir measurements.
1896.					
September 21	Swiftcurrent Creek	Sec. 19-15-13-3	J. Gibbons	24.73	
1907.					
July 15	"	Sec. 27-7-21-3	R. J. Burley	1.25	
1909.					
August 2	"	"	"	2.49	
August 19	"	Sec. 22-7-21-3	F. T. Fletcher	1.06	
August 17	Spring Creek	Sec. 17-8-20-3	"	0.08	
August 19	Sexton Creek	N.W. 21-7-21-3	"	0.41	

Waterton River Drainage Basin.

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1907.					
August 14	Backfat Creek	Sec. 3-6-27-4	I. J. Walmsley	No flow.	
1906.					
September 5	Blakiston Brook	Sec. 4-2-30-4	J. F. Hamilton	54.46	Known as Pass Creek.
1907.					
July 18	"	"	"	270.5	
1906.					
September 10	Cottonwood Ck.	Sec. 20-2-29-4	"	4.1	
1907.					
July 17	"	"	I. J. Walmsley	18.4	
July 17	Cottonwood Creek, Branch of	"	"	17.8	
1906.					
September 3	Crooked Creek	Sec. 16-2-29-4	J. F. Hamilton	8.0	
July 23	"	Sec. 22-2-29-4	I. J. Walmsley	36.3	
August 27	Drywood Creek	Sec. 17-4-29-4	J. F. Hamilton	225.8	
August 30	"	"	"	123.9	
1907.					
July 11	"	"	I. J. Walmsley	154.1	
August 14	Foothill Creek	Sec. 29-5-27-4	"	2 2	
1906.					
September 7	Lost Creek	Sec. 20-1-29-4	J. F. Hamilton	11.16	

WATERTON RIVER DRAINAGE BASIN.—*Continued.*

Date.	Stream.	Locality.	Hydrographer.	Discharge.	Remarks.
1907.					
July 22.........	Lost Creek	Sec. 20-1-29-4.....	I. J. Walmsley.....	71.7	
July 23.........	Little Crooked Ck.	Sec. 22-2-29-4.....	"	5.05	
1906.					
September 12...	Oil Creek.........	Sec. 23-1-30-4.....	J. F. Hamilton...	29.41	
1907.					
July 18.........	"	"	I. J. Walmsley....	216.1	
1906.					
September 4....	Pine Creek.......	Sec. 21-3-29-4.....	J. F. Hamilton...	12.8	
1907.					
July 13.........	"	"	I. J. Walmsley....	41.3	
1894.					
August 16......	Waterton River...	Sec. 13-6-26-4.....	A. O. Wheeler....	611.9	
September 4....	"	Sec. 1-3-29-4......	"	501.9	
1906.					
September 6...	"	Sec. 8-2-29-4......	J. F. Hamilton...	648.6	
September 26...	"	Sec. 20-5-27-4.....	"	300.2	
1907.					
August 15......	"	Sec. 20-5-27-4.....	I. J. Walmsley....	885.9	
1906.					
August 25......	Yarrow River.....	Sec. 8-24-9-4......	J. F. Hamilton...	526.9	
August 28......	"	"	"	243.8	
August 30......	"	"	"	121.1	
1907.					
July 11.........	"	"	I. J. Walmsley....	207.8	

INDEX

C.

D.

SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR

1910

PRINTED BY ORDER OF PARLIAMENT

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1911

To His Excellency the Right Honourable Sir Albert Henry George, Earl Grey, Viscount Howick, Baron Grey of Howick, a Baronet, G.C.M.G., &c., &c., &c., Governor General of Canada.

MAY IT PLEASE YOUR EXCELLENCY,—

The undersigned has the honour to lay before Your Excellency, in compliance with 6-7 Edward VII, chapter 29, section 18, the Summary Report of the operations of the Geological Survey during the calendar year 1910.

WILLIAM TEMPLEMAN,
Minister of Mines.

To the Hon. WILLIAM TEMPLEMAN, M.P.,
Minister of Mines,
Ottawa.

SIR,—I have the honour to transmit, herewith, my summary report of the operations of the Geological Survey for the calendar year 1910: which includes the reports of the various officials on the work accomplished by them.

I have the honour to be, Sir,
Your obedient servant,

(Signed) R. W. BROCK,
Director Geological Survey.

TABLE OF CONTENTS

ILLUSTRATIONS.

Drawings.

Map.

SUMMARY REPORT

OF THE

GEOLOGICAL SURVEY BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR 1910.

To the Hon. WILLIAM TEMPLEMAN, M.P.
Minister of Mines.

SIR,—I have the honour to submit herewith, a summary report on the operations of the Geological Survey for the calendar year 1910.

Several changes in the personnel of the Survey took place during the year. Messrs. J. F. E. Johnston, O. O'Sullivan, and F. O'Farrell, draughtsmen, resigned. The following appointments were made:—

Dr. P. E. Raymond, as invertebrate palæontologist; Dr. Edward Sapir, as anthropologist in charge of the Division of Anthropology; Mr. Stanley G. Alexander, as draughtsman; Miss C. A. Macdonald, as stenographer.

The present organization of the Survey is as under:—

Administrative and General.—Director, secretary, resident caretaker, 3 stenographers, 2 publication clerks, messenger, night-watchman, 3 fire-watchmen, cabinet-maker and carpenter.

Geological Division.—11 geologists, 6 assistant geologists, 1 compiler.

Palæontological Division.—1 vertebrate palæontologist, 2 invertebrate palæontologists, 1 assistant palæontolgist.

Mineralogical Division.—Mineralogist and curator, assistant curator, collector and distributer.

Topographical Division.—Topographer, 3 assistant topographers, custodian of instruments.

Draughting Division.—Geographer and chief draughtsman, 9 draughtsmen, clerk.

Photographic Division.—Assistant photographer.

Natural History Division.—Botanist and naturalist, assistant botanist and naturalist, stenographer, preparator, taxidermist.

Anthropological division.—Anthropologist.

Library.—Librarian, assistant.

As a consequence of the rapid development of Canada the work devolving upon the Survey has vastly increased, and the staff is numerically unable to successfully cope with it. A large increase is, therefore, necessary. Lack of accommodation in the old Sussex street building, occupied by the Survey, prevented additional appointments. Now that the Victoria Memorial Museum with its increased room and facilities is being occupied, every effort will be made to strengthen the staff, particularly in the divisions that are relatively weakest.

While the Survey is being liberally provided with funds for its work, in one respect it is suffering—the salaries paid to technical officers are too low. A marked improvement has been made in this regard during the past three years, but more will have to be done if the Survey is to attract and retain the type of man that is needed to secure good results. The work is such that anything short of the best is worse than none at all. Hence the first requirement is the man; the facilities for work are of only secondary importance. When the Survey has secured the right man, it should be in a position to retain his services. To do this it is not necessary to compete in salary with private corporations. The officials are willing to remain with the Survey at salaries greatly less than they could secure from business corporations; all that is required is a salary sufficient to enable the official to live without financial worry, and to properly educate his children. The initial salary into Division II A is sufficient to attract the class of young men required, i.e. students who have taken their Ph.D. degrees in geology, but to retain them it is necessary to promote them into Division I B, when they have established a reputation for good work. They can not be expected to wait for the flux of time and the annual increase to place them there. Similarly, promotion from Division I B to Division I A must be made when the official has taken a front rank in his profession.

To secure a mature geologist who has had a wide experience, and has demonstrated by his work the possession of first rate ability, it would be necessary to appoint him in Division I A. While some of our own capable officials are still in Division I B, this seems unfair, hence to secure a qualified staff, the only recourse is the slow process of training men—with a prospect of losing them when they become efficient.

COMMITTEES.

The Geological Committee, consisting of Messrs. McConnell, McInnes, LeRoy, and Young (Secretary), and the Map Committee, consisting of Messrs. Dowling, Senecal, Boyd, and Dickison (Secretary), have rendered excellent service in connexion with reports and maps. A great deal of important work falls upon the members of these committees, especially upon the secretaries, demanding much time, and for which individual credit cannot be given. Marked improvements in reports and maps have been made by the committees, and improved standards have been fixed. Encouraged by the success of these committees, a Library Committtee has been formed, and a Museum Committee, consisting of officials responsible for the various divisions of the Museum, will be organized.

FIELD WORK.

The geological and topographical field work undertaken by the Geological Survey during the past season has, as usual, been economic in its bearing, most of it directly so; but a little has been on the broader problems of Canadian geology whose solution is required for the interpretation of the facts gleaned in the detailed examination of the mining districts. Most of the fields selected are those in which work has been specially asked for by the mining profession, Boards of Trade, etc. Not all such requests received could be met, on account of the lack of specially qualified men to take charge of the operations. So far as possible, however, this was done. The guiding principle in the selection was to choose those districts in which the work would be likely to prove of most immediate or of greatest value. The parties were distributed as follows:—

Mr. D. D. Cairnes was engaged in investigating the ore deposits of the Atlin district, B.C. This district has for a decade been known as a placer field. During the past season some promising developments in lode mining have taken place.

Mr. R. G. McConnell spent the season studying the geology and ore deposits of the Stewart district at the head of Portland canal, B.C. This district atttracted a great deal of attention during the summer. While promising deposits have been found, exaggerated reports sent out threatened a wild boom, which, fortunately, the Survey was able to assist in preventing, by the publication of official despatches from its representative in this field.

Mr. G. S. Malloch made a topographical survey of this district.

Mr. W. W. Leach continued his topographical and geological mapping of the Hazelton district, B.C. The approach of the Grand Trunk Pacific railway brings this section into prominence. Promising discoveries of silver-lead, copper, and coal have beeen made.

Mr. R. H. Chapman, assisted by Messrs. Chipman, McLean, MacKay, McElhanney, and Wookey continued the topographical mapping of Vancouver island. Mr. McLean continued the triangulation of the island as control for the topographic maps. Mr. Chapman divided his forces into three parties and completed the mapping of three sheets.

Mr. C. H. Clapp made a detailed examination of the area of the Victoria and Saanich sheets, which were topographically mapped the previous season by Mr. Chapman. Vancouver island is now atttracting many setttlers and the topographical and geological mapping of the island is of great and immediate value.

Mr. C. H. Camsell completed his topographical and geological survey of the Tulameen district, B.C., and made a reconnaissance from the International Boundary line to the Nicola valley. This section is noted for the variety of its minerals, and prospect of railway transportation is bringing it into notice.

Mr. L. Reinecke completed his topographical mapping of the Beaverdell mining district, West Fork of the Kettle river, and began a study of its geology and ore deposits.

Mr. W. H. Boyd made a topographical survey of the Deadwood Mining Camp and continued his survey of the Slocan district.

Mr. O. E. LeRoy made a study of the geology and ore deposits of Deadwood, completed his investigation of the ore deposits of the Slocan silver-lead district, and made a preliminary examination of Franklin Camp, North Fork of the Kettle river.

Mr. S. J. Schofield continued his topographical and geological survey of East Kootenay.

For the correlation of the formations met with in the mining camps, and for the deciphering of their complicated geological structure, several detailed geological sections across the Cordillera in Canada are required. Such a section has been constructed by Mr. R. A. Daly, along the International Boundary line. A similar section is now needed along the main line of the Canadian Pacific railway. Work upon this was commenced the past season.

Mr. J. A. Allan was engaged in the vicinity of Ice river.

Mr. H. S. Shimer studied in detail the Devono-Carboniferous rocks near Banff.

The Cambrian rocks near Field have been made the subject of careful study, for several seasons, by Dr. C. H. Walcott, Secretary of the Smithsonian Institution, Washington. Incidentally, it may be mentioned that Dr. Walcott found here one of the most remarkable deposits of fossils ever discovered.

Mr. D. B. Dowling continued his exploration of the coal-bearing rocks on the east slope of the Rockies. This year he was delimiting the coal formations in the neighbourhood of Jasper park, Yellowhead pass. Being on the Grand Trunk Pacific railway these fields are of special importance.

With settlement of the country the demand for clays suitable for all kinds of clay products becomes urgent. If found, important industries are developed; without them, a serious burden is imposed upon the communities. Mr. Heinrich Ries, of Cornell University, who last year reported on the clays of the Maritime Provinces for the Survey, and Mr. Joseph Keele, spent the season investigating the clay resources of the western provinces.

Mr. W. McInnes mapped and more accurately defined the geological boundaries in the district north of Cumberland House and The Pas, work which is at present desirable in anticipation of the early construction of the Hudson Bay railway.

Mr. J. D. Trueman spent the season in the Gunflint Lake district, western Ontario. This area has never been mapped geologically, and on account of its proximity to known iron districts its examination was called for.

Mr. W. H. Collins completed his geological map of the Gowganda district, and commenced the mapping of the unsurveyed but promising district west of the Timiskaming and north of the Sudbury sheets.

Mr. W. A. Johnston continued his topographical and geological surveys in the Lake Simcoe district.

Mr. C. R. Stauffer began a resurvey of the geology of southwestern Ontario in which important non-metallic mineral deposits occur. No detailed study of its geology has been made since the early days of the Survey, the reports and maps of which are long since out of print. Quarries, wells, borings, etc., have brought to light much additional information, so that a revision of the geology of this district will be welcomed.

Mr. Morley E. Wilson was engaged in mapping and examining the district east of Abitibi lake. This district is similar to northern Ontario and it is hoped that similar mineral discoveries may be made in it.

Mr. J. A. Dresser continued his investigations into the economic geology of the Eastern Townships of Quebec.

Mr. J. W. Goldthwait studied the raised marine beaches south of the St. Lawrence river. This work has a bearing on the clays, sands, and soils of the region. The elevation of the land relative to the gulf has been comparatively recent; it is important to ascertain if it has been uniform or greater at one point than another, and also, if possible, whether the uplift is still in progress.

Mr. G. A. Young made a geological and topographical survey of the Topique district, New Brunswick. For some years this field has been brought to the attention of the Survey, there being a strong feeling in New Brunswick that it may prove to be possessed of mineral wealth.

Mr. M. Y. Williams made a detailed study of the district about Arisaig, N.S. This presents probably the best section of Silurian rocks in eastern America, and their detailed study here, it is hoped, may lessen the difficulties of investigation in other localities in which this formation occurs.

Mr. E. R. Faribault continued his mapping of Nova Scotia and his investigation of the gold-tungsten bearing rocks. Leaving his party at work in the field, Mr. Faribault spent the two mid-summer months in the Chibougamau district, Quebec, as one of the commissioners appointed by the Quebec Government to report on the geology and mineral resources of the Chibougamau Lake district, his services having been loaned by the Survey to the Quebec Government for this purpose.

Mr. W. J. Wilson spent a few weeks in the Maritime Provinces collecting fossils to aid in fixing geological horizons, and Mr. P. E. Raymond collected in the neighbourhood of Ottawa, with a similar object.

No detailed work was done by the Survey in Porcupine, as this district was receiving attention at the hands of the Provincial Bureau of Mines of Ontario. By mutual arrangement, duplication of work is avoided.

IMPORTANT MINERAL DISCOVERIES AND DEVELOPMENT DURING THE YEAR.

In the reports of the field officers which follow will be found particulars of interest regarding new mineral discoveries and developments during the year. Among the more important are the following:—

The encouraging developments following prospecting for lodes in the Atlin district, reported upon by Mr. Cairnes.

The Portland Canal and Stewart district, studied by Mr. McConnell.

The promising silver-lead prospects in the Hazelton district reported on by Mr. Leach.

The discovery of diamonds in peridotite from Olivine mountain in the Tulameen district, southern British Columbia, where Mr. Camsell has been at work. While of scientific interest rather than of commercial importance, it will be worth the prospector's while to be on the lookout for diamonds in the gravels of streams draining areas of these basic igneous rocks. Such areas are not uncommon in British Columbia. Similar basic rocks are also known in Ontario and Quebec. Commercial diamonds of the first quality have been found in the glacial drift in Illinois, Ohio, and other States. As this drift material has come from northern Ontario and Quebec it is presumed that the source of the diamonds is somewhere in this northern section also. The only known original matrix of the diamond is a peridotite or closely related rock, so that, while diamonds are perhaps not confined to such rocks, so far as present knowledge goes they are the most promising ones to prospect for these gems.

The Tulameen peridotite also carries gold and platinum.

A sample of peridotite and an included vein from the Johnny Bull claim, Trout creek, about 10 miles from Summerland, Okanagan lake, assayed for the Survey by the Mines Branch for platinum, yielded positive results.

The silver-lead district of the Slocan examined by Mr. LeRoy was at one time the leading silver-lead camp of Canada. Some important discoveries were made there during the past year and it affords a promising field for further development.

On the Grand Trunk Pacific, in the neighbourhood of Jasper park, where Mr. Dowling was engaged during the past season, coal seams have been opened.

Messrs. Ries and Keele have found some good fireclays during their examination of the clays of the western provinces.

Lignites have beeen found in well digging and borings at several points on the plains where domestic fuel is badly needed.

In Ontario the most important development has been in the Porcupine gold district which was visited by the writer. Its geological study and mapping was undertaken by the Ontario Bureau of Mines. Farther north, at Grand Rapids on the Mattagami river, iron ore, reported to the Survey in 1877-78 by R. Bell, was receiving some attention and was also under investigation during the past season by the Ontario Bureau of Mines.

The work by Mr. Dresser in the Eastern Townships of Quebec shows that expansion is possible in the non-metallic mineral industries.

Near Moncton, N.B., a gas field has been tapped. It was visited in March by the writer, but since then new wells have greatly increased the production. A little oil has also been encountered with the gas. This field gives promise of becoming important.

The examination of the clay samples which Messrs. Ries and Keele collected in the Maritime Provinces last year has shown that very valuable clays similar to those of New Jersey occur in New Brunswick and Nova Scotia.

Mr. Faribault reports that the development of the tungsten deposits, so far as it has gone, indicates that these are of commercial importance.

TOPOGRAPHICAL DIVISION.

During the past year considerable progress has been made in the organization of the topographical division. To this the generous assistance of the United States Geological Survey, afforded through Mr. R. H. Chapman, contributed in no small degree. A corps of carefully selected topographers is being trained, and our standard topographical maps, now being made, will compare favourably with those produced anywhere. Perhaps no part of the work of the Geological Survey is of more immediate economic value. For not only are these accurate topographical maps necessary as base maps for the detailed geology of mining camps, to make it sufficiently exact for economic purposes, but they are in themselves very valuable to the mining and other engineers, since they may be used in many of the engineering problems which are constantly arising, thereby saving for developing and other directly productive uses large sums which would otherwise be required for private surveys.

NATURAL HISTORY DIVISION.

In addition to geological work, the Geological Survey is called upon by the Department of Mines Act to engage upon work in natural history, anthropology, etc.

Mr. John Macoun spent the field season in Nova Scotia collecting information and material illustrative of the botany of the Province. He also supervised the work of Mr. C. H. Young, who was collecting marine fauna on the Nova Scotia coast.

Mr. James Macoun went to the northwest coast of Hudson bay to collect the flora and fauna of that district.

ANTHROPOLOGICAL DIVISION.

While the Survey has done some important work in anthropology in the past, it has been spasmodic and entirely secondary. With the rapid settlement of the country, the time has come when work along this line must be vigorously prosecuted, for settlement destroys the materials, and unless they are collected and preserved now they will be lost forever, and the succeeding generations of Canadians will search in vain for authentic information concerning the native races of their country.

Since this work was called for in the organic law of the Department and the time was opportune, a Division of Anthropology was established this year and Dr. Edward Sapir appointed to take charge of it. The plans of the Anthropological Division include field work among the native tribes of Canada for the purpose of collecting extensive and reliable information on their ethnology and linguistics, archæological field work, the publication of results obtained in these investigations, and the exhibition in the Museum of specimens illustrative of Indian and Eskimo life, habit, and thought.

Mr. Sapir spent the field season in the west, more particularly in the neighbourhood of Alberni, Vancouver island, studying the Indians of this section.

Mr. C. Stefansson, who is in the Arctic under the joint auspices of the American Museum of Natural History and the Geological Survey, continued his study of the life and habits of the Eskimo east of the Mackenzie river. He had a trying winter, on account of the failure of the hunt, but managed to withstand the hardships. The last year he expected to spend near Coronation gulf.

PUBLICATIONS.

The results of the investigations of the Survey are given to the public in the form of maps and reports. Since, however, a great many different classes and individuals find the work of the Survey of interest and value for very different purposes, it is impossible in a general report to present the matter in the form and in the detail that might be desirable for any single class or individual. A great deal of information is acquired that may be of value to particular persons but not to the general public, hence must be omitted in a report. Much of such information is given to individuals in the field, and this is perhaps the most valuable service rendered by the Survey. A great deal is supplied by correspondence. This branch of the Survey's work is growing rapidly. To avoid delay, information that is of immediate interest to the public is furnished through press bulletins, which are sent to the press throughout Canada and also to those individuals who have expressed a wish to have their names placed on the "Notice list" of the Survey. Timely information concerning the Porcupine gold district, the Stewart district, Portland canal, the Atlin district, Hazelton district, etc., was made public in this manner.

During the year 30,325 publications were distributed to libraries and to individual applicants. Of these 18,852 were distributed in Canada, 3,282 in the United States, 1,225 in Great Britain, and 6,966 in other countries. The sale of publications amounted to $461.44.

A list of the maps and reports published during the year will be found near the end of this report.

Attention is called to the fact that maps recently published by the Survey may be obtained printed on linen. For field use, or hard service, the linen maps are very serviceable, being unaffected by moisture and practically indestructible. An extra charge of ten cents is made to cover the cost of the material.

PHOTOGRAPHIC DIVISION.

Up to the present the work of the photographic division has been confined almost exclusively to developing and printing negatives obtained by officials in the course of their field work, and to photographing specimens for illustrating reports. Blue-printing and some map reducing and enlarging have been done in the draughting division. A great economy of time and money may be effected by equipping a photographic laboratory for process work, as this may take the place of handwork by draughtsmen, thereby releasing them for productive work. Provision is being made for this in the new photographic laboratory, and it is expected that it will result in less delay in the publication of our maps.

Much of the topographic mapping is done by a photographic method, and a large part of the work of the photographic division is the developing and enlarging of the negatives obtained. for the use of the topographers in the compilation of their maps.

During the year over 1,200 topographic negatives were developed and over 1,000 enlarged prints made. About the same number of ordinary negatives were developed and over 4,000 prints made from them.

The negatives in the possession of the Survey acquired during the past forty years of field work in all parts of the Dominion form a very valuable collection, illustrating the physical features, geology, timber and other resources of the greater part of Canada. These are being catalogued as occasion permits, so that they may be readily accessible for use.

EDUCATIONAL WORK.

By a little extra effort and at a comparatively small expenditure the Survey is able to materially assist technical education in the educational institutions of the country. Reports and maps that may be of use in the higher grade schools and colleges are supplied free of cost. To institutions of at least high school grade, attractive cabinets of typical Canadian rocks, minerals, and ores are also furnished free. Positions as student assistants on field parties are reserved for college graduates or students who have finished at least their second year, and who are specializing in geology, mining, or topography. The experience gained in the field supplements the college work and is of great and direct educational value.

VICTORIA MEMORIAL MUSEUM.

For many years museum halls and storage accommodation in the old building have been taxed to their utmost capacity and as a natural result little has been possible in the way of new acquisitions. During the past year, however, some important collections were obtained and preparations made for moving the collections to the new Victoria Memorial Museum. Although the building was not completed and is still in the contractor's hands, moving was begun in November, and at the close of the year the greater part of the offices and collections had been placed in the new building, where the valuable material will no longer be in danger of destruction from fire. On account of lack of accommodation in the old building, not only was the Museum stifled, but the general work of the Survey was seriously handicapped. These disabilities are removed in the new quarters. The Museum can now expand and the work of the Survey be accelerated. The Museum will include the illustrative material acquired by the various divisions of the Survey, namely, mineralogy and geology, biology, and anthropology. It will, therefore, be a complete natural history museum. In the old Museum, mineralogy and geology were dominant, the other divisions being only sparingly represented. It is the intention to increase the economic material in the mineralogy and geology division so that Canadian ores and their products, their mode of occurrence, etc., may be thoroughly represented, and to greatly strengthen the biological and anthropological divisions. A large amount of material suitable for public display is already on hand, which for lack of room could not be placed in the old exhibition halls. For the present it is the intention to restrict the Museum to Canadian material (except in educational collections where necessary objects may be lacking in Canada) in order to make it, first of all, the great Canadian Museum, whose collections in Canadian material will surpass all others. When this has been accomplished in all divisions it may be advisable to enlarge its scope, and make it a world museum. It is proposed to utilize some space for scientific collections. As a National Museum it is the natural repository for all Canadian objects of scientific value. Much of such material is of no interest to the general public, and, therefore, should not take up valuable space in the exhibition halls, but should be so arranged, catalogued, and stored as to be accessible to Canadian students and scientists from abroad who may wish to study Canadian material. It will be some time before the exhibition halls can be made ready for the public. The old furnishings are unsuitable, and new modern cases will be provided. The specimens for public display will each have to be selected, labelled, and placed in position. This involves an immense amount of labour that has to be done personally by the officials in charge as it cannot be relegated to temporary helpers. In the old building, on account of lack of space, little could be done in this direction. Now that the material is in the new building this work will be pushed.

INTERNATIONAL GEOLOGICAL CONGRESS.

At the instance of the Geological Survey, the Government of Canada and the Canadian Mining Institute invited the International Geological Congress to hold its next meeting in Canada. This invitation has been accepted and in 1913 about one thousand of the leading geologists, representing every civilized country, will visit Canada and study the geology and mineral resources of this country.

WORK OF THE DIRECTOR.

Summary.

Routine work occupied the greater portion of the year. In January, the American Museum of Natural History, New York, was visited, also the Carnegie Museum, at Pittsburgh. In March, the meeting of the Canadian Mining Institute in Toronto was attended as were meetings of council throughout the year. The meeting of the Nova Scotia Mining Institute was also attended. Returning from the latter the property of the Maritime Oldfields Company, near Moncton, was visited. In May, I accompanied the Hon. Wm. Templeman to Washington, Philadelphia, and New York, to visit the United States Geological Survey, the Smithsonian Institution and United States National Museum, the Museum of the University of Pennsylvania, Philadelphia, and the American Museum of Natural History, New York. As a result of the information obtained it was decided to equip the New Victoria Memorial Museum on the lines now being followed by the American Museum of Natural History.

Notes on Field Work.

In June, a few days were spent in the Porcupine district.

In July, a day was spent at Kazabazua, Que., investigating a rumoured discovery of gold ore, 1½ miles from Danford Lake post-office. A 30 foot pegmatite dyke in crystalline limestone was found to be the discovery. It is coarse, the quartz occurring in masses up to 10 feet in diameter. Feldspar, including some plagioclase, coarse hornblende, pyrite, graphite, and sphene are the associated minerals. Such pegmatites might in places afford commercial feldspar. Some mica deposits occur in this district.

August and part of September were occupied on the Hudson Bay trip of His Excellency Earl Grey.

During the latter part of September I went to Los Angeles to represent Canada at the meeting of the American Mining Congress. A week was spent examining the oil field of California. From California I came north to examine, in company with Mr. John Sterling, Inspector of Mines of Alberta, into the condition of Turtle mountain.

Gas near Moncton, N.B.

The Maritime Oldfields, Ltd., of Moncton, have been boring for oil and gas, west of the Petitcodiac river, 10 miles south of Moncton, and about 5 miles north of Hillsborough. At the time of my visit, March 18, several wells were completed and new holes were being started. Well No. 3 had passed through three groups of oil and gas sands and at 1,725 feet was stopped on account of salt water being encountered. This had been shut off and the well was pumping about two barrels of oil per day and had a rock pressure of gas of about 100 pounds. It was estimated to flow about 1,000,000 feet per day.

Well No. 5, drilled to 1,407 feet, also passed through three groups of sands, and was yielding a little less oil but more gas than No. 3. The oil was a thick green petroleum and was being supplied to the Intercolonial railway at Moncton.

Since the time of visit boring has been vigorously prosecuted, and it is now reported that the Company has ten wells with an estimated flow of gas of about 39,000,000 cubic feet per day (estimated by rise in pressure in the first minute), and a yield of oil of about 25 barrels per day. Two new wells are about ready to produce, and others are being started.

The deepest well is 2,175 feet. The rock pressure of the gas is given as varying in the different wells from 30 pounds to 610 pounds.

It is proposed to supply the town of Moncton with gas from this field.

Porcupine District, Ontario.

This district will be found described in detail in the report of the Bureau of Mines, Ontario. It will be sufficient in this place to quote a few sentences from the press bulletin issued by the Geological Survey in June last.

"Most of the gold occurrences so far located are in the township of Tisdale, but some of the properties are in Whitney, Mountjoy, Ogden, Deloro, and Shaw. A new discovery has just been announced from Kamiskotia lake, west of the Mattagami river. Then, of course, there are the older discoveries at Nighthawk lake. The prevailing rocks are greenstones (including old diabases), quartz-porphyries, and schist, presumably of Keewatin age, with some slates, greywackes, and conglomerates, probably Huronian. The quartz seems to occur in any of the rocks and in all manner of forms. There are some well-defined veins, there are some large apparently isolated masses of it, the so-called 'domes,' and there are numerous irregular quartz stringers, which may swell out in places to large masses, that may or may not have a vertical extension. The majority of the veins and zones of quartz stringers seen had a strike approximately northeast, while that of the rocks was more nearly east—that is they were distinctly cutting across the strike or schistosity of the rocks, as the case might be. A few had a strike of a little south of east. The quartz holds many inclusions of more or less altered country rock. Pyrite is rather extensively developed in and along these inclusions. The gold, which is often coarse, is distributed in much the same way as the pyrite, with which it is usually rather closely associated, but some may be found in the pure quartz. A little galena, blende, and chalcopyrite may also be present. A ferruginous carbonate, probably ankerite or siderite, is, next to quartz, the most abundant gangue mineral. It weathers deeply to reddish-yellow iron oxide. Calcite, chlorite, talc, probably sericite and feldspar were also noticed.

"Porcupine is fortunate in having had a number of strong interests take hold in the initial stages of the camp, which ensures intelligent development and a thorough test of some of the more promising prospects. Plants were brought in during the winter, and a surprising number of properties are equipped with power plants.

"The 'show' properties at present are the Timmons, Dome, and Foster.

"The Timmons (Hollinger) is about seven miles west of Porcupine lake and a mile and a half east of the Mattagami river. A clearing of forty acres has been made and substantial mine buildings erected. The plant consists of two boilers, a compressor, hoist, and dynamo; a crusher and small prospecting stamp mill are being erected. The buildings are lighted with electricity, and supplied with hot and cold water, baths, etc. A number of veins are exposed. On the largest, with a maximum width of about 20 feet, three shafts have been sunk, the distance between the first and last being about 800 feet. For the greater part of this distance, vein is exposed. The deepest shaft is about 90 feet, and is in a 12 foot vein at the bottom. Sinking is being continued. Beautiful ore, carrying free gold, is obtained at the bottom of the shaft, and over the surface showings gold splashes are liberally scattered. About 300 tons of very promising ore is on the dump, from which almost anywhere showy specimens might be obtained. Several lots of ore from the dump, sent out for sampling, are said to have yielded high results. The fresh ore is very promising looking and seems quite as good at 90 feet as on the surface. A number of other veins have been stripped, one of which has been traced about 300 feet, and shows gold at various points.

"The Dome is also under vigorous development. Here two large masses of quartz, 60 feet or so in width and of considerable length, are opened up. Coarse gold adorns the surface of the quartz at a number of points, and the systematic sampling of the quartz is said to yield very satisfactory results. Several shafts have been sunk and diamond drilling is now to be undertaken to determine the conditions at depth. A small test mill is being erected, and the property is well equipped with a good plant and buildings.

"The Foster vein is a belt or vein of the iron carbonate filled with transverse masses and veins of quartz. The quartz contains many inclusions of the carbonate in which sulphides and gold have been deposited. This vein or belt has been traced by trenching and stripping at intervals for nearly half a mile, and has a width, where exposed on the Foster, of from 6 to 20 feet. Fine showings of gold occur, and the clean-cut character and extensive horizontal dimensions of the lode suggest that it may have an equally strong vertical extension.

"From the above it will be seen that there are some grounds for the hopefulness regarding the future of this new camp. Of course there are properties here which will furnish specimens but never anything more, and many that will not do even this. There are some that will be 'teasers,' with just enough quartz with values to attract money for their development; but not enough in one place, or not enough continuity to the bodies to be exploited profitably. But there are some really promising prospects, which, even if they should not prove altogether satisfactory with depth, yet may, on their present showings, have quite a tidy output of gold.

"The development during the next few months, which will furnish some clue as to the deeper conditions, will be followed with much interest. The history of gold mining in Ontario has not been highly encouraging; but it is to be remembered that gold mining in Ontario is to-day in exactly the same position as was silver mining seven years ago, and the chances of finding a notable gold camp are to-day quite as good as were the chances of locating a Cobalt at that time.

"Porcupine is as yet in the prospect stage. But it has some of the essential qualities of a gold camp, sufficient to have induced experienced mining men to take up options at high figures, and to undertake large expenditures to determine if it possesses all the essential factors."

Since the above was written, development has proceeded steadily, with such satisfactory results that several of the companies are erecting large mills to handle their ores. The Ontario Government is building a railway into the camp from the Timiskaming and Northern Ontario railway, at Kelso. It is expected to be in operation in July.

Turtle Mountain, Frank, Alta.

Since the great landslide at Frank in 1903 the Survey has kept Turtle mountain under inspection, as the northwest shoulder overlooks the town in a threatening manner. On October 12, with Mr. W. H. Boyd, of the Survey, I again visited Frank. In this examination we were accompanied by Mr. John P. Sterling, Provincial Inspector of Mines, and three representatives of the coal company whose property lies along the base of the mountain.

We found the northwest shoulder to be in a more threatening condition than it was last year. Until last year it exhibited no signs of movement nor, apart from its structure, of any weakness. Last year, however, two small cracks were detected, but so slight that their existence might have been questioned. This year they were quite marked. The cracks between the shoulder and the peak also show development. In most cases the block severed by a crack is not large enough to cause damage, but as the joint planes along which the cracks form dip towards the face of the cliff, only those near the face can open, the weight of the inverted wedge tending to keep the joint closed. Moreover, the surface is covered with shingle so that only a gaping crack makes itself visible, hence a dangerous break back from the face of the cliff along which an enormous slide might take place, might not be detectable on the surface even at the time a slide was about to occur.

The cracks on the north shoulder are significant as indicating that movement has taken place and that the solidity of this huge mass of rock is not to be relied upon. The recent movements indicated by these cracks may well be ascribed to the disturbing effects of mining operations.

In view of what has already occurred, of the present condition of Turtle mountain, and of the damage to property and life that would result in case the northwest peak and shoulder fell, it does not appear safe to take further liberties with this mountain and in my opinion the coal seams near its base should not be disturbed.

The Hudson Bay Route.

OBSERVATIONS MADE IN CONNEXION WITH THE TRIP OF HIS EXCELLENCY THE GOVERNOR GENERAL—EARL GREY—TO HUDSON BAY.

Interest in the country tributary to Hudson bay and in the Hudson Bay route, has been reawakened by the determination to proceed with the construction of the Hudson Bay railway. His Excellency the Governor General—Earl Grey—who has always shown a keen desire to secure first-hand information regarding Canada and its resources, and a lively interest in "the continuous disproof of the theory of the frozen north," which has made up its recent history, undertook last summer to go over the Hudson Bay route with a small party.

His Excellency has extended to the writer, who had the privilege of accompanying him, permission to publish as a Geological Survey report an account of the trip and a description of the districts traversed.

ITINERARY.

On August 3, the party left Winnipeg, and on the 4th embarked at Selkirk on the steamer *Wolverine,* dropped down the Red river and traversed Lake Winnipeg. On the evening of the 5th, a stop was made at the mouth of the Saskatchewan, and on the morning of the 6th, Warren landing, at the outlet of Lake Winnipeg, was reached. The journey from Warren landing to Norway House, about 23 miles, was made by launch. The route lies down the Nelson river into Playgreen lake. From Playgreen lake the Nelson issues in several branches, the two main channels of which reuniting at Cross lake, enclose Ross island, 53 miles long and 21 miles wide. The eastern channel, or Sea river as it is sometimes called, leaves Playgreen lake near the eastern end, in several branches that unite at Little Playgreen lake. Norway House is situated on one of these branches, at the entrance to Little Playgreen lake.

At Norway House, the canoe journey commenced, the route followed being the regular Hudson's Bay Company boat route via the Hayes river to York Factory. Leaving Norway House in the afternoon of August 8, in twelve canoes, manned by Norway House Indians, Little Playgreen lake was crossed and Sea river descended about 10 miles before camping. About 20 miles below Norway House, Sea River falls necessitates a short portage and about 8 miles below the falls the boat route leaves the river and ascends a small tributary from the east, known as the Echimamish river. The dark water of this swampy, marshy stream, is in strong contrast to the bluish white Nelson river. A short distance up, the stream expands into a shallow rush-grown stretch of water known as Hairy lake. Camp was made on the evening of the 9th, on marshy ground at a fork of the stream. Ascending the Echimamish three dams, maintained to render the stream navigable for York boats, were passed and the head of the stream reached at Painted Stone portage. A lift over this rock transferred the canoes to Hayes River water, which is followed to the sea. After a stretch of narrow river and several small lakes, Robinson portage was reached, where camp was pitched on August 10. This portage, about a mile in length, is the only long one on the whole route, and is overcome by a rude tram, provided with several push cars. From Robinson portage, the stream flows through a marshy lake, and enters a narrow, rocky defile. York boats follow the river, but our canoe route left by a half mile portage eastward, and rejoined the boat channel in Pine lake, a few miles farther down. After a further stretch of river, Windy lake was reached, on the shores of which camp was pitched for the night of the 11th. From Windy lake the river is divided into numerous rapid channels, and several short portages are necessary. In this part of its course, its direction is west of north, at right angles to the general direction. After a few miles of turbulent water, Oxford lake was reached. This lake is a fine body of water about 30 miles long, running northeast. It is irregular in outline and is broken by many islands. Oxford House, situated at the outlet, on a ridge of clay between Oxford and Back lakes, was reached on the night of August 12. Leaving Oxford House on the afternoon of the 13th, we paddled round to Back lake and down the stream, here known as Trout river, to Trout falls. The course of Trout river is southwest. It is a rapid stream with several chutes that have to be portaged; Trout falls, the most important one, has a drop of about 16 feet. The river discharges into Knee lake, a narrow, island-dotted lake about 45 miles long. Camp on August 14 was made on a point about 15 miles from the northeast end of the lake. A stretch of river, about 10 miles in a straight line, known as Jack river, connects Knee lake and Swampy lake. A number of rapids occur, especially on the lower portion of this river. Camp was made near the outlet of Swampy lake. Owing to unfavourable weather, the 16th was spent in camp. On the 17th the journey was resumed through Swampy lake and down the river here known as Hill river. For about 20 miles it is full of islands. Rapids are numerous, some could be run with full loads, some were run in light canoes, and some had to be portaged. Shortly after lunch the "Hill," the only outstanding topographical feature on the route, was passed. Camp was pitched at Rocky Point portage. Although numerous rapids were run, about a dozen portages were made during the day. On August 18, the three remaining portages, White Mud, Borrowick falls, and the Rock were made. From the latter to the sea, a distance of nearly 110 miles, no rapids occur, but the current is swift, so that an up-stream journey would be slow and heavy. From Nelson river to the Rock, the general course of the route had been northeasterly. From the Rock, the river takes a more northerly direction. Favoured by the current, and unimpeded by rapids, progress from the Rock was rapid. Fox river, a tributary from the west, was passed shortly after lunch, and camp was made about 16 miles below it. On the 19th, after three hours' paddling, the Shamattawa branch, a large river from the southeast, was reached; by noon, Penneygutway; and about six o'clock we landed at York Factory. Off York, the party embarked on the Canadian Government steamer *Earl Grey*, and proceeded to Churchill, about 180 miles distant.

From Churchill, the *Earl Grey* traversed the 600 miles across Hudson bay to Hudson straits, passing within sight of Coats and Mansfield islands. A short stop was made at Sagluk bay, on the north shore of Ungava, east of Cape Wolstenholm. The cruise was then continued along the north side of Charles island, along the coast of Baffin island and Resolution island, and across the straits, at their entrance, to Port Burwell, a Moravian Mission on the west side of one of the islands of the peninsula which separates Ungava bay from the Atlantic. Leaving Port Burwell, the steamer rounded the Button islands and ran down the Labrador coast to Newfoundland, Cape Breton and Prince Edward Island, finishing the cruise at Pictou, Nova

Scotia. Stops were made at Okkak and Indian harbour on the Labrador coast, Port Anthony and Bay of Islands in Newfoundland, Sydney on Cape Breton Island, and Charlottetown, Prince Edward Island.

GENERAL CHARACTER OF THE COUNTRY—LAKE WINNIPEG TO HUDSON BAY.

[1] The country from Lake Winnipeg to Hill river is typical Laurentian plateau country, similar to much of northern Ontario and Quebec. Low, rounded, rocky hills of about equal elevation are separated by vales, often occupied by marshes, streams or lakes. The watercourses are countless, and ramifying in a most intricate fashion. Lake succeeds lake, joined by river stretch, tranquil or spilling over rocky ledges from level to level. Along the Nelson river the shores are usually rocky, but rarely exceeding 20 or 30 feet in height, with rushes and willows along the water's edge. The shores of Hairy lake are somewhat bolder, but the Echimamish for most of the way filters through a swamp. From Painted Stone, rock hillocks skirt the river and lakes, reaching a maximum of perhaps 150 feet on the canoe route near Pine lake. Near here the first cut clay bank was noticed. Near Oxford House the shores again become higher, approximating 100 feet. Clay banks also appear. Oxford House is situated on a peninsula of clay about 50 feet high. While some rock is exposed, good soil extends from Oxford lake to Knee lake. Beyond Knee lake the country is low to near the Hill. Here clay banks become continuous, rising gradually in elevation to the Rock. The Hill itself has an elevation of about 400 feet.

The Pre-Cambrian rocks disappear a couple of miles below the Rock, and the country from there to the sea is level and drift-covered. Into this clay the river has cut its channel, forming high banks, steep cut where the river impinges, but shelving on the other side. The banks are about 10 feet high at the Rock, but gradually lower, going down stream, to less than 30 feet at York.

CLIMATE.

The climate of the country in the neighbourhood of Norway House does not differ materially from that of Manitoba. Towards Hudson bay conditions are less favourable. The winters are cold, but generally fine and enjoyable. Every resident spoken to, from Norway House to Newfoundland, expressed a decided opinion that winter was the most enjoyable season. The Hayes river at York on the average freezes about the last week of November, and opens about the middle of May. The summers are bright and warm, without an excess of rain. From the agricultural standpoint, the important temperature is that of June, July, and August, for this is what determines the crops that may or may not be ripened. The long days have a favourable influence, and it is probable that climatic conditions are suitable for ordinary agriculture to about half way between Lake Winnipeg and York.

AGRICULTURAL LAND.

Along the watercourses, rock exposures are more numerous than inland, so that from them a judgment cannot be formed of the amount of land suitable for agricul-

[1]The route from York Factory to Winnipeg is well described by Sir John Franklin and by Dr. John Richardson in Franklin's "Narrative of a Journey to the Shores of the Polar Sea, 1819-20-21." It is also referred to by Robert Bell, in Part CC, Report of Progress, 1877-78, Geological Survey of Canada.

ture. Along the route followed, only occasional patches were seen, but large areas are known to lie to the north. Soil became more noticeable about Oxford House, increasing in amount until, below the Rock, no rock exposures were seen. In places, artificial drainage would be necessary to render the land fit for agricultural uses. At Norway House, wheat, barley, vegetables, small fruits, cucumbers, melons, etc., have been cultivated. At Oxford House, barley, vegetables, and hay are grown. At York, potatoes and some vegetables have been successfully raised, but the area near Hudson bay, while perhaps suitable for ranching and dairying, is probably outside the limit for ordinary agriculture.

FLORA AND FAUNA.

The whole country from Lake Winnipeg to York is timbered, but as the route followed had been the boat route from York, used for almost a century, for a large part of the entire trade of the northwest, the forests have suffered repeatedly from fires, so that practically all is second growth, and no sizable timber was seen. Where the original forest is preserved, merchantable sizes may be expected in the upper portion of the district, and pulp wood for some distance down, but what with forest fires, muskeg and climatic conditions near the bay, it seems unlikely that the timber of that particular district will prove of great value, except for local purposes. Around the southern end of the bay, conditions, of course, are different, and the forest is of greater economic importance. The trees are principally spruce, poplar, and tamarack; canoe birch disappeared on the lower part of the Hayes.

As might be expected on an old route of travel game was not plentiful. Except that Arctic varieties are found in the northern part, the species do not differ in any essential respect from those of northern Ontario. At York, a polar bear had been shot in the Fort two days before our arrival. The waters are well stocked with fish of marketable varieties. The whitefish of Oxford lake are famous, and are said to excel even those of Lake Winnipeg.

GEOLOGY BETWEEN LAKE WINNIPEG AND YORK.

As the journey was made rapidly, with few stops, only a general idea of the geology could be obtained. Pre-Cambrian rocks, which form the eastern shore of Lake Winnipeg, are exposed all the way to the Rock, and for a few miles beyond. For the rest of the distance to York, no solid rocks are exposed, but it is evident from the loose fragments that it is underlain for the most part by sedimentary rocks of lower Palæozoic age, similar to those exposed on the neighbouring rivers, and which form a basin, fringing the bay, from Churchill to Rupert river, at the southeastern end of James bay.

Overlying the solid rocks, except where removed by subsequent erosion, is a mantle of glacial drift which is overlain, towards the bay, by stratified marine clays or sands.

Keewatin?.

The rocks which are considered as probably Keewatin, consist of various schists—banded quartzose schists, green biotite schists, dark hornblende schists, sericite

[1] The names applied to the rocks in the following descriptions are field names, and would probably have to be altered somewhat upon exact microscopical determination.

schists, rather massive chlorite schists, hornfels, greenstones, including coarse diabase-like rocks often epidotized and with well marked pillow structure, the cracks being sometimes filled with calcite.

Laurentian.

The commonest rocks are grey granites, often passing into gneisses, and holding inclusions, often reaching large dimensions, of a dark gneiss. No contact between these rocks and the supposed Keewatin was seen so that their relationship was not established, but near the contact some cherty bands in the granite-gneiss were observed, which appeared to be inclusions from the Keewatin. At the east side of Hairy lake a mass of anorthosite occurs. Cutting the Keewatin, and the Laurentian rocks above mentioned, is a red granite which sends numerous pegmatite dykes into the older rocks. As no rocks younger than the Laurentian were recognized, its age cannot be exactly fixed, but unless it should be proved post-lower Huronian, it may be included in the Laurentian.

Cutting the Keewatin of Knee lake are dykes of a grey syenite porphyry.

On Painted Rock portage and on Oxford lake dark lamprophyric dykes were observed cutting the grey granite and gneiss.

No conglomerates or other rocks that could be recognized as Huronian were seen at any of the points at which we touched.

Palæozoic.

The Palæozoic rocks were not seen in place, but numerous loose fragments, some containing fossils, are abundant towards the bay. These consist principally of limestone or dolomite. That the district from near the Rock to the bay is underlain by Palæozoic sediments is also suggested by the flatness of the country, and it is made practically certain by comparison with the Shamattawa branch and with the Nelson and other neighbouring rivers where similar conditions prevail and where the Palæozoic beds are actually exposed.

Pleistocene.

The rock surfaces are everywhere well glaciated and in most places still preserve the glacial striæ. The direction of striation is usually about southwest. But at the Rock two sets are preserved, the older almost west and the newer about south 18° east. Erratic boulders are numerous. Inland they remain perched on the slopes and tops of the hills, showing that these have not been wave swept as in portions of northern Ontario where most of the erratics have been washed into the hollows.

The glacial drift consists of boulder clay usually of a light somewhat yellowish or greyish colour, with, as a rule, comparatively few boulders.

In some places sands occur. Towards the coast the boulder clay is overlain by stratified clay in which marine shells occur.

Distribution of Rocks.

From Lake Winnipeg to Hairy lake on the Echimamish, the rocks are the grey granite and gneiss cut by red granite dykes and pegmatites. At the inlet of Hairy lake, on the south shore, the rock is the coarse red biotite granite, cutting a coarse feldspathic rock that appears to be anorthosite. The latter rock consists principally of feldspar (labradorite) in square or rounded crystals, about which are wrapped thin, long augite crystals, giving it the appearance of leopard rock. Other facies of this rock are white, like quartzite, but made up of long feldspar crystals with a square cross-section. The red granite, and probably the anorthosite also, holds inclusions of large size—one hundred feet or greater—of a nacreous mica schist and of the coarse grey gneiss.

On the Echimamish about 8 miles above Hairy lake the rocks supposed to be Keewatin first make their appearance. The first exposure seen was a banded quartzose schist standing on edge. Its general appearance is suggestive of some of the Keewatin iron-formation rocks. A similar rock was seen at the forks of the creek. At the first dam a tuff-like rock, containing feldspar grains, and slaty rocks that might be ash beds, are encountered. At the second dam is a somewhat massive chloritic schist with coarse mica, and quartzose schists. The dip of the rocks appears to be vertical. Veinlets of reddish smoky quartz occur in all these rocks. At the third dam coarse grey gneiss reappears followed by red granite. At the Painted Rock portage the gneiss is well banded; dark bands of augen gneiss alternate with cherty quartz, or pegmatite bands. Biotite and hornblende schist bands also occur. A small dyke of lamprophyre cuts this rock. The chert and hornblende schist resembles iron formation, but the gneiss bands, which are from half an inch to 3 inches wide, form the bulk of the rock. Granite and gneisses continue down the Hayes river past Robinson portage to the half-mile portage by which the canoe route leaves the river. On this portage is a dark hornblende schist somewhat contorted and faulted, and seamed with quartz veinlets and pegmatite and aplite dykes. Across the lake from the east end of the portage is a well jointed phyllite. These rocks continue on the canoe route for about 5 miles, when the Laurentian granite and gneiss come in, and through Pine and Windy lakes and the first 5 miles of Oxford lake only granite and gneiss were seen. At the south point of the west bay of Oxford lake the gneiss is cut by a 20 foot lamprophyre dyke. An island about 2 miles west of Sevenmile point is composed of diorite or diabase somewhat squeezed, and in places epidotized and showing the pillow structure that is common in Keewatin greenstones. The feldspar and coloured constituent are, however, still distinct.

At the first portage above Trout falls is a greyish porphyritic rock with feldspar phenocrysts one-half inch long. At Trout falls is a micaceous schistose rock with small feldspars. It resembles a hornfels, but is almost certainly a squeezed igneous rock. Bands and small lenses of a gabbroidal rock are included in it, and it is veined by somewhat rusty, watery quartz.

At the entrance to Knee lake a disturbance of the compass was noticeable, due no doubt to magnetite on the south side of the inlet which Bell describes as "interstratified with grey siliceous and micaceous schists running about east and west." As we sailed down this part of the lake no opportunity was presented of personally examining these rocks. Through the glass the rocks appeared to be mainly greenstone or massive schist with some quartz veins. At the beginning of the Narrows the rock is a schist with greenish cherty "eyes", varying from one-fourth inch to several feet long. They resemble pebbles somewhat, but are evidently the remnants of bands of chert, broken by pressure. Inland is a massive greenstone showing pillow structure, with calcite fillling some of the cracks.

Near the end of the Narrows the rock is a green sericite schist with lenticles of calcite and dolomite which on weathering give the rock a pitted surface. It resembles a contact metamorphosed limestone.

In the Narrows a small island which I did not see, called Magnetite island, is reported by Richardson to consist of " mica slate highly impregnated with magnetite, iron ore, and having its thin layers impregnated with layers of that mineral". Bell describes it as consisting of " fine grained magnetic iron in thin layers, interlaminated with others of quartzite and mica schist. The rock is twisted and corrugated and breaks with a splinty fracture".

In the lower expansion of Knee lake the rock is a greenstone, probably diabase, squeezed and in some places epidotized with a well marked pillow structure and cut by quartz veins and dykes of syenite porphyry. On the islands near the lower end of the lake the rock is a mica schist with calcite and dolomite bands cut by some fair sized quartz veins.

These supposed Keewatin rocks continue for a short distance below the lake. Here the grey gneiss reappears and continues to below the Rock, below which only drift is exposed.

This band of Keewatin rocks, it will be noted, extends with a few intermissions, from a short distance up the Echimamish to below Knee lake. Similar rocks are mapped by Tyrrell on Pipestone and Cross lakes on the Nelson, and it seems probable that they belong to the same band.

The rocks seen by the writer had a marked resemblance to the Keewatin and so far as relationships were observed, they were also suggestive of this. The cherty masses seen strongly resembled those of the "iron ore formation" found in the Keewatin of the Lake Superior district. The descriptions given by Richardson and Bell of the occurrence of magnetite are also suggestive of "Iron ore formation".

No minerals of economic importance were observed, but the Keewatin and Huronian belts are worth prospecting. It is in these that the Sudbury, Cobalt, Porcupine, and other camps of northern Ontario occur. The quartz veins seen were "hungry", but it is encouraging to find quartz so common and promising veins might be found by prospecting.

Mr. J. B. Tyrrell reports arsenical pyrites and copper pyrites in the Pipestone Lake area on the Nelson river, and a mica deposit of possible commercial value on Cross lake.

Mr. Wm. Ogilvie of the Department of the Interior has informed me that galena carrying 25 ounces of silver to the ton has been found on a lake north of Nelson House near the divide between Burntwood and Churchill rivers.

Iron deposits of importance may occur in the bands of iron ore formations.

It is perhaps worth noting that among the boulders from the drift along the lower part of the river banded jasper hematite ore, like that of the Lake Superior deposits, occurs, also basalts and melaphyres like the Lake Superior copper rocks, together with beautiful porphyries, and perthite. It is difficult to say where the boulders came from as both westerly flowing and southeasterly flowing glaciers passed over this section, but these rocks might be almost local and perhaps underlie the Silurian. They are known to occur on the east coast of Hudson bay, also south of James bay, and it seems not improbable that they also fringe the west coast; in other words that the Huronian forms a big basin in which the bay rests, in much the same way as it does about Lake Superior. Wherever we landed in the north country to Port Burwell, iron ore formation rocks were noticeable, so that its distribution would seem to be widespread.

HUDSON BAY.

Hudson bay has a length of about 900 miles and a maximum width of 600 miles. The east coast, which is composed of Pre-Cambrian rocks, is rugged, but the west coast from the mouth of Rupert river at the head of James bay, to the mouth of Churchill is low and flat, being underlain by flat-lying Palæozoic rocks. At ebb tide wide, often boulder strewn, mud flats are exposed. From Churchill north, the Pre-Cambrian rocks obtain and the coast becomes rugged.

York Factory is situated on the narrow point of land which lies between the mouths of Hayes and Nelson rivers. Both have funnel-shaped mouths opening northeastward, the Hayes being about 3 miles across and the Nelson about 15, but rapidly narrowing up stream.

The sediment brought down by the rivers, particularly by the Nelson, has silted up the mouths of the rivers and formed a huge bar, that extends for many miles out to sea. As the Nelson is one of the large rivers of the world it may be expected to maintain a well marked channel through the bar, but the Hayes is rapidly silting up with the material discharged by the Nelson.

Fort Churchill is situated at the mouth of Churchill river on a tidal lagoon enclosed by rock ridges, that form a fine well protected, though somewhat circumscribed, natural harbour. It lies within the barren grounds, but only a short distance beyond the northern limit of the forest. On both sides, a few feet above high tide, are dry sandy flats, parts of an old raised beach. Several other gravel beaches are found on the sides of the hills and up to their summits. These raised beaches are also marked features along Hudson strait and all the way down the Labrador coast. The rocky ridges that enclose the lagoon rise to heights of from 60 to 100 feet, and are composed of a massive coarse-grained feldspathic, arkose quartzite. In the quartzite are a few irregular quartz veins up to a foot in width and a few small pegmatite dykes. From the physiography it is impossible to say whether the bottom of the lagoon has a thick mantle of gravel and thus would be easy to deepen by dredging or whether it has practically a rock botttom; but it is quite possible that it has the former.

On Coats or Mansfield island the sedimentary rocks of the lower Palæozoic could be seen.

Sagluk bay, which is on the south side of Hudson strait between Cape Wolstenholme and Cape Weggs, is a fine harbour about 8 miles long enclosed between hills about 500 to 1,000 feet high. The mouth is about a mile wide. Soundings gave us 10 fathoms of water over the bar at the entrance. The rocks are gneisses and granite with heavy trap dykes. No other rocks than these Laurentian gneisses and granites were seen until we reached the Labrador coast.

No economic minerals were observed at the points touched at on Hudson bay and Hudson strait, and little is known of the mineral possibilities of this section as, except on the east coast of Hudson bay where some prospecting has been done on the iron ore formation, the territory is still unprospected. The observations of explorers, however, would indicate that there are opportunities here for prospecting, and if anything is found there are no natural difficulties that would prevent mining. On the west coast of Hudson bay south of Marble island, Tyrrell has found promising showings of copper ore (chalcopyrite). Iron ore formation occurs along the east coast of Hudson bay and on the west shore of Ungava bay, and as previously remarked, the widespread occurrence of boulders of iron formation makes it probable that it may be found at other localities. Mica is being mined at Lake harbour on the north side of Hudson strait. Graphite occurs in extensive bands to the south of Port Burwell. Gold has been found at the head of Wager inlet, and argentiferous galena, and molybdenite have also been noted.

On account of its great size and its length of coast-line, a tremendously large territory is tributary to Hudson bay. At present it is unprospected, but when the railway is built to the bay, access to all this territory will be comparatively easy and prospecting will no doubt be undertaken. Having regard to the results obtained from prospecting similar formations in northern Ontario, it is only reasonable to suppose that prospecting in the Hudson Bay district will result in some gratifying discoveries.

Timber.

Only the southwestern and southern portions of the district tributary to the bay are likely to furnish timber of economic importance.

Game.

Fishing is likely to become an industry of Hudson bay. Whaling has been prosecuted for years. The possibilities of fisheries so far as known are shown in the following extracts from Geological Survey reports:—

[1] "The numerous large lakes of the several watersheds, and most of the rivers, especially those flowing north and east, are stocked with an inexhaustible supply of food fishes of large size and superior quality, including among other species the lake and brook trout, land-locked and sea-run salmon, whitefish, pike, pickerel, suckers, and ling or freshwater cod. Along the southern, eastern, and northern coasts, the cod is taken in large quantities as far as Ungava bay, which is the present limit where trial has been made for taking this fish. Salmon are found plentifully along the coasts as far as the west side of Ungava bay, which appears to be the western limit of the Atlantic salmon. Very little is known officially or otherwise concerning the fisheries of that great inland sea, Hudson bay, and a great amount of wealth may be lying dormant in its waters from lack of knowledge concerning its fisheries. As regards the inland fisheries, owing to the distance from available routes to a market, they will probably never be used to their full extent, and even the best situated lakes

[1]Annual Report, Geol. Surv. Can., Vol. VIII. (New Series) 1895, Part L.

will not be fished for many years to come, or until railways are built through the interior. The following kinds (of fish) were taken in the net along the Eastmain river: whitefish, pike, pickerel, and suckers. In the lower parts where the banks and bottom are formed of clay, sturgeon are taken in abundance by the Indians; and from the mouth to the first fall, and in the tributary streams, small whitefish and sea-trout ascend from the sea in large numbers, from about September 1, until the river is closed by ice. Trout are also caught in the rapids of the upper part of the river. The salmon fishery is carried on at a number of places along the river (Koksoak) below the post, during the month of August, and the annual catch averages one hundred tierces for export. Salmon are also taken in the mouths of the Whale and George rivers, the average catch at the former place being fifty tierces, and at the latter one hundred and twenty tierces. Formerly the Company employed a small refrigerator steamer in this trade at Ungava, and the frozen salmon were taken to London for sale. This has been abandoned for several years, and the salmon are now split and salted. The white porpoise is also taken at Ungava on the Leaf river, a stream a short distance north of the mouth of the Koksoak, and at George river. The total amount of oil so obtained is about eighty tierces of forty gallons each.

Accipenser (sp).—A species of sturgeon is very plentiful in the Rupert river, being taken in large quantities at Lake Nemiskau, where the Indians congregate and dry the fish during September. The fish here are usually under three feet in length. Also abundant in the river from Lake Nemiskau to its mouth. Common in the Eastmain river, from its mouth to Conglomerate gorge. Also found in the lower part of the George river, and in the Nottaway at Lake Obatogamau, near its head.

Coregonus clupeiformis (Mitchell. Milner (Common whitefish).—Found abundantly throughout the interior, in lakes and rivers. Largest fish taken in Lake Mistassini, 14 pounds weight. Average weight, 3 or 4 pounds. A small species of whitefish closely resembling the common whitefish is caught in abundance in the shallow water along the east coast of James bay. These fish ascend the rivers of James bay during the autumn months along with sea trout.....

Salmo hearnii, Richardson (Hearne's salmon).—A small salmon with bright red spots on its sides, is found along the northeast coast of Hudson bay, and probably belongs to the species. Its southern limit is a small river a few miles south of Cape Jones. It is taken in nets set in the salt water near Long island, just north of Cape Jones, and also in some small streams flowing into Richmond gulf. The Eskimo also report it common in some of the rivers north of Richmond gulf.

Salvelinus fontinalis (Mitchell), Gill and Jordan (Brook trout).—This fish is abundant in many of the rivers and lakes of the Labrador peninsula. Sea-run fish of this species are plentiful along the shores and lower parts of the rivers from the St. Lawrence to the southern part of James bay...........In the Koksoak and George rivers, the average weight of the sea-run is about seven pounds............

In James bay, the trout taken along the coast and in the lower parts of the rivers are generally small and do not exceed two pounds in average weight................

In the Koksoak river, for a few miles below Lake Kaniapiskau, large trout were abundant, but lower down they became smaller, until the sea-run fish were met with.

Esox lucius, Linn. (Pike).—Common on the rivers of the southern, eastern, and western watersheds; not so abundant in the Koksoak river. It varies in weight from two to fifteen pounds.

Stizostedium (Mitchell), Jordan and Copeland (Wall-eyed pike, doré, 'perch' of the Hudson's Bay Company.)—Common..........also in the Rupert and Eastmain rivers of the western watershed............not found in the Big river, or streams to the north of it............average weight, three pounds."

"Fish seemed to be everywhere abundant in the lakes and streams...........It is probable that some of the true salmon ascend the inlets and streams west of the northern part of Hudson bay, but the fact was not definitely determined."[1]

"The small streams and lakes (between Hudson bay and Clearwater lake) are well stocked with trout and whitefish. In the Clearwater, large brook and lake trout are plentiful, especially in the rapids below the lakes."[2]

"The fisheries of Hudson bay will probably prove to be its greatest natural resource, as along the east coast the sea is found well stocked everywhere with food fishes. In James bay a net set at random along the shore or about the islands caught fish. These are usually sea-run brook trout and whitefish, identical with the Lake Superior whitefish, and being sea-run are, like the trout, much improved in flavour, These trout and whitefish vary in weight from one to six pounds and are the best of foodfish. Similar fish are found abundantly along the entire coast to Cape Wolstenholme. The Arctic trout or Hearne salmon is found along the northern coast as far south as Seal river, which is situated a few miles north of Cape Jones. This is a beautiful fish with well flavoured, dark pink flesh and it varies in weight from one to fifteen pounds, the average being about five pounds. These fish are salted at Fort Chimo on Ungava bay and fetch nearly the same price in London as salted salmon from the same locality. They are very plentiful about the mouths of the northern rivers and along the coast, while Eskimos report them abundant at the Belcher and other islands lying off the east coast. There is no doubt that the fish equals or surpasses in colour and flavour the salmon of British Columbia. Cod are known to exist in Hudson bay, being taken at Cape Smith and at Comb hill in James bay by members of the expedition. The Eskimos also catch them in Nastapoka sound and at the Belcher islands; at a number of places in James bay they are also taken by Indians.

"The specimens of cod taken by us were not very large, but the men who caught them were Nova Scotia fishermen and said they were true cod and identical with those taken on the Grand Banks. Food for these fish is abundant in Hudson bay and there is no reason why extensive fisheries in this Canadian inland sea should not exist. The undoubted presence of cod in Hudson bay deserves investigation, as a very valuable and exclusively Canadian fishery may be found there. The presence of cod points to that of halibut in the deeper waters of the bay."[3]

"The rivers afford a limited supply of whitefish, and a small species of this fish is caught in the tidewater along the west shore of James bay............Sutton Mill

---

[1] Annual Report, Geol. Surv. Can., Vol. IX. (New Series) 1896, Pt. F.
[2] Annual Report, Geol. Surv. Can., Vol. IX. (New Series) 1896, Pt. L.
[3] Annual Report, Geol. Surv. Can., Vol. XIII. (New Series) 1900, Pt. D.

lakes are well supplied with a slender variety of grey trout and the streams running to the north into Hudson bay are, at certain seasons, well stocked with brook trout. In August the stream draining Sutton Mill lakes was full of these fish, and several fine specimens were caught on the lake above at the narrows."[1]

"Nothing is at present known of the fisheries of the deeper waters of the strait and bay, and the knowledge of the fisheries of these waters is confined to the coasts and rivers. In the southern part of the bay, large quantities of sea-run trout and whitefish are taken by the natives. The Arctic salmon, a fish superior to the best Pacific salmon, is plentiful along the eastern side of the bay to the northward of James bay, as well as in the mouths of the rivers of the northern and northwest coasts, and along the shores of the strait. Lake trout is a common fish in these northern rivers and lakes. Cod have been taken in several places along the east side of Hudson bay as far north as Cape Smith; on the western side little is known of this fish beyond the occurrence of a few in Roes Welcome, and some small specimens taken among the ice at Fullerton. A cod fishery has been carried on for a number of years at Cape Chidley, and these fish are said to be plentiful along the east side of Ungava bay, but do not appear to go farther westward through the strait from the Atlantic. Cod are reported to be abundant in some of the fiords of the south side of Frobisher bay.

"Two long narrow bays pierce deep into the comparatively flat country of northern Baffin island from the neighbourhood of the bend and a very fine salmon river empties into the more eastern bay................Finding that Arctic salmon were plentiful at the mouth of the little river about a mile from the ships, a small net was borrowed, and two boats were sent away to secure a supply of fresh fish. They returned loaded in an hour, having made but four casts of the net, in which over a thousand splendid fish were taken, varying in weight from three to ten pounds, and aggregating at least 5,000 pounds."[2]

"Speckled trout and whitefish are plentiful at the mouths of all the rivers entering the bay. When at the mouth of the Kaskattamagan, we set the net at low tide and at the following low tide had over a hundred trout and whitefish, over two pounds each."[3]

White porpoise or white whale are plentiful and when Hudson bay is opened up will probably furnish the basis of an industry. When we were at Port Burwell last summer (at the end of August) cod were plentiful and were easily obtained by jigging. From the above it will be seen that the possibilities of fishing industries in this great Canadian inland sea are promising.

Navigation.

At the time we were on the bay and in the straits, navigation was as safe and pleasant as it is anywhere. In fact, for summer navigation the route is ideal. The season is, however, short. The information which could be gleaned regarding the period of navigability confirmed the published opinions of A. P. Low, who estimates it as from the latter half of July to the early part of November—three and a half to four months. Ice in the straits will usually prevent an earlier opening and cold, fog,

[1] Geol. Surv. Can., Vol. XIV, Part F.
[2] The Cruise of the *Neptune*, 1903-4, pp. 296-7; 59.
[3] Geol. Surv. Can., Summary Report, 1905, p. 76.

and snowstorms put an end to it in November. The straits and bay do not freeze solid but are covered with floating ice. The bay itself is navigable for probably about seven months. Churchill harbour is open on an average for five months, and the Nelson for a considerably longer period.

PORTIONS OF ATLIN DISTRICT, B.C.

(D. D. Cairnes.)

INTRODUCTION.

The field season of 1910 was devoted to mapping and geologically investigating certain portions of Atlin mining district which occupies a position south of and adjoining the western part of the northern boundary of British Columbia. Prof. J. C. Gwillim has reported on Atlin district,[1] and a reconnaissance topographical and geological map accompanies his report; but until and during the years 1899 and 1900, when Prof. Gwillim performed the field work for this map and report, placer was the only form of mining in which any marked interest had been taken. Since then gold, silver, copper, and antimony ores, as well as coal seams, have been discovered, and in some cases prospects have been developed to some extent; and it is now hoped that these deposits will continue to be mined when the gold-bearing gravels, which are slowly becoming exhausted, can no longer be worked at a profit.

The prime object of the past summer's work was to obtain an estimate of the importance of the various ore and coal deposits of the entire Atlin district; and with this purpose in view practically all the properties in the area were examined. In addition, a topographical and geological survey was made of the belt around Taku arm and the upper end of Atlin lake, and was extended from these waters to the south and west as far as time permitted. The area mapped has an average width, from east to west, of 20 miles, extends southerly from the 60th parallel (the British Columbia-Yukon boundary) about 50 miles, and includes the greater number of the more important ore deposits so far discovered in Atlin district. The surveyed area includes also the western edge of the tract covered by Prof. Gwillim's map.

In the performance of our work my party and I received the hearty support of all those interested in mining with whom we came in contact, for which I desire to express my sincere thanks. Particularly am I indebted to Mr. J. A. Fraser, Gold Commissioner, Mr. J. Cartmel, Mining Recorder, and Captain James Alexander, Mr. B. G. Nicol, and Mr. J. Dunham, owners of the Engineer mines, for assistance rendered and for courtesy extended during the season.

My assistants for the summer were Mr. G. G. Gibbins, Mr. P. A. Fetterly, and Mr. John Lanning, who performed the greater part of the topographical portion of the work. Mr. Gibbins also assisted in geology when circumstances permitted.

SUMMARY AND CONCLUSIONS.

Rich gold-tellurium ores occur in a number of veins on the east side of Taku arm above Golden Gate, at the Engineer mines and adjoining properties; and gold-silver ores have been found in promising amounts at several points on Bighorn creek, on Munroe mountain, Boulder mountain, and elsewhere to the east of Atlin lake, at a number of points on the west side of Taku arm above Golden Gate, and on Hoboe creek, which empties into the upper end of Torres channel, an arm of Atlin lake. A number of wide, persistent veins containing silver-lead ores have been found on the tributaries of Fourth-of-July creek, particularly on Crater creek and in its vicinity. Native copper has been discovered in veins, and also distributed through the basalts on the southern end of Copper island. Antimony ores occur along the

[1] Gwillim, J. C.—"Report on the Atlin Mining district, British Columbia," 1901

west side of Taku arm, about 10 miles above Golden Gate, and large bodies of iron and copper ores have been developed to some extent on Hoboe creek. In addition to these ore-minerals, coal has been found to the northeast of Sloko lake, and probably exists at other points in the neighbourhood, and elsewhere in Atlin district.

A considerable number of these mineral deposits occur along the shores of Taku arm, and have thus direct boat connexion with the railway at Caribou (Carcross). The majority of the other occurrences are on, or within a short distance of navigable waters, and are not far from the railway. During the past summer the railway commission decided that the rates to be charged by the White Pass and Yukon railway on ores should not exceed $1.75 per ton from Caribou to Skagway, whence the ores and concentrates can be sent directly by boat to the various coast smelters, if desired.

It may be said then, that Atlin district possesses quite a variety of economically valuable minerals, which occur, in places, in deposits of considerable size, and in some of the mineral veins pockets of very rich gold ore have been found; also practically all the deposits are readily accessible. The quartz mining industry in this locality has made a good beginning and will probably continue to develop in the future. The results are particularly encouraging when it is considered that, since 1899, when interest was first shown in quartz mining in this district, nearly all persons engaged in mining devoted practically all their attention to placer deposits, and that there has been but a relatively slight amount of prospecting for quartz.

General Character of the District.

TOPOGRAPHY.

The portion of Atlin district surveyed the past summer (1910), as previously mentioned, is a northerly-trending belt, that extends about equal distances on both sides of Taku arm for nearly its entire length, and continues southerly to include the upper portion of Atlin lake. Since the main topographic features of British Columbia here trend northwesterly, and Taku arm runs almost due north, the southern portion of the area mapped adjoins and slightly penetrates the Coast range, while the northern limit reaches well out into the Interior Plateau region which borders the Coast range along its eastern limits. The transition from the plateau to the mountain belt in Atlin district is gradual, so much so that it is, in many places, difficult to determine where one ends and the other commences.

The plateau topography is characterized by two main, striking, features—the numerous, irregularly distributed, wide, deep, steep-walled valleys, and the elevated, and often but slightly undulating inter-valley plateau-fragments that originally constituted portions of an extensive plain. This upland surface here, as elsewhere in the Central Plateau region, bears no relation to rock structure, and the sandstones, shales, granites, schists, limestones, volcanics, etc., have been truncated, regardless of their respective degrees of hardness, structural features, etc. Towards the northern or lower end of Taku arm the plateau surface is approximately 3,200 feet above the lake level, or 5,360 feet above the sea, and towards the southern end it is somewhat higher.

The distinctive plateau characteristics of the upland have been in many places almost if not quite effaced by erosion, and in such cases the topography consists of irregularly distributed, rounded, frequently gently contoured hills whose summits are remarkably uniform in elevation. In other parts, considerable areas of high plain still exist, and enclose within their borders small residuary summits; or, in some cases, detached portions of the upland are merely undulating, and without considerable elevations.

As the Coast range is approached the upland becomes more dissected, and the character of the topography gradually changes to a type composed mainly of rugged peaks and ridges, with intervening valleys bordered by precipitous walls in which numerous ice masses are nestling. The ice becomes more and more plentiful, until, a few miles to the south of Atlin lake and Taku arm, the great Llewellyn glacier is encountered, which overrides all but the loftier peaks and spurs.

Some time subsequent to the deposition of the Jura-Cretaceous beds—the most recent consolidated sediments in the district—the tract now included in the Central Plateau region of southern Yukon and northern British Columbia, in the writer's opinion, was subjected to a long period of sub-aerial erosion, which continued until a plane-like surface resulted, having an elevation slightly above that of the sea, and with only occasional residuary peaks and ridges rising above the general level; for these results to be attained, the land during this time must have remained in a state of almost perfect stability. This erosion cycle was terminated by a gradual uplift[1] of the Central Plateau region, together with adjoining portions, at least, of the Coast range[2]; and erosive processes thus received new life and energy, with the result that the larger streams commenced deepening their channels in the elevated terrane; the effects of stream action, in this respect, were later accentuated by glaciation. The main ice masses occupied the master depressions, such as that of Taku arm, and were effectual in straightening and planing their walls, and in widening and lowering their floors. The valleys thus produced were wide, deep, and steep-sided. The ice also caused the valleys, in places, to become floored to considerable depths with glacial silts, sands, gravels, boulder clays, etc. The portions of the valley bottoms that were last occupied by these glaciers now contain lakes, since the ice retreated up the valleys so rapidly that only the lower portions were filled with glacial debris, thus causing reversed slopes, and effectually impounding the water above.

In the present plateau region the only representatives of the former glaciers are the few small ice masses that still occupy occasional cirques; so that here nivation[3], or snow-drift action, has been most effective in the uplands, and has tended to smooth over inequalities in the land surface rather than accentuate them. In the Coast Range region, however, on account of the higher altitudes there, the ice is still abundantly present, and the lines of cirques, on opposite sides of the ridges and around the summits, excavate and quarry ever downward and backward until they meet, and rugged knife-like ridges or arrêts, as well as pinnacle-like summits, result.

CLIMATE.

The climatic conditions in Atlin district are fairly well known, and are similar to those in other portions of British Columbia. Placer mining operations on the surface generally commence early in May, and continue until about the first

---

[1] Since the most recent consolidated sediments in this portion of the Interior Plateau were deposited before the erosion cycle referred to commenced, it is impossible to determine in this district when the planation occurred. G. M. Dawson, A. H. Brooks, and others, however, have obtained information in other districts, that tends to show that the erosion was largely post-Eocene, and that the uplift which closed the cycle took place in late Pliocene or early Pleistocene times.

Brooks, A. H.—"Geography and Geology of Alaska"; Prof. paper, No. 45, U.S. Geol. Surv., pp. 270-279, 292-296.

[2] Brooks, Hayes, Spencer, Dawson, and others consider the Coast range to be also an uplifted and subsequently dissected plane of mature erosion.

Hayes, C. W.—"An expedition through the Yukon district," Nat. Geol. Mag., vol. 4, p. 128.

In addition, Brooks, Spencer and others consider the Coast range, and the Interior Plateau, to be regions of synchronous planation.

Spencer, A. C.—Bull. Geol. Soc. Amer., Vol. 14, p. 132.

Brooks, A. H.—Prof. paper, No. 45, U.S. Geol. Surv., pp. 270, 286-290, 293.

Mr. R. G. McConnell, on the other hand, although he admits the peneplain characteristics of the Interior Plateau, maintains that the Coast Range topography shows no evidence of ever having been peneplanated.

This entire question will be fully discussed in the writer's detailed report, now in preparation.

[3] Nivation in its different phases, relations, etc., is discussed in the two following articles:

Matthews, F. E.—"Glacial sculpture of the Bighorn Mts.; Wyo.;" U.S. Geol. Surv., 21st Ann. Rep., Pt. II, 1849, pp. 173-190.

Hobbs, W. M.—"Cycle of mountain glaciation;" Geol. Journ., Feb., 1910, pp. 147-163.

of November, and all outside and surface work in connexion with mining and similar industries may be continued for six months in the year. Besides, on account of the very long days in this somewhat northern latitude, surface work may be performed during a considerable part of the summer by night as well as by day, without the aid of artificial light.

The rivers and creeks generally open early in May, but on some of the lakes the ice remains until the first week in June. Slackwater stretches freeze over any time after the middle of October, but occasionally the rivers and lakes remain open until December.

During the summer months the climate is pleasantly warm and neither too dry nor too wet. The winter also, although somewhat long and cold, is enjoyed by those living in the district, and is believed to be very healthful.

FAUNA AND FLORA.

The valleys are generally well forested, but trees of any considerable size are not commonly found more than 500 feet above the valley bottoms; however, in some places the forests extend to 1,500 feet, and quite large trees were found in some sheltered spots, as much as 2,000 feet above this level. The main varieties of trees that occur are white spruce (*Picea alba*), black spruce (*Picea nigra*), balsam fir (*Abies subalpina*), black pine (*Pinus Murrayana*), aspen poplar (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), willows (*Salix*), dwarf birch (*Betula glandulosa*), and a species of alder. Of these, the white, and black spruce are the most abundant and valuable, and occur in about equal numbers; they thrive best in the valley bottoms, where straight and well grown specimens 2 feet to 3 feet in diameter 3 feet from the ground are not uncommon, and the majority of the larger representatives have 12 to 18 inch stumps. The black pine is not nearly so plentiful as the spruce, and only rarely exceeds 12 inches in diameter 3 feet from the ground. The balsam fir thrives best on the slopes near timber-line, where many trees were observed having 12 to 18 inch stumps. On the flats bordering Taku arm, the best of the timber has been cut, in places, for saw-mill purposes. Aspen poplar and balsam poplar constitute a large portion of the forest growth both in the valleys and on the hillsides, but rarely have over 10 inch stumps, and the wood is of value mainly as fuel. Willows, dwarf birch, and alder, occur plentifully both in the valleys and on the slopes, and the dwarf birch, in places, extends to the plateau-level, and with the willows and alder, in places, constitute so dense a growth that walking is very difficult.

Several varieties of wild fruits were noted, of which crow or heather berries (*empetrum nigrum*), are the most plentiful and are found abundantly in most places to above timber line. As these berries are very juicy and palatable, they are much prized by persons engaged in mountain climbing in these northern districts. Low bush cranberries (*Vaccinium Oxycoccus*), high-bush cranberries (*Viburnum pauciflorum*), red currants (*Ribes rubrum*), black currants (*Ribes Hudsonianum*), gooseberries (*Ribes lacustris*), strawberries (*Fragaria cuneifolia*), raspberries (*Rubus strigosus*), blue berries (*Vaccinium uliginosum and V. ceaspitosum*), and Saskatoon berries (*Amelanchier florida*) also occur in more or less abundance in many parts of the district.

Moose, caribou, sheep, and goats are somewhat plentiful in many localities. The caribou is the large giant variety, Osborn's caribou (*Rangifer osborni*); the goat is the white or antelope goat (*Oreamnos montanus*); and the sheep are of two varieties, Dall's mountain sheep (*Ovis dalli*), and the saddle-back or Fannin's mountain sheep (*Ovis fanninii*). Black, brown, and grizzly bears are also plentiful. Wolves, wolverine, beaver, otter, marten, and lynx are somewhat common. Ordinary red foxes, as well as cross, black, and silver foxes, are occasionally found. Ptarmigan are exceedingly plentiful, of which the rock ptarmigan (*Lagopus rupestris*), and white-tailed ptarmigan (*Lagopus leucurus*), are found above timber line, and during the summer months live mainly on the highest, often snow-capped summits. The willow ptarmigan (*Lagopus lagopus*) exist during the summer months at about timber line. Blue grouse, or Richardson grouse (*Dendragopus Richardsonii*), fool hens, or Franklin grouse (*Canachites franklinii*), willow grouse or Oregon ruffed grouse (*Bonasa umbellus sabini*), are fairly plentiful, and occasionally prairie chicken, or northern sharp-tailed grouse (*Pediaecetes phasianellus*), were also seen: these live mainly in the timber, and preferably in the valley flats. Rabbits, which are periodically plentiful, have been almost extinct for the past three years, but during the past summer they were noticed to be again rapidly increasing in numbers.

The lakes are generally well supplied with fish, mainly lake trout, whitefish, and grayling. Grayling are also plentiful in many of the streams.

General Geology.

GENERAL STATEMENT.

As previously mentioned, the southern portion of the district surveyed the past summer extends into the Coast range, which is mainly composed of granitic rocks, chiefly granodiorites. The geology of the portion of the mapped area to the east and the northeast of the Coast range is somewhat complex and many types of rocks are represented, including sedimentary, metamorphic, volcanic, and plutonic varieties. Highly altered schists, gneisses, and limestones, as well as more recent andesites, sandstones, arkoses, tuffs, and shales have been extensively invaded by granitic rocks. This complex is in turn intersected and partly buried by andesites, andesitic tuffs, and granite—and syenite-porphyries. Newer than all these is a group of rhyolites and rhyolitic tuffs and breccias, which are themselves covered in places by superficial deposits.

TABLE OF FORMATIONS.

Sedimentary Rocks.

System.	Formation.	Lithological Character.
Quaternary	Superficial deposits	Chiefly gravels, sands, boulder clays, silts, muck, peat, and soil.
Jura-Cretaceous	Tantalus conglomerate	Conglomerate chiefly, with some sandstones and shales.
	Laberge series	Conglomerates, sandstones, arkoses, tuffs, shales, slates, and quartzites.
Devono-Carboniferous	Braeburn limestone	Limestones.

Igneous Rocks.

System.	Formation.	Lithological Character.
Tertiary (?)	Wheaton River volcanics	Chiefly rhyolites and rhyolitic tuffs and breccias.
	Klusha intrusives	Chiefly granite-porphyry.
	Chieftain Hill volcanics	Chiefly andesites and andesitic tuffs and breccias.
	Coast Range intrusives	Chiefly granodiorites.
Devonian (?)	Perkins group	Chiefly greenstones, andesites, tuffs, and diabase.

Unclassified Rocks.

Devonian (?)	Taku group	Highly Metamorphosed.	Cherts and slates.
Pre-Devonian, probably all lower Palæozoic.	Mt. Stevens group		Chiefly schistose amphibolites, quartzites, gneisses, and limestones.

DESCRIPTION OF FORMATIONS.

Unclassified Rocks.

Mt. Stevens Group.[1]—The members of the Mt. Stevens group occur mainly in the southwestern portion of the district, in the form of a more or less connected belt, generally 1 to 10 miles wide, that extends along the edge of the Coast Range granitic region. These are predominately schistose amphibolites, gneisses, and limestones. The amphibolites are prevailingly fine-grained, greenish rocks, that vary in structure from highly fissile to slightly schistose. The gneisses are mainly mica varieties having the appearance of mashed, coarsely-textured, granitic rocks. The limestones occur usually in bands 1 to 6 feet thick, associated with the schists.

These rocks are much altered, distorted, and plicated, and are all believed to be of lower Palæozoic age. They are at least the oldest rocks in this district.

Taku Group.[2]—The rocks of the Taku group outcrop only in a few small areas, and consist mainly of cherts and slates. The cherts vary in colour from light grey to black, but grey and black varieties predominate; in places they are reddish on weathered surfaces due to the oxidation of small amounts of contained iron minerals; they are hard and brittle and break invariably into sharp-edged, irregularly-shaped fragments. The slates generally have a slaty structure well developed, cleave readily into thin plates, and are dark, or nearly black.

These rocks are more recent than the members of the Mt. Stevens group, but are apparently older than all the other formations of the district.

Sedimentary Rocks.

Braeburn Limestones.[3]—The Braeburn limestones outcrop extensively in this district, and compose the hills on both sides of Taku arm for 20 miles above Tagish lake. They are at least 3,000 feet thick, and vary in structure from semi-crystalline to crystalline, and range in colour from greyish-blue to almost white. These rocks are prevailingly heavily bedded, and in only rare cases are definite bedding planes distinguishable. The lower members, in places, include some hard cherty or siliceous

---

[1] This name was first applied in Wheaton River district, Y.T. See:—
Cairnes, D. D.—"Wheaton River district, Yukon Territory"; Geol. Survey Summary Report, 1909, p. 50.
Cairnes, D. D.—"Wheaton River district"; Geol. Survey Branch, Dept. of Mines, Canada. In press.

[2] These Taku rocks correspond with the cherts and slates in Windy Arm district (*a*) and are considered there as probably belonging to Dr. G. M. Dawson's Lower Câche Creek series, (*b*). However, as this correlation with the southern British Columbia rocks is not considered as altogether established, the new name Taku group has been adopted for these rocks in Atlin district and southern Yukon, and is here used for the first time.
(*a*) Cairnes, D. D., "Report on a portion of Conrad and Whitehorse Mining districts, Yukon": Geol. Survey Branch, Dept. of Mines, Canada, 1908, pp. 26-29.
(*b*) Dawson, G. M.—Report of Progress, Geol. Survey of Canada, 1876-77.
Dawson, G. M.—Ann. Rept., Geol. Surv. of Can., 1887-88, Vol. III, Pt. B, pp. 170, 171.
Dawson, G. M.—Ann. Rept., Geol. Surv. of Can., 1894, Vol. VII, Pt. B, pp. 37, 49.

[3] This name was first employed in the Tantalus coal area. See:—
Cairnes, D. D.—"Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district"; Memoir No. 5, Geol. Survey Branch, Dept. of Mines, Canada, 1910, pp. 28, 29.

beds, which are generally not far above the underlying rocks of the Taku group. These limestones are believed to be mainly of Carboniferous age,[1] but may include Devonian members.

Laberge Series.[2]—The rocks of the Laberge series outcrop over possibly one-half of the entire district mapped this season, and consist of shales, sandstones, quartzites, conglomerates, greywackes, and tuffs, which have an aggregate thickness of at least 5,000 feet. The most conspicuous members of this series are greyish to greenish, finely textured to medium-grained, homogeneous appearing rocks, which frequently exhibit no distinct bedding planes, and are, in places, with difficulty distinguished from some of the andesitic rocks in the district. They are apparently predominantly pyroclastics, and grade into distinct sandstones. Associated with these greenish rocks, in places, are numerous beds of dark grey to almost black, generally soft, friable shales, accompanying which are numerous bands, generally only a few inches in thickness, of brownish sandstones. Near the bottom of the Laberge series are some characteristic, coarse conglomerate beds, the constituent pebbles and boulders of which are mainly granitic rocks, limestone, and greenish volcanics. Boulders 6 to 8 inches in diameter are of common occurrence, and some were noted as much as 2½ feet long. In the vicinity of intrusive rocks the Laberge shales, sandstones, etc., become hard, dense, quartzitic, and cherty.

A number of fossils have been collected from these beds in different parts of southern Yukon, but the specimens were of only a sufficiently definite character to show that the rocks are of upper Jurassic or Cretaceous age. A few invertebrate remains were collected this summer from Atlin district, but these also are poorly preserved, and may belong to either the Jurassic or Cretaceous periods.

The gold-tellurium ores at the Engineer mines and their vicinity, and the antimony vein discovered on the west side of Taku arm, 10 miles above Golden Gate, occur in this series.

Tantalus Conglomerate.[3]—In the area mapped the past season only one small exposure of the Tantalus conglomerate was found, and this was on an inconspicuous summit on the south side of Graham inlet, about 5 miles southwest of Taku Landing; here only about 30 feet of the beds remain, as the overlying portions have been removed by erosion; however, it is probable that more of these conglomerates occur farther to the south and southwest, where the accompanying coal seams should also be found.

The Tantalus conglomerate consists almost entirely of conglomerate beds, the component pebbles of which consist entirely of quartz, chert, and slate. The beds are generally even in texture, homogeneous in appearance, and dark in colour; and

---

[1] Dr. G. M. Dawson collected Fusilinae from the limestones on Windy Arm, Y.T., near Tagish lake, which are the same as the Braeburn limestones of Atlin district. This shows these to be in part at least of Carboniferous age, and Dr. Dawson considered the Windy Arm members to belong to the Câche Creek series of B. C. (*a*), (*b*). In the writer's report on Windy Arm district, these limestones are considered as probably belonging to the Upper Câche Creek series (*c*), but as this correlation is not considered to be altogether established, the name Braeburn limestones is used in this report, as these limestones have been traced from Tantalus district, where the name was first used, to Taku arm.

(*a*) Dawson, G. M.—Report of Progress, Geol. Survey of Canada, 1887.

(*b*) Dawson, G. M.—"Report of Explorations in British Columbia": Report of Progress, 1876-77, Pt. B., Vol. VII.

(*c*) Cairnes, D. D.—"A portion of the Conrad and Whitehorse mining district"; Geol. Survey Branch, Dept. of Mines, Canada, 1908, pp. 25-26.

[2] This name was first employed in the Braeburn-Kynocks area, see:—

Cairnes, D. D.—"Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district"; Memoir No. 5, Geol. Survey Branch, Dept. of Mines, Canada, 1910.

The Laberge rocks also occur in Wheaton River district, see reports mentioned above, under "Mt. Stevens Group."

[3] This name was first applied in Tantalus coal area. The Tantalus conglomerates have also been found in Braeburn-Kynocks coal area, in Wheaton River district, and also in Whitehorse district. See reports mentioned in the above footnotes.

their component pebbles are rarely over 2 or 3 inches in diameter. Associated with, and intercalated in these conglomerates are a few shale beds, and in most places also, where any considerable portion of the conglomerate section has been seen, coal seams have been found.

The conglomerate beds overlie, apparently conformably, the members of the Laberge series.

Superficial Deposits.—Overlying all the consolidated rock formations of the district are the Quaternary superficial deposits, which consist of both Pleistocene and recent accumulations. The glacial deposits consist chiefly of gravels, sands, silts, and boulder clays, which floor all the master valleys of the district, and in fact the presence of the numerous lakes is due to their valleys being dammed by glacial accumulations. The channels of the larger streams are also mainly in these deposits, which, in many places, reach well up on the hillsides. Overlying these Pleistocene materials are the recent accumulations, composed mainly of fluvial and littoral sands, gravels, and silts of the present waterways, muck and soil.

Igneous Rocks.

Perkins Group.[1]—This group consists mainly of greenstones, andesitic rocks, and basic eruptives, apparently diabase. The largest exposure occurs on the south side of Graham inlet, almost due south of Taku mountains, is about 1½ miles wide by 2 miles long, and consists mainly of greenstones and rocks resembling andesites and andesitic tuffs. The only other outcrops noted occur on the east side of Taku arm below Golden Gate, are only a few hundred feet in diameter, and consist of diabase-like rocks. The greenstones are mainly pale-greenish to greyish-green in colour, and are generally finely textured, but still distinctly recognizable in the field as holocrystalline. The andesitic rocks are also greenish in colour, and have always a macroscopically aphanitic ground-mass which frequently encloses distinct plagioclase and hornblende phenocrysts. The rocks which appear to be diabases are prevailingly coarsely textured, dark green, and appear to consist almost entirely of basic plagioclase, pyroxene, and chlorite.

These Perkins members are more recent than the Mt. Stevens group, and older than the Coast Range intrusives, but evidence was not obtained to show whether the Taku or the Perkins group is the newer.

Coast Range Intrusives.—The Coast range is built up largely of the granitic rocks of the great Coast Range batholith which is exposed along the upper ends of Atlin lake and Taku arm, and trends thence northwesterly. Many dykes and irregularly shaped intrusive areas of these granitic rocks, which have been called the Coast Range intrusives,[1] outcrop in the vicinity of Taku arm. These intrusives are prevailingly fresh and unaltered in appearance, and are predominantly greyish in colour, although sufficient orthoclase exists in places to give them a somewhat pinkish or reddish aspect. Under the microscope these rocks prove to be generally granodiorites, or quartz granodiorites, but true granites and diorites also occur. In places, these intrusives are quite porphyritic, and feldspar phenocrysts 1½ to 2 inches long are occasionally to be seen.

The Coast Range batholith is believed by the various geologists who have studied it to have come into existence as such, in about Jurassic times. However, in Atlin district, pebbles and boulders of these granitic rocks occur in the lowest conglomerate beds of the Jura-Cretaceous sedimentary series, showing the granitic materials to be the older; and also dykes and intrusive masses of rocks having identically the same appearance, cut the upper members of the Laberge series, which is at

[1] The name Perkins group was first applied in Wheaton River district, Y.T. See reports referred to in the previous footnotes.

[1] The name Coast Range intrusives was first employed in Wheaton River district. See reports mentioned in previous footnotes.

least, as mentioned above, over 5,000 feet in thickness, and thus indicate that these granitic rocks are more recent than the sedimentaries. The Coast Range intrusives are thus of two ages, and chemical and microscopical tests are now being made to determine if any practical method can be found for distinguishing these rocks in the field where contacts with formations of known ages are not obtainable. So far it has not been possible to separate the older of these granitic rocks from the newer.

A number of the mineral-bearing quartz veins of the district occur in these intrusives.

Chieftain Hill Volcanics.[1]—These rocks occur mainly in two belts, one of which extends from Taku Landing northwesterly towards the mouth of Tutshi river, and is 2 to 6 miles wide, and possibly 25 miles long; the other area lies to the west of the Engineer mine and Edgar lake, and is 4 to 6 miles wide and apparently about 10 miles long. Other small exposures and numerous dykes were noted in various localities.

The Chieftain Hill volcanics are mainly mica-hornblende, and augite-andesites, and andesitic tuffs and breccias. They vary considerably in mineralogical composition, and have a wide range of colour, showing many shades of red, blue, green, and brown, but they generally possess a rather typical andesitic habit. A distinct porphyritic structure is prevailingly noticeable, and phenocrysts of feldspar are generally present, while those of hornblende and biotite frequently occur. Some augite-andesities are dark-greenish, dense, finely textured, rocks in which none of the mineral constituents are discernible, and in which no phenocrysts are apparent to the unaided eye. Rocks with a dense, aphanitic, reddish, greyish, or greenish, ground-mass, in which well formed plagioclases are abundant, are, however, the commonest types.

These volcanics are more recent than the Coast Range intrusives, and for the greater part newer than the sediments of the Laberge series, but also appear to be in part contemporaneous with these beds.

Klusha Intrusives.[2]—Klusha intrusives occur chiefly as dykes which are to be found in most portions of the district; they are, mainly at least, granite-porphyries, and are prevailingly greyish in colour, and of a coarsely granular habit, so that all the principal mineral components are distinctly discernible with the unaided eye. These rocks possess a holocrystalline porphyritic structure, and consist of a micro-granitic, or micropegmatitic quartz-feldspar ground-mass, in which alkali feldspar and lime-alkali feldspar phenocrysts are plentiful, and in which biotite and hornblende commonly occur.

These intrusives are more recent than all the Jura-Cretaceous sediments, and also the Chieftain Hill volcanics, and are thus probably of Tertiary age.

Wheaton River Volcanics.[3]—No extensive areas of Wheaton River volcanics occur in this district, but numerous dykes and small patches, generally only a few hundred feet or less in diameter, were noted. These volcanics include rhyolites and rhyolitic tuffs and breccias, which are prevailingly nearly white to light grey in colour. In places, however, these rocks contain considerable pyrite, which oxidizes to limonite and gives them a bright red, to brownish-red or yellowish-red appearance. The rhyolites have always a megascopically aphanitic ground-mass, in which phenocrysts of quartz, orthoclase, and plagioclase occur. The quartz exists frequently in

---

[1] The name Chieftain Hill volcanics was first applied in Wheaton River district. See reports mentioned in previous footnotes.

[2] The name Klusha intrusives was first given in Tantalus coal area, Y.T. These rocks have also been identified in Conrad and Whitehorse mining districts and in Wheaton River district, Y.T. See reports mentioned in previous footnotes.

[3] This name was first applied in Wheaton River district in 1909. See reports referred to in previous footnotes.

distinct dihexahedrons, which are as much as 1/32 of an inch in diameter. Well formed megaphenocrysts of orthoclase and plagioclase also occur, but those of the alkali feldspar are much the more plentiful. The tuffs and breccias consist chiefly of fragments of rhyolitic materials, that vary in size from microscopic to several inches in diameter.

These Wheaton River volcanics appear to be nearly contemporaneous with the Klusha intrusives.

Economic Geology.

GENERAL STATEMENT.

Atlin became known as a productive placer gold camp early in the year 1898, after the discoveries by Miller and McLaren,[1] who first found gold in paying quantities, in this district, on Pine creek, in January of that year. Since that time a number of creeks on the east side of Atlin lake, and within distances of 15 or 20 miles from the town of Atlin, have continued to make this district one of the most important placer camps in Canada. During the summer of 1899 a number of quartz claims were located, and since that time a few properties of this type have been developed more or less from time to time, but the attention of those interested in mining has always been mainly directed to placer deposits.

In the portion of Atlin district mapped during the past season, no placer deposits have been discovered, but a considerable number of quartz claims have been located, practically all of which were examined during the course of the regular field work. In addition, during the latter part of the season, the more promising deposits of ore and coal, discovered in the remaining portions of Atlin district, were also visited. The placer deposits were not examined, as the geology of these deposits was covered by Prof. Gwillim's previous work, and conditions pertaining to them have not materially altered since. Development has been more rapid in the case of the other mineral deposits in the district, so that their examination was considered the more urgent. The chapter on economic geology in this report, therefore, describes the deposits of economically valuable minerals, other than placer gold, that have been discovered not only in the area surveyed during the past season (1910) but also in the greater portion of the entire Atlin mining district (Fig. 1).

During the past summer some pockets of remarkably rich gold-tellurium ore were found at the Engineer mines on Taku arm and in this vicinity, and this discovery has helped to arouse enthusiasm in quartz mining in the district, so that the future of this industry is now much more promising than it was.

For convenience of description the economically important mineral deposits other than of placer gold, in the district, may be tentatively classified as follows:—

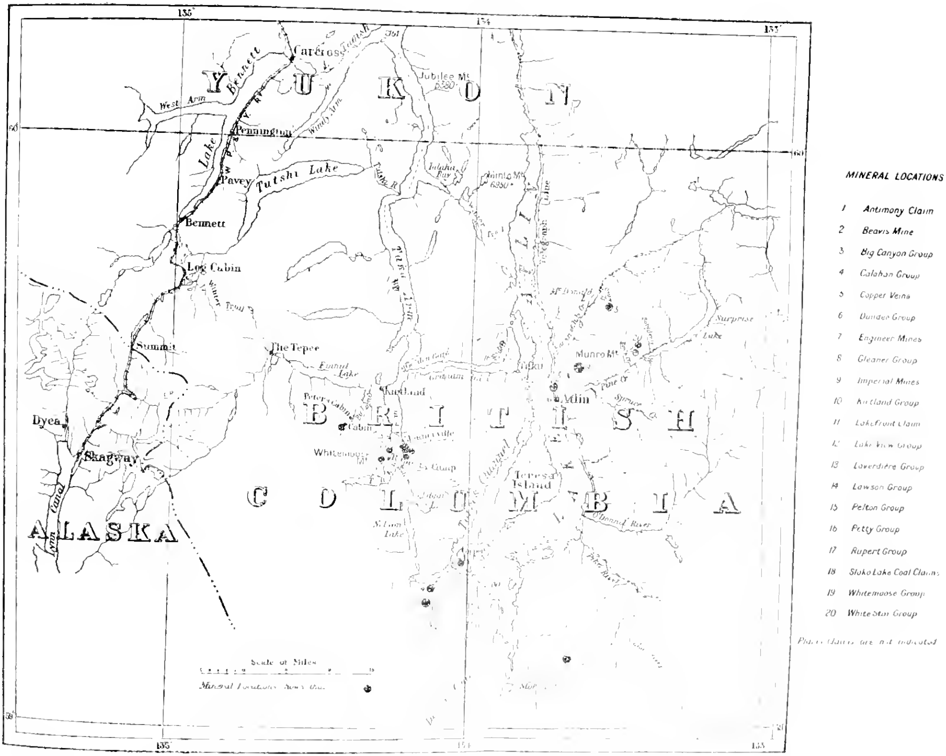
(*a*) Gold-tellurium quartz veins.
(*b*) Gold-silver quartz veins.
(*c*) Cupriferous silver-gold veins.
(*d*) Silver-lead veins.
(*e*) Copper veins.
(*f*) Antimony veins.
(*g*) Contact-metamorphic deposits.
(*h*) Coal.

GOLD-TELLURIUM QUARTZ VEINS.

General.

Gold-tellurium quartz veins have been discovered in Atlin district in only one locality which is situated on the east side of Taku arm above Golden Gate. The

[1] For a historical account and description of placer mining in Atlin district, see:—Gwillim, J. C.—"Report on the Atlin Mining district, British Columbia"; Geol. Surv. of Can., 1901.



26a—p. 6

Fig. 1. Sketch map showing Mineral Locations, Atlin Mining District, B.C.

greater number of these veins, and the bulk of the rich ore found in them, occur at the Engineer mines, but veins carrying pockets of good ore have also been discovered on adjoining properties.

The Engineer Mines.[1]

General.—This property is situated on the east side of Taku arm, about 10 miles above Golden Gate (Fig. 1) and consists of eight connected claims, four of which extend to the waters edge and the other four adjoin these to the east. This group is owned by the Northern Partnership, composed of Captain James Alexander, Jno. Dunham, B. G. Nicol, and K. Wawrecka.

The Engineer mines were first located in 1899, and a joint stock company was formed, known as the Engineer Mining Co., which held the property until 1906. The claims are then believed to have lapsed, and were located by Edwin Brown and partners, who held the property one year, when it was acquired by the present owners.

Summary.—The ores at the Engineer mines occur in veins, in Jura-Cretaceous shales, slates, and other dark, finely textured sediments. The veins range from simple veins a few inches in thickness to compound veins over 200 feet thick, and consist largely of quartz, calcite, and intercalated and brecciated wall-rock. The chief metallic mineral in these veins is native gold, and, in addition, there are small particles of tellurides, some native antimony, and occasional particles of pyrite. The veins are thus of value only for their gold content.

It is not even approximately known what average amounts of gold the larger veins contain, but tests so far have given results ranging from traces to about $10 per ton. Pockets and shoots of remarkably rich ore occur in a number of the narrower veins, that have thicknesses of from 6 inches to 4 feet, and it is these that have been mainly prospected and developed.

This group of claims is easily accessible, being situated on the shore of Taku arm, and thus directly connected by navigable water with Caribou on the White Pass and Yukon railway. The property is still in the uncertain prospect stage, but possesses some promising features.

Geological Formations.—The geological formations at and in the vicinity of the Engineer mines are predominantly Jura-Cretaceous shales, slates, and finely textured greywackes and tuffs of the Laberge series, which have been invaded to a considerable extent by dykes of andesite and granite-porphyry. The ores occur prevailingly in dark to almost black shales and slates, which are in places faulted, folded, and considerably distorted, but which have a general strike of about N 63° W, and dip at an average angle of about 35° to the northeast, *i.e.* away from the water's edge.

General Characteristics of the Veins.—Two large central compound veins or hubs, consisting of quartz and intercalated and brecciated shale, slate, and altered rocks, occur, from which several veins radiate in prevailingly northwesterly and southeasterly directions. In addition, a number of veins have been discovered, which are not, as yet, traceable into any central quartz area.

Hub A (Fig. 2) is at least 200 feet wide at its widest point, and is over 300 feet in length, but, owing to a covering of superficial deposits, neither the entire length nor width of the vein was obtained. This mass consists mainly of quartz, but also contains a large proportion of intercalated bands of shale and slate. In places, bands of shale 1 to 2 inches thick alternate with veins of quartz of similar thickness. At

[1] Gwillim, J. C.—"Report on the Atlin mining district, British Columbia"; Ann. Rep. Geol. Surv. of Can., 1899, Vol. XII, p. 45 B.
"Atlin district"; Ann. Rep. Geol. Surv. of Can., 1900, Vol. XIII, p. 55A.
Report of the Minister of Mines of British Columbia, 1900, pp. 760, 761, 778; 1904, pp. 80-81.
British Columbia Bureau of Mines, Bulletin No. I, 1910, pp. 5-6; Herbert Carmichael, Provincial Assayer.

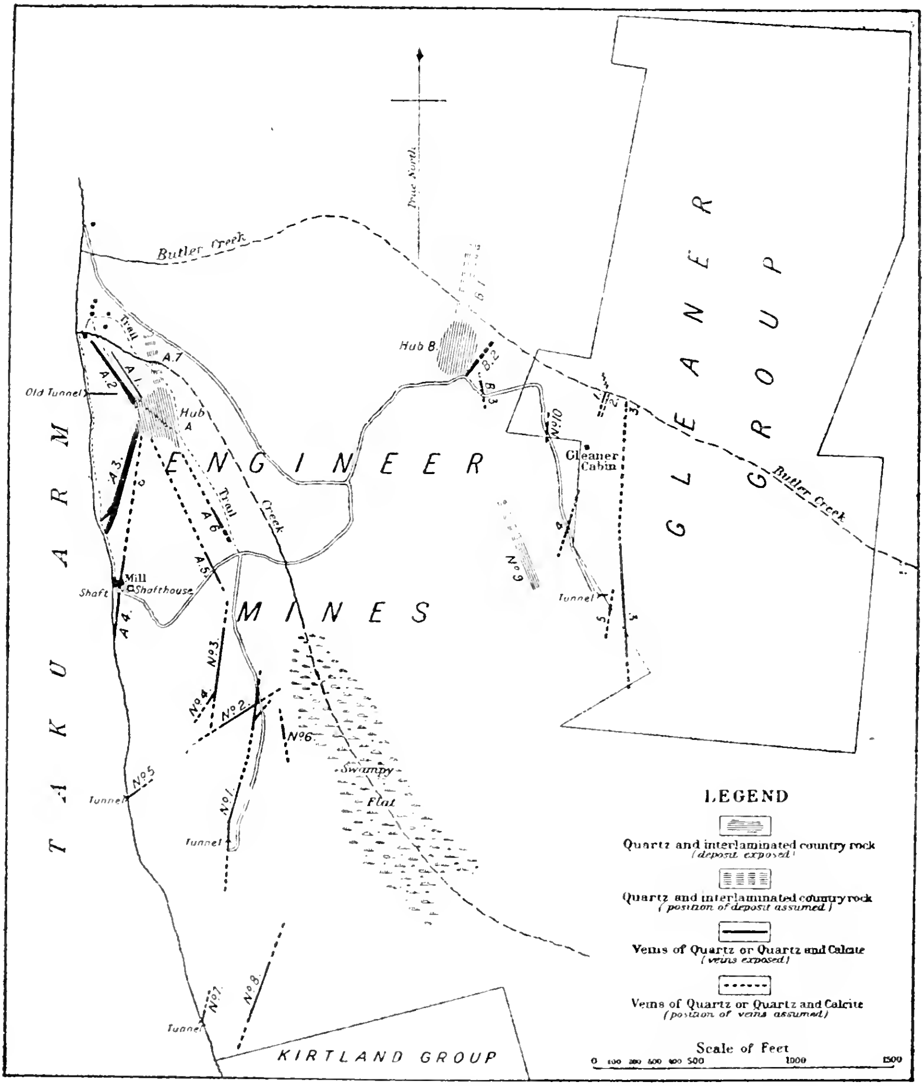


Fig. 2. Vein Outcrops at Engineer Mines and Gleaner Group, Atlin Mining District, B.C.

other points, owing to breaking and crushing, the rock has been much brecciated, and the particles have been cemented together mainly with quartz and calcite. The relative amounts of those secondary minerals and original rocks vary greatly, so that in some places there is a considerable predominance of rock, and in others the vein consists almost entirely of quartz and calcite.

Three veins A 1, A 2, and A 3, have been definitely traced to a junction with hub A. In addition, A 4, A 5, and A 6 strike towards A, and although, owing to superficial covering, they could not be followed absolutely to the central area, their strikes indicate that they join it. The strike and form of the quartz also indicate the presence of a wide vein as indicated by A 7, but this is not exposed.

Hub B is very similar in appearance to hub A, contains a large amount of intercalated and brecciated shale and slate, and is in reality a compound vein. It is at least 270 feet wide, as this much is exposed to view, but neither wall was found. Towards the edges of the vein, the proportion of rock gradually increases, and probably this increase continues, producing walls of an indefinite character.

The following tables give the main characteristics of all the veins, except the two hubs which have just been described:—

Vein.	Strike.	Dip.	Thickness.	Distance Traced.	Remarks.
A 1....	N 68° W	80° to NE	6 to 10 feet..	300 + feet..	Consists mainly of quartz.
A 2....	N 70° W	Apparently nearly vertical.	20 to 30 feet.	400 + feet...	Consists mainly of quartz.
A 3....	N 18° W	Nearly vertical.	Average 30 feet.	350 + feet...	Towards southern end and near the shore, the vein splits up into several veins 6 inches to 2 feet in thickness. Vein includes considerable intercalated shale, in places up to 20 per cent of its volume; the remainder of the vein is mainly quartz.
A 4....	N 30° W	70° to 80° to SE	2 to 3 feet...	250 feet.....	Consists mainly of quartz.
A 5....	N 64° W	80° to NE	2 to 10 inches	300 feet. ..	Consists mainly of quartz.
A 6....	N 64° W	70° to 80° to NE	4 to 20 feet..	200 + feet.	Where thin, vein consists mainly of quartz, but in thickest portions, includes up to 30 per cent of intercalated shale layers. Vein to a considerable extent lies conformable to bedding planes of formation, and so differs from the majority of the veins.
B 1....	N 20° W (?)	(?)	50 + feet...	30 feet......	Contains up to 30 per cent or 40 per cent of brecciated and interlayered rock.
B 2....	N 5° E	Vertical (?)..	10 to 12 feet.	50 feet......	Consists mainly of quartz.
B 3....	N 64° W	(?)	3 to 4 feet...	100 feet....	Consists mainly of quartz.
No. 1...	N 21° W	50° to 60° to NE	6 inches to 3 feet.	600 feet.....	Consists mainly of quartz.
No. 2...	N 23° E	Nearly vertical in most places.	2 to 12 inches	200 + feet. .	Consists mainly of quartz.
No. 3...	N 28° W	Approx. 70° to NE	1 to 10 inches. In most places 4 to 6 inches.	450 + feet...	Consists mainly of quartz. Intersects No. 4 vein and persists through it.
No. 4...	N 1° E	80° to SE	2 to 6 inches	50 feet.... .	Consists mainly of quartz.

Vein.	Strike.	Dip.	Thickness.	Distance Traced.	Remarks.
No. 5...	N 24° E	Nearly vertical.	6 to 14 inches	30 feet......	Consists mainly of quartz. Thought by owners to be, and probably is, the southwest extension of vein No. 2, but between the most southwestern known portion of No. 2 and the nearest exposed part of No. 5 is a distance of over 400 feet, so the correlation is uncertain ; however the dips, strikes, and characters of the outcrops are similar.
No. 6...	N 24 W	70° to SE	6 to 18 inches	50 feet..	Consists mainly of quartz.
No. 7...	N 20° W Approximately	Nearly vertical.	4 to 16 inches	30 feet......	Consists mainly of calcite and quartz, the calcite predominating.
No. 8...	N 13° W	80° to SW	10 to 15 feet.	300 feet.....	Brecciated vein, composed almost entirely of broken and comminuted portions of shale and slate cemented together, chiefly by quartz and also to some extent by calcite. The proportion of the gangue minerals in the vein varies from possibly 75 per cent or 80 per cent to less than 50 per cent.
No. 9...	Apparently N 56° W	(?)	50 + feet...	150 feet.	Strike indicates that it joins hub B, which it much resembles in character, being a typical brecciated vein.
No. 10..	N 47° W	(?)	Approximately 4 feet.	75 feet.....	Consists mainly of quartz, and varying amounts of intercalated shale and altered rock.

All bearings in this report, unless otherwise mentioned, are magnetic. The magnetic declination in this district is about 33°.

Mineralization of the Veins.—The gangue and ore minerals of these veins are mainly quartz, calcite, native gold, one or more telluride minerals, pyrite, limonite, and native antimony. The majority of the narrower veins are composed almost entirely of quartz, with relatively small amounts of calcite; however, as mentioned above, the fissure filling of No. 7 vein consists predominately of calcite. In addition to these two gangue minerals a number of the veins, particularly the hubs and wider veins, contain considerable intercalated and brecciated shale and related materials, and also a greenish chloritic mineral which appears to result from the alteration of the wall-rocks.

The quartz is commonly well crystallized, and long delicate prisms are very characteristic; these occur in parallel bands with the familiar comb structures, or radiate from some central particle or mass of rock or ore. In the considerable amount of intercrystal space that thus results, the metallic minerals have largely been deposited. Dense, massive, quartz occurs in places, mainly in the larger veins, but even there, vugs lined with quartz crystals are of frequent occurrence. Calcite occasionally exists in distinct crystals which usually line the interior of the various small cavities in the veins.

Native gold is the most common metallic mineral in the veins, and is in places plentifully distributed through pockets or shoots of ore, either in fine grains or thin scales of varying dimensions, which gradually merge into leaves half an inch across. Associated with the gold are occasional minute and imperfect prismatic forms of a brass-yellow telluride, the principal base of which is gold; this telluride is probably mainly calaverite. A few specimens of native antimony were also found. Occasional particles of pyrite, and its oxidation product, limonite, also occur in some of the veins.

Development Work.—The original Engineer Mining Company ran a cross-cut tunnel about 200 feet long from the water's edge to tap hub A, but instead of cutting this quartz body, the tunnel encountered only vein A 2, and did not extend to the larger deposit; about 100 feet of drifts and cross-cuts were driven from this tunnel. The Company also sank a shaft about 20 feet deep on vein A 4, near the point where it comes to the shore of Taku arm. They also sank a compartment shaft that was intended to tap vein A 4 just back of the present mill; this shaft was filled with water when visited by the writer, but is said to be about 70 feet deep. A few small surface cuttings were also made by this Company.

The Northern Partnership deepened the 20 foot shaft on vein A 4, but had to cease operations until winter on account of water. Two tunnels were also commenced on veins No. 5 and No. 7, from the water's edge, but were each only driven about 10 feet; a tunnel was also started on vein No. 1 (see fig. 2), but was only run about 30 feet. Vein No. 1 has been followed almost continuously for 600 feet by trenching from 6 inches to 6 feet deep. A trench 1 to 7 feet deep has also been dug along the outcrop of vein No. 2 for about 200 feet. In addition, a few shallow trenches and open-cuts have been made in hub A and hub B, and on veins A 5, A 6, B 3, No. 3, No. 4, No. 6, and No. 8. This constitutes practically all the development work that has been so far performed on the Engineer Mines property. During the past season the Northern Partnership performed their work practically all on the surface, with the object of determining as far as possible the number of veins, and the portions of them, that contain ore immediately available for milling. This surface prospecting and development was carefully, although necessarily slowly conducted, and has given very satisfactory results.

A 2 stamp Joshua Hendry mill, the construction of which was commenced several years ago, was completed during the early part of the season, and was in operation during the latter part of the summer.

Values.—But few assays have been made by the Northern Partnership of the ores on their property; instead, the owners have depended almost entirely for guidance in development upon the visible presence or absence of native gold, with the result that no reliable estimate can be formed as to the probable amount of gold that the hubs and larger veins contain. Minute specks of native gold are, however, to be seen in all the larger deposits, and the few assays that have been made of the quartz from these gave results ranging, in most cases, from traces to about $10 per ton. Very rich ore occurs in pockets or shoots in a number of narrower veins, the best being obtained from veins No. 1, No. 2, No. 5, No. 7, and A 4; in addition, a number of sacks of good ore were taken from No. 3, No. 6, A 5, and A 6.

The pockets appear to occur prevailingly at points where the veins are intersected by cross-fissures; they vary considerably in size, some holding only a portion of a sack, while others contain several sacks, and the greater part of the ore has a value of from $1 to $5 per pound. The only body of good ore of sufficient size to be termed a shoot, that has so far been explored, is in vein No. 1; this has an average thickness of from 1 to 2 feet, is at least 20 to 30 feet in length, measured along the strike of the vein, and has been followed downwards for 30 feet without any apparent depreciation in value. This shoot might possibly better be described as a portion of a vein in which pockets are more numerous than is usually the case, but practically all the material so far obtained from it has been pay ore.

The first 800 pounds of selected ore that was milled during the past season yielded 20 pounds 4 ounces (Troy) of gold, and the next 1,000 pounds gave 20 pounds 8 ounces (Avoirdupois); and, in addition, the tailings in each case are claimed to contain approximately 30 per cent to 40 per cent of the original gold content, but this was not investigated. The ore taken from the various prospecting trenches, open-cuts, short tunnels, etc., during the season up to September 1, was valued at about $25,000, and from the part of this that was milled, $8,000 in gold bullion was obtained.

In addition to the high grade pockets and shoots, considerable of the quartz between these on veins No. 1, No. 2, No. 5, and A 4, will probably pay to mill, and in some places it is claimed to run from $100 to $200 per ton, but the writer does not believe it will average more than a small portion of the smaller of these amounts. The entire 3 feet of ore in the shaft on vein A 4 is reported by the owners to average $200 per ton. Some splendid ore specimens have been obtained from No. 7, but this vein has not been explored for over 10 feet, and not more than about a sack of the rich material has been obtained.

The Gleaner Group.

General.—The Gleaner group consists of three claims and a fraction that lie to the east of and adjoin the Engineer mines (Fig. 1). These claims were located in 1900, and in 1901 the owners formed a joint stock company, known as the Gleaner Mining and Milling Company, who still hold the property. This Company is capitalized for $250,000, the president is Mr. David Stevens, the secretary-treasurer is Mr. P. F. Scharschmidt, of Whitehorse, Y.T., and the board of directors include the above named officers and Mr. R. Butler, of Atlin, B.C., Dr. Lindsay, of Calgary, Mr. D Von Cramer, of Vancouver, Mr. M. H. McCabe, of Victoria, and others.

A wagon road 4,300 feet long, with a good grade, was constructed during the past summer from the tunnel on the Gleaner group (see Fig. 2) across the Engineer property, to the shore of Taku arm, from which point there is direct steamboat connexion with Caribou on the White Pass and Yukon railway, 65 miles distant.

Geological Formations.—The rock formations on the Gleaner claims are the same as at the Engineer mines, *i.e.,* they consist mainly of the Jura-Cretaceous shales, slates, greywackes, tuffs, and breccias of the Laberge series, which have been invaded by occasional dykes of andesite and granite-porphyry. The sediments are in places somewhat folded, faulted, and distorted, but in a general way have a fairly uniform strike of about N 60° W, and dip at 30° to 40° to the northeast, under the high mountains in that direction.

The Veins.—The ores on these claims all occur in quartz veins, mainly in the dark, finely textured members of the Laberge series, and at least four veins have been discovered on the property (see Fig. 2). No. 1 and No. 2 veins are simple fissure-fillings, and consist mainly of quartz. These are exposed on the south bank of Butler creek, strike about N 20° W, and are from 20 to 30 feet apart. On the north side of Butler creek a vein from 3 to 10 inches thick is also exposed, which is, in all probability, the extension of either No. 1 or No. 2. This is here broken and offset by a number of faults, having displacements of from a few inches to several feet each. On the wagon road, about 750 feet from where these veins cross Butler creek, a vein is exposed (marked No. 4, see Fig. 2) which is traceable about 100 feet, strikes N 20° W, is from 1 to 2 feet thick, and is probably also the extension of either No. 1 or No. 2 vein. On the south side of Butler creek, about 80 or 100 feet above No. 2 vein, No. 3 vein is exposed, and has a thickness of 3 to 4 feet; this is really only a faulted zone in the formation, into which has been introduced a considerable amount of quartz, which occurs mainly in the form of narrow stringers, and also as a cement uniting the various rock fragments. About 700 feet from here, in a southerly direction in the apparent line of strike of No. 3, is a similar zone or compound vein about 10 feet thick, that is apparently the extension of No. 3, and has been traced for at least 400 feet, with a general strike about N 25° W. No. 5 vein is exposed about 100 feet to the south of the Gleaner tunnel, is apparently about 2 feet in thickness, and strikes approximately N 15° W.

Quartz is practically the only gangue mineral in these veins, and with the intercalated layers and fragments of wall rock, constitutes nearly the entire vein-filling,

[1] Report of Minister of Mines, British Columbia, 1904, p. G. 81, and G. 91.

with the exception of the small amounts of native gold, iron pyrite, and iron oxide. Where the gold occurs it is generally finely disseminated through the quartz, but in places thin leaves and flakes half an inch across have been found. This mineral has so far been obtained chiefly in pockets or shoots which are generally small, but during the latter part of the past summer a pocket or shoot was discovered on the north side of Butler creek that contained several sacks of ore, through all of which native gold was plentifully visible to the naked eye.

Development.—Some small open-cuts and trenches have been made on the veins outcropping along Butler creek, and a tunnel 180 feet long has also been driven from a point about 1,000 feet to the south of the creek, that was intended to cross-cut vein No. 3, but so far this quartz deposit has not been encountered.

The Kirtland Group.

The Kirtland group is owned by Thos. Kirtland and Captain W. Hawthorn, R.N., and consists of six claims that extend along the east shore of Taku arm from the Engineer group southward to 100 feet or so across Hale creek, a distance of approximately 8,000 feet (Fig. 1). The geological formation on this property is the same as at the Engineer mines, and on the Gleaner group, and the veins that have so far been discovered resemble those found on these properties. However, on the Kirtland group, only a slight amount of prospecting has yet been performed, and this has practically all been confined to the Jersey Lily claim, which adjoins the Engineer group. Several simple quartz veins a few inches in thickness, and one brecciated vein 2 to 3 feet thick, have been discovered. Two pits about 10 and 14 feet deep respectively have been sunk, and a few open-cuts and trenches have been dug.

Since this property adjoins the Engineer mines, and the formation is apparently identical on the two properties, it is hoped that rich ores will also be discovered on the Kirtland group when the claims have become more thoroughly prospected. So far little gold has been found.

GOLD-SILVER QUARTZ VEINS.

General.

Gold-silver quartz veins have been discovered at a number of points in Atlin district, the most important of which are: on the White Moose group and on the Rupert group on the west side of Taku arm above Golden Gate; on the Lawsan group on Bighorn creek; at the Beavis mine near the town of Atlin; on Munroe and Boulder mountains, east of the town of Atlin; and on the Brothon and Alvine claims on Hoboe creek near the head of Atlin lake.

The White Moose Group.

General.—The White Moose group is situated on the west side of Taku arm opposite the Engineer mines (Fig. 1), and consists of eight claims, which are owned by four persons, three of whom are Dr. H. E. Young, and Messrs. J. Johnson and Robt. Grant. Two veins, distinguished as the North and South veins, respectively, have been discovered on this property. Five claims have been located in the valley bottom along the strike of the North vein, and these extend along the shore from a point about half-a-mile above the mouth of Buchan creek southward, the length of the five claims. The other three claims have been located along the South vein, which strikes in a northwesterly direction; and the most easterly of these claims extends to the shore of Taku arm, and adjoins the most northerly of those located on the North vein.

Geological Formations.—The rocks in the vicinity of the White Moose group, with the exception of occasional dykes, all belong to the Mt. Stevens group of lower

[1] Report of Minister of Mines, British Columbia, pp. G. 81, G. 82, G. 92.

Palæozoic (?) age and consist mainly of greenish schistose amphibolites that are much contorted, faulted, and metamorphosed.

The Veins.—Outcrops which are thought to be portions of one vein—the North vein—occur at intervals for a distance of over 5,000 feet, strike in a general way N 40° W, and dip to the northeast at angles ranging from 40° to 60°. It is possible, however, that these various exposures represent more than one vein, but they all lie in the same general line of strike, dip to the northeast, contain identical mineral combinations, and in every way appear to have a common origin and to be parts of one fissure-filling; so all these vein-portions are here, for convenience in description, considered as belonging to the so-called North vein, which varies in thickness from 18 inches to 4 feet, and consists mainly of quartz, which is predominately massive, bright, and white to colourless. In places, slightly vesicular white quartz occurs, and occasional small patches of white calcite were also noted. In addition to these gangue minerals, the vein is fairly well mineralized, chiefly with argentiferous tetrahedrite (grey copper), pyrite, and chalcopyrite (copper pyrites), but galena and malachite (green copper stain) also occur. At the most northerly exposure of the vein, where it outcrops at the shore, a small shaft has been sunk; here the vein is about 2 feet thick and in places is composed largely of metalliferous minerals, mainly tetrahedrite, chalcopyrite, and galena, with subordinate pyrite, and malachite. Towards the southern end of the claims on this vein, some trenches and open-cuts have been made, a shallow prospect shaft has been sunk, and a cross-cut tunnel has been commenced, which has, however, not tapped the ore as yet. The vein at the shaft, and in the vicinity, has an average thickness of about 2 feet, and above the tunnel is 7 feet thick, but is here not so well mineralized as in places where the thickness is less. It is not known at all definitely how much gold and silver the ore in this vein carries, but a number of the assays that have been made gave results of from $10 to $15 in gold, and from 20 to 100 ounces of silver per ton.

The South vein is from 6 to 10 feet in thickness, strikes approximately N 57° W, dips to the southwest at angles ranging from 50° to 70°, and is composed mainly of quartz containing varying amounts of disseminated galena and chalcopyrite; the metallic constituents were nowhere noted, however, in sufficient quantities to constitute any considerable portion of the vein material. It is not known yet what this quartz assays.

The Rupert Group.

The Rupert group is owned by Messrs. Allan Rupert and James Johnson, and consists of eight claims located on the east face of Whitemoose mountain, which is situated on the west side and near the upper (south) end of Taku arm (Fig. 1). Five veins have been discovered on this property, and the float from a sixth has been found. The rock formation here is the same as on the White Moose property, and consists of the rocks of the Mt. Stevens group, largely the greenish amphibolite members, which are here highly schistose and much folded, mashed, broken, and metamorphosed. The veins appear all to be approximately parallel, and are best exposed on the mountain slope directly above, *i.e.*, to the west of Rupert's camp on the west shore of Taku arm. For convenience in description these veins have been numbered consecutively, beginning at the lowest and ascending towards the top of the mountain.

Vein No. 1 outcrops prominently in a gulch, at an elevation of 1,700 feet above Taku arm, strikes about N 80° W, and is from 2 to 3 feet in thickness. No. 2 vein lies about 300 feet, measured vertically, above No. 1, is from 6 to 8 feet in thickness, strikes N 73° W, and has a nearly perpendicular attitude. No. 3 vein is from 2 to 3 feet in thickness, outcrops about 70 feet above, and strikes and dips practically parallel with No. 2. No. 4 vein is approximately 950 feet above (measured vertically) No. 1, dips at high angles to the southwest, and is from 4 to 12 inches in thickness. Vein No. 4 appears to be about 4 feet in thickness, and to lie approximately 1,300 feet above No. 1, but it was only noted at one point, and the strike and dip could not be determined on account of the small extent of the outcrop. Nos. 1, 2, 3, and 4 are each traceable along the side hill for several hundred feet, have fairly persistent strikes and thicknesses, and appear to be similarly mineralized throughout. All consist mainly of quartz, which is prevailingly white and massive, although occasional vugs and bunches of vesicular crystalline quartz were noted, and in places the quartz is stained reddish with iron oxide. Galena is the prevailing metallic mineral present, and usually occurs sparingly distributed through the quartz gangue. Occasional particles of pyrite and native gold also occur. No. 2 vein is more heavily mineralized than the others, and in one place 6 feet of well mineralized ore occurs. The best specimens of native gold are believed to have been found in vein No. 4.

On the top of the hill above No. 5 vein, and lying along the northern edge of the glacier, are a great number of angular pieces of ore, some of which are as much as several hundred pounds in weight. This ore is different from that of the other veins, so far discovered on the hill, as the metallic minerals pyrite and galena are more abundant in it, and frequently exceed the gangue in amount; also pyrite is here the most abundant metallic constituent, whereas in the lower veins pyrite is of somewhat rare occurrence. A heavily mineralized vein of apparently considerable thickness must, therefore, exist under this glacier.

It is not known what amounts of gold or silver these veins contain, but assays running from $100 to $300 are claimed to have been obtained; however, it is probable that average tests would give results not exceeding a small portion of the smaller of these amounts. The property is on the lake front, very favourably situated for mining purposes, and the information that has been obtained concerning these claims appears to at least warrant further exploration and development.

The Lawsan Group.

General.—The Lawsan group is owned by Messrs. Fred Lawsan, Thos. Kirtland, Wm. Powell, Robt. Pelton, and Dan Sullivan, and Agnes A. Lawsan, and consists of six claims located on the west side of the valley of Bighorn creek, 10 miles distant, measured along the wagon road, from Kirtland on Taku arm (Fig. 1). This property was first staked in 1898, has since that time been owned by several parties, has lapsed twice, and was located by the present owners in 1909. The greater number of the veins that have been discovered are on the Bighorn claim, where all the development work has been done.

Geological Formation.—The rock formations on this group and in its vicinity, with the exception of occasional dykes, consist of the members of the Mt. Stevens group, of which the finely textured, greenish amphibolites predominate, and in these the mineral veins prevailingly occur; in addition, mica and sericite schists, as well as quartzites occur. Some of the Mt. Stevens rocks are in places quite fissile, and all are decidedly schistose, and have been folded, faulted, crumpled, and so metamorphosed that their original character has been masked, and in some cases entirely destroyed; they have also been invaded by numerous post-Palæozoic dykes of andesite, rhyolite, and the granite-porphyry. The formation in general strikes about N 15° E, and dips to the northeast at angles up to 15°.

The Veins.—The veins on this property are lense-shaped and are practically everywhere conformable to the foliation planes of the enclosing rock: no fissure veins intersecting the formation were noted. The lenses are divisible into two groups, formed at different times; of these the older veins were affected by pronounced dynamic activity before the newer ones came into existence. All the lenses are quite similar in their general appearance, and the two groups can only be distinguished in the field by observing the faulting. The earlier veins are much more broken than the later ones, in fact although quartz veins and vein fragments are plentifully distributed throughout the formation in this vicinity, and outcrops from a fraction of an inch to several feet in width are everywhere to be seen, yet entire lenses more than a few inches in thickness, and 5 or 6 feet in length, are of rare occurrence. Some lenses are so faulted that one end only is removed; others are curtailed at both ends; and the original fragments have, in places, been again subdivided so that a considerable variety of forms result. One fragment 4 to 5 feet in thickness was noted that had lost both ends, and only a central portion 10 feet long remained. Another vein with an average thickness of 8 inches outcropped for 60 feet, and one end was complete and terminated in regular lense fashion, while the other end terminated abruptly, showing that an original portion was removed. Many lenses and lens fragments occur up to 20 feet in length and as much as 2 feet in thickness. A few lenticular veins occur. however, associated with those just described, that have been formed since the greater part of the faulting occurred, and so have been unaffected by these movements. The largest quartz lens noted was from 4 to 24 inches in thickness and over 200 feet in length; this is the vein on which the bulk of the work on the Bighorn claim has been performed.

The veins or lenses are composed of quartz which is in places rust-stained, and carries small amounts of galena, chalcopyrite, pyrite, and native gold. Some specimens were seen in which particles of gold existed, which were as much as 1/20 of an inch in diameter. In other places small flakes or leaves of gold were noted up to 1/8 of an inch across. Also, from the limited amount of prospecting and assaying that has been performed, it has been fairly conclusively demonstrated, for the Bighorn claim at least, that the gold only occurs in economically important amounts in the newer veins, and that the older more broken lenses are practically barren. The owners claim that the 200 foot lens will average $160 in gold and silver to the ton, the bulk of this amount being in gold.

Two tunnels 55 and 30 feet long, respectively, have been driven, and some open-cuts and trenches have beeen made. Also a temporary ærial tramway 1,700 feet long has been constructed to carry the ore from the tunnels down to the valley bottom. The British Columbia government constructed a wagon road during the past summer from the end of this tramway to Kirtland, on Taku arm, a distance of 10 miles, so that the properties are now quite accessible.

Other Bighorn Claims.

About 1½ miles north of the Lawsan group, and also on the western slope of Bighorn valley, at a point about opposite Peter's cabin (Fig. 1), a fissure-vein outcrops, which is traceable for a distance of at least 3,000 feet, and throughout this distance is remarkably persistent in dip, strike, thickness, and mineralization. This vein occurs cutting the schistose and gneissoid members of the Mt. Stevens group of rocks, has an average thickness of about 3½ feet, strikes N 56° E, and has an almost perpendicular attitude. The fissure filling consists almost entirely of quartz, throughout which are occasional particles of pyrite. This vein is remarkable for its persistency, and for the fact that it is the only fissure vein noted in this locality. The quartz is believed to carry a few dollars per ton in gold, but none of the known assays so far obtained have given more than $10 per ton in gold and silver.

At least two claims—the Birdie and the Gold Cup—owned, respectively, by Wm. Powell and Fred. Lawsan, are located on this vein, and on the Gold Cup two tunnels 35 feet and 160 feet in length, respectively, have been driven in on the quartz.

The Imperial Mines.[1]

The Imperial mines are owned by Messrs. T. H. Jones and James Stokes, of Atlin, and William A. Moore, of Nanaimo, B.C., and consist of four Crown granted claims, situated on the south side of Munroe mountain, 5 miles in a northwesterly direction from the town of Atlin (Fig. 1). This property was first located in 1899, and in 1900 was bonded to the Nimrod Syndicate of London, England, who surveyed and Crown granted the claims, built a five stamp mill and bunk house on the property, and did considerable development. At the end of a year this syndicate abandoned the property, and Mr. Herbert Pearce obtained an option on it for two years, 1901-2, since when no work has been performed on the property.

The rock formation at the Imperial mines appears to be nearly everywhere of a greenish, finely textured, volcanic rock that exhibits, in most places, considerable hornblende, and for convenience in the field has been given the indefinite name greenstone.

All the work on these claims has been applied to developing one main vein or lode, which strikes approximately N 70° E, dips from 50° to 60° to the southeast, contains, where it has been exposed, from 1 to 7 feet of vein material, and has been traced for a distance of over 500 feet. The vein is not simple in form, but consists, in most places, of quartz and associated minerals, which fill several close, parallel fissures; and also includes portions of the intervening wall-rock that have been altered by metasomatic replacement processes, and now consist, to a considerable degree, or entirely, of secondary ore materials. The vein is thus a compound vein, or since replacement has been effective to a considerable degree in altering the intervening and intercalated rock portions, the term lode is probably more appropriate.

On account of its compound nature this vein naturally varies considerably in thickness, and is also irregular in strike and dip. The main mineralized fault-zone which constitutes this lode is fairly persistent, but the various small included breaks are quite erratic, and in most places the lode is divisible into two or more distinct parts. In the upper tunnel on the property a rather typical section gives:—

—	Feet.	Inches.
Hanging wall		
Quartz, etc	2	1
Rock somewhat replaced	2	0
Quartz, etc	0	7
Rock considerably altered and heavily iron-stained	1	6
Quartz	0	7
Foot-wall		

Another section 30 feet to the northeast shows:—

—	Feet.	Inches.
Hanging wall		
Quartz, etc	2	0
Rock, heavily iron-stained and somewhat decomposed	2	7
Quartz, etc	1	1
Foot-wall		

[1] Report of the Minister of Mines, British Columbia, 1900, p. 777, 1904, p. G. 74, G. 76, G. 91.

The vein material appears to have an average aggregate thickness of from 2 to 3 feet, and consists mainly of quartz, which is often iron-stained or rose-coloured, and frequently exhibits crustification and comb structures, but is also in places quite massive in appearance. Sparsely distributed through the quartz are particles of galena, chalcopyrite, pyrite, malachite, and native gold. Pockets or shoots occur, however, in which these metallic minerals occur more plentifully.

In addition to this main lode, numerous other veins and stringers exist on the property, and the lower tunnel has cross-cut several fissures that contain from 6 to 8 inches of quartz and associated metallic minerals.

What average amounts of gold and silver this main lode contains are only approximately known, but a considerable portion of it probably carries from $10 to $30 per ton in these minerals. In 1902 a test sample of this ore, weighing 3,267 pounds net, was sent to Pellow-Harvey, Bryant, and Gilman, of Vancouver, B.C., who reported the ore to contain:—

Gold, 1·29 ozs. valued at $20 per oz..	$25 80
Silver, 1·26 ozs valued at $0·52 per oz..	66
Total..	$26 46

This firm also adds: 'The best method of treating this ore would be first to save the gold by amalgamation on the plates from a stamp-battery, and then cyanide the tailings, when a total extraction of about 97 per cent of the gold and silver contents should be saved.'

A mill-run, continued for several weeks by the Nimrod syndicate in 1900 upon the ore of this vein, gave, according to their published report, a little over $10 per ton in gold.

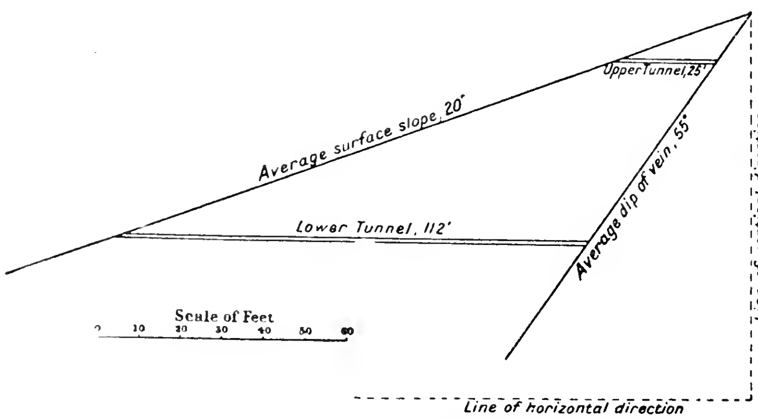


Fig. 3.—Section Through Working of Imperial Mines, Atlin Mining District, B.C.

The average slope of the south face of Munroe mountain is about 20°, and the vein dips in the same direction, but at an average of approximately 55°, so that the ore gradually gets farther from the surface of the mountain, but until the foot of the mountain is reached continues to be readily accessible by cross-cut tunnels.

Two cross-cut tunnels have been driven; the upper tunnel tapped the vein at a distance of 25 feet, and the lower one reached the ore in 112 feet. From the ends of these tunnels drifts have been driven in both directions, and 580 feet, in all, of underground work has been performed.

The entrance to the lower tunnel is 1,030 feet in elevation above the surface of Atlin lake at the wharf in Atlin, from which point there is a good wagon road to the mines. Plenty of water is available at the base of Munroe mountain for crushing and milling requirements, and the falls on Pine creek nearby would afford ample power for any mining requirements.

This property thus possesses many natural advantages, and contains a considerable tonnage of ore which, although low grade, should yet prove workable by modern methods.

The Beavis Mine.[1]

The Beavis mine is owned by the Gold Group Mining Company, Limited, in which Messrs. H. Maluin and Wynn Johnson are the principal shareholders. This property consists of nine mineral claims, three of which are Crown granted, and is situated on the east shore of Atlin lake, 1½ miles north of the Atlin post-office. (Fig. 1.)

Several thousand dollars have been expended in the development of these claims, mainly on two shafts, which, when visited in October, were filled with water, so that no definite information could be obtained concerning their depth or the character of the ore deposit. From the material exposed on the dump, the rock in the shafts appears to be mainly black chert, and chert breccia, but a granite-porphyry dyke also cuts the formation in this vicinity. The ore apparently consists of a quartz vein carrying some pyrite and free gold.

Boulder Mountain Claims.

A number of claims have been located on the east slope of Boulder mountain, between Birch and Boulder creeks, about 12 miles in a northeasterly direction from Atlin (Fig. 1); of these the White Star group[2] of three claims owned by Captain Wm. Hawthorne, R.N., and the Lake View group[3] of three claims owned by Jos. Clay have been the most explored. Other claims between and adjoining these groups are also being held, and on some of them the same veins are supposed to outcrop that are found on the Lake View and White Star properties.

The formation in the vicinity of these claims consists of the members of the Mt. Stevens group of rocks, mainly the chloritic and sericitic schists, quartzites, and limestones.

On the White Star group two veins have been discovered; of these the upper one occupies a fissure in finely textured chloritic schists, is from 4 to 5 feet in thickness, strikes N 70° W, dips to the southwest at angles ranging from 80° to 85°, and outcrops at an elevation of 1,650 feet above the lower end of Surprise lake. This vein consists mainly of quartz, which is sparsely mineralized with galena, pyrite, and occasional particles of native gold. A tunnel 58 feet long has been driven on the ore.

Approximately 400 feet down the mountain slope from this upper vein is an exposure of quartz, across which a trench 30 feet long has been dug without coming to its edges, so that the dip, strike, etc., of this deposit are not known. The quartz contains occasional particles of pyrite and iron oxide, but has not been found to carry any other metallic minerals.

On the Lake View group two veins have also been discovered, that are about 400 feet apart and strike approximately in the direction of the White Star group. These are thought by the owners to be probably the same veins as those found on the White Star property, but sufficient work has not yet been performed to entirely justify this conclusion.

The upper vein on the Lake View group is from 3 to 4 feet, and the lower one is about 30 inches in thickness. The quartz of both is sparsely mineralized with

[1] Report of Minister of Mines, British Columbia, 1904, pp. G. 78, G. 91.
[2] Report of Minister of Mines, British Columbia, 1904, pp. G. 76, G. 77, G. 92.
[3] Report of Minister of Mines, British Columbia, 1904, pp. G. 76, G. 77, G. 92.

galena, pyrite, and rare specks of native gold. A tunnel over 150 feet in length has been driven, two shafts about 35 and 27 feet deep respectively have been sunk, and a number of trenches and open-cuts have been dug on this group of claims, with the result that the two veins thereon have been traced for several hundred feet.

A few samples have been obtained from these Boulder Mountain deposits that assayed from \$100 to \$300 per ton, and one or two are claimed to have given even higher results, but an average of the veins would probably not exceed \$10, and might be somewhat less. From the various tests that have been made, however, it is hoped that a considerable portion of the quartz will pay for mining when such can be done economically. Further, in all probability, other veins will yet be discovered in this vicinity, as the mountain is in many places covered with a mantle of superficial materials that hide the bed-rock and whatever ores it contains.

The Laverdiere Group.

The Laverdiere group is owned by three brothers, Messrs. Noel, Frank, and Thomas Laverdiere, and consists of six claims, three of which are Crown granted, and two fractional claims. This property is situated on the west side of Hoboe creek, about 2 miles from where it runs into West bay, which forms the upper end of Torres channel, an arm of Atlin lake. (Fig. 1.) The principal ore body on the Laverdiere group, or at least the one most highly valued and that on which the bulk of the development has been expended, is described under 'Contact Metamorphic Deposits.' In addition, two fissure veins have been discovered on the Alvine and Brothon claims, respectively, that appear from the limited amount of work that has been performed on them to belong to the gold-silver quartz veins, and so will be here described. It is possible, however, that they would be more appropriately classed under high-grade silver veins.

The vein on the Alvine claim strikes approximately N 30° W, has an average thickness of about 2 feet, and occurs in the Coast Range granitic rocks. This deposit consists almost entirely of a gangue of quartz, which is in most places somewhat stained with iron-oxide, and with which is associated a small amount of white calcite. Disseminated through this gangue is, nearly everywhere, more or less argentiferous tetrahedrite (grey copper containing silver) and in addition, small particles and flakes of native silver also occur. It is not known what this ore will assay, but its general appearance warrants the expenditure of sufficient work to thoroughly explore the vein.

On the Brothon claim another mineralized fissure occurs in the Coast Range granitic rocks, which strikes N 85° E, has an almost vertical attitude, and can be traced from near the level of the valley bottom several hundred feet up the mountain side. In places, this fissure includes between its walls several inches of quartz which is associated with some calcite, and contains more or less galena and tetrahedrite, and also occasional particles and flakes of native silver. Near the valley this fissure includes only about one-fourth of an inch of decomposed clayey material, through which and the somewhat altered and replaced walls for 6 to 14 inches on each side of the fault, is a certain amount of disseminated argentiferous tetrahedrite, and native silver. Assays of the mineralized wall-rock have been obtained that gave results as high as 600 ounces, and it is claimed that a zone 12 to 14 inches in thickness, bordering the fissure, will average from 20 to 30 ounces of silver per ton.

CUPRIFEROUS SILVER-GOLD VEINS.

Table Mountain Claims.

The Petty Group.—The Petty group is owned by Mr. Ira Petty, and consists of two claims which are situated on the southeastern corner of Table mountain, overlooking Graham inlet, and are about 3½ miles in a northwesterly direction from Taku Landing (Fig. 1).

The rock formation in this vicinity consists mainly of the Chieftain Hill volcanics, which are here prevailingly greenish andesites and andesitic tuffs. These have been extensively invaded by dykes of granite-porphyry, belonging to the Klusha intrusives.

The ore all occurs in the granite-porphyry and exists mainly in the form of fissure veins, but also includes more or less mineralized and replaced wall-rock. Only one main vein has been so far exploited on the Petty group, and this strikes N 30° E, and has an average dip of about 40° to the northwest. The vein consists mainly of quartz, calcite, galena, chalcopyrite, pyrite, malachite, and azurite, and one small cavity was found to be lined with small crystals of the rare mineral linarite (a basic sulphate of lead and copper). The quartz is generally rust stained, and occurs associated with varying amounts of calcite, which in places even exceed the quartz in amount. Galena and chalcopyrite are the most abundant ore minerals present, and occur in approximately equal amounts, and in sufficient quantity in places to constitute the greater portion of the vein material. This vein has a thickness, at the widest point so far discovered, of about 2 feet, but rapidly diminishes to 6 inches or less within a distance of 50 feet in each direction, and has not been followed for over 100 feet. It is possible, however, that further development may show the vein to extend a somewhat greater distance. In addition, several other mineralized fissures occur in places on both sides of this main fissure, and within distances of 1 to 2 feet from each wall; and the rock between these is, to some extent, replaced and impregnated with various ore materials; so that at the main shaft the ore might be considered to have a total thickness of 3 feet at the surface, but towards the bottom of the shaft its thickness is much less. The ore is claimed to contain $4 or $5 per ton in gold, with the main values in silver and copper; but so few tests have been made, that it is uncertain what average amounts of these metals the ore carries.

An inclined shaft 90 feet deep has been sunk on the ore, commencing at the most promising point on the surface, and within 50 feet an open-cut has been dug. A trail has been made from the shore up to the workings, which are about 1,200 feet in elevation above, and directly overlooking Graham inlet.

The Dundee Group.—The Dundee group is owned by the British Crown Gold and Copper Mining Co., of Victoria, B.C. This Company was incorporated November 29, 1909, with a capital of $1,000,000, and with Mr. Scott I. Wallace, of Seattle, Wash., as secretary-treasurer, and Messrs. W. W. Felger, F. G. Holder, A. C. Pellissier, and Wm. F. Howe as directors. The property consists of two adjacent claims, one of which, the Dundee, adjoins the Petty group to the northeast, in the supposed direction of strike of the Petty vein (Fig. 1). The formation on the Dundee group is the same as on the Petty claims, and the ore also occurs associated with a granite-porphyry dyke. Only one vein has been developed on this property, and this strikes N 30° E, dips to the northwest at 40° to 50°, is lens shaped, and for 10 or 15 feet has a thickness ranging from 1 to 2½ feet. Thirty feet to the northwest from this point of greatest thickness at the surface, the vein is not more than 1 inch thick, and it cannot be traced more than 20 feet to the southwest. It has been supposed that this is the same vein as that on the Petty group, as both strike in the same direction; however, there appears to be no support for this assumption, as the vein on the Dundee claim distinctly terminates within 100 feet, at most, of the places where it outcrops, in the direction towards the Petty claims; this is clearly evident from the fact that the rocks are all well exposed in a draw 100 feet from the outcrop of the Dundee vein, in a direction towards the Petty shaft, and although any vein crossing this draw would be easily seen, none is to be found. Further, if the vein continued from the Petty shaft in the line of strike it there maintains, it would pass considerably above the showing in the Dundee claims.

The Dundee vein is similar in appearance to that on the Petty group, and consists of a quartz and calcite gangue, highly impregated with galena, chalcopyrite, malachite, and azurite. The wall-rock also contains a considerable amount of these minerals disseminated through it. Instead of following a fissure in the central portion of a granite-porphyry intrusion, however, as in the Petty group, the vein here continues near the edge of a granite-porphyry dyke, but was nowhere seen to depart from this rock into the surrounding andesitic materials.

Two tunnels, having respectively lengths of approximately 20 and 150 feet, have been driven on the Dundee claims, neither of which has cross-cut the vein; and in addition two small open-cuts have been dug. A trail has been constructed from the shore of Graham inlet up to the higher of these workings, which is about 700 feet above and directly overlooking the water.

The Pelton Group.—The Pelton group is owned by Mr. R. L. Pelton, of Taku Landing, and consists of two claims, which adjoin the Dundee group in the direction of the general line of strike of the vein on that property (Fig. 1). The rock formations on the Pelton claims are the same as on the Petty and Dundee groups, but no ore has been encountered as yet.

SILVER-LEAD VEINS.

Veins on Crater Creek and Vicinity.

General.—When visited in October, 1910, about a dozen claims were held on Crater creek and in the vicinity, and of these, those on which the most development has been performed, and which exhibit possibly the most promising showings, constitute the Big Canyon group of four claims, which were located in 1899 and are owned by Messrs. John Malloy, Thomas Vaughan, and M. Summers. Mr. S. Johnson also owns several claims in this locality (Fig. 1).

The formation in the vicinity consists mainly of a coarsely textured, light coloured, granitic rock, which, in many places, is porphyritic, and contains feldspar phenocrysts often exceeding an inch in length. This formation has been extensively invaded by dark green, finely textured, andesitic dykes, which are everywhere in evidence. The ore deposits as a rule occur entirely within the volcanic intrusives, but in a few places were observed to lie at the contact between these and the granitic rocks, and, in all cases, seem to be genetically related to the dykes.

Big Canyon Group.[1]—Two main mineralized dykes or veins occur on the Big Canyon group; of these, one crosses the right branch of Crater creek possibly 300 or 400 feet above, and the other meets the main creek a short distance below the forks of the creek.

The upper dyke strikes N 40° E, dips 80° to 85° to the northwest, has an average width of about 30 feet, and is traceable on the surface for at least several hundred feet. This dyke, where exposed and explored on the left bank of the creek, is roughly divisible into three portions of about equal thickness. The upper third has been subjected to repeated faulting, and now consists predominantly of brecciated fragments cemented together mainly with infiltrated quartz, there being an increasing proportion of cement as the central portion of the dyke is approached. The upper edge of the dyke thus consists mainly of rock, which decreases gradually until at a distance of about 10 or 12 feet there is a predominance of vein and ore materials.

The middle third of the dyke contains the bulk of the ore, which occurs in the form of one or more fissure veins, including numerous narrow veinlets, and in irregularly-shaped bodies, bunches, etc., which occur between and replacing the breccia fragments. Metasomatic replacement is here very clearly and vividly illustrated, as breccia fragments can be found in all stages of transition, from those consisting entirely of original rock materials, to others formed altogether of secondary ore and vein matter, with generally the original shape of the fragments still preserved. Galena

[1] Report of Minister of Mines, British Columbia, 1900, pp. 760, 778, 779.

and arsenopyrite (arsenical iron pyrite) are the prevailing ore minerals, but pyrite, zinc blende, and ankerite[1] also occur. In addition to these minerals, a certain amount of quartz and calcite, and more or less altered dyke rock occur, constituting the gangue of the ore. In places, however, almost no quartz or calcite are present, and in one of the tunnels in this dyke a body 4 feet in thickness, composed almost entirely of galena, was noted.

The lowest 10 feet of the dyke has been here but slightly affected, but lying along the foot-wall is a vein of ore about 1 foot thick, composed mainly of galena, arsenopyrite, and altered dyke rock.

The lower of the two main ore-containing dykes on the Big Canyon group strikes N 40° E, dips at angles from 80° to 90° to the northwest, is traceable for at least 3,000 feet and possibly considerably farther, and is, wherever seen, from 8 to 15 feet wide. This dyke, in a general way, much resembles the upper one just described, but here no distinct zones or persistent bands were noted, and the ore varies in position from place to place along the vein, but appears generally to be best near the foot-wall. From 4 to 12 feet of this dyke is heavily mineralized, mainly with galena, zinc blende, and arensopyrite, but pyrite, as well as chalcopyrite (copper pyrite), also occurs. Here also the ore occurs filling various fissures and irregular cavities, and forming numerous narrow veinlets; and also exists in irregular bodies, bunches, particles, etc., replacing the original dyke rock. Constituting the cavity fillings is a considerable amount of quartz and calcite, which are almost entirely absent where metasomatic processes have been prevailingly effective.

In addition to these two main bodies, a number of small veins, generally a few inches in thickness, were noted, which possess the same general appearance and characteristics that distinguish the larger deposits.

In the deposits on the Big Canyon group, as well as those elsewhere in the vicinity, both the filling of cavities, including fissures, and the replacement of the original rock, have been instrumental in producing the ore deposits; but, of the two processes, the latter appears to have been the more effective.

A most striking feature in connexion with these deposits is the persistency with which the faulting and subsequent mineralization adhere to the andesite dikes. In one place a fault, or rather a fault zone, was followed for over 3,000 feet, and for the entire distance it remained confined to a dyke that nowhere exceeds 15 feet in width; and at no point, though it might almost be expected to do so, does the fracturing extend into the granitic rocks on either side. This phenomenon is apparently due to one or both of two causes. In the first place there appear to be a number of old, well-defined lines of weakness in the formation in this locality, and at the time of the andesitic intrusion the main dykes followed these, and since that time the various stresses to which the earth's crust has been here subjected have found relief along the same lines. It may also be that the dyke materials are more brittle, and less resistant to the forces that have here been active than the granitic rocks, and that on this account mainly, the fractures have been confined to the dykes. Whatever the cause, it is evident that faulting has been active along these definite lines for a long period, commencing before the andesitic intrusion, and continuing possibly to the present time, but at least until long after the bulk of the ore and vein materials was deposited in the faulted and brecciated dykes, since more recent veinlets were discovered cutting portions of the deposits in practically their present condition.

The ores of the two larger deposits on the Big Canyon group contain only a small amount of gold, generally under $4 per ton, but they are believed to carry more important amounts of lead and silver. It is not known definitely how much of these metals the ores contain, but from the information obtainable it is thought that they

[1] $CaCO_3$, + (Mg, Fe, Mn) CO_3, or a dolomite in which magnesia is more or less completely replaced by protoxide of iron, or of iron manganese.

are decidedly low grade, but that they occur in quantities holding sufficient lead, silver, and gold to make them worthy of careful exploration and investigation.

On the upper vein two tunnels have been driven, the lengths of which could not be determined on account of ice which they contained, but they probably have an aggregate length of over 100 feet. A shaft, possibly 40 or 50 feet deep, has been sunk on the lower vein, and several open-cuts and shallow pits have been dug. Two cross-tunnels have also been commenced, which have, however, not yet tapped the ore. There are, in addition, a number of open-cuts, trenches, etc., on this property.

Other Deposits.—Crossing Crater creek at a point about 300 feet in elevation below where the upper vein on the Big Canyon group crosses the right fork, is a dyke which strikes N 27° E, dips from 80° to 90° to the southeast, and is about 5 feet in thickness. Where this dyke is exposed on the right bank of the creek, about 2 inches of ore occurs on the hanging wall; and on the left bank of the creek, where the ore is claimed to be considerably thicker, a short tunnel has been driven, which when visited had so caved in that the hanging wall side of the dyke was not visible. The ore seen was very similar to that in the Big Canyon veins.

At approximately 1,500 feet in an easterly direction from the showings on the Big Canyon group on Crater creek another dyke occurs, which is about 6 feet in thickness, strikes N 40° E, and has an almost perpendicular attitude. This dyke has been subjected to faulting and brecciation until it is now composed almost entirely of rock fragments, more or less cemented with quartz, calcite, galena, arsenopyrite, and zinc blende. In places the secondary minerals constitute about half the filling between the granitic walls. A shaft about 10 feet deep has been sunk on this material.

Besides these, a number of similar, and promising deposits of ore are believed to occur in the vicinity, but on account of the lateness of the season, and the prevailing stormy weather, they were not examined.

COPPER VEINS.

Copper veins were noted in Atlin district in only one area, which includes the southwestern corner of Copper island[1] and the adjoining small islands in Atlin lake (Fig. 1). Several claims were held here for a number of years by the Laverdiere brothers, but were allowed to lapse during the year 1910. The formation consists of reddish and bluish, prevailingly coarsely textured basalts and tuffs, of which the tuffs predominate, and in places consist almost entirely of basic volcanic fragments, but grade into rocks containing a predominance of sedimentary materials.

A number of veins, from a fraction of an inch to 6 inches in thickness, and composed mainly of calcite and disseminated particles of native copper, intersect these basalts and tuffs. The veins consist in most places mainly of calcite, but pieces of copper weighing several pounds each are occasionally found in them. Associated with the native copper are malachite (common green copper stain), and occasionally cuprite (red oxide of copper), and tenorite (black oxide of copper). Copper also occurs, both in small disseminated particles and collected along the various seams adjoining the veins.

ANTIMONY VEINS.

Antimony veins were noted in Atlin district at only one point, which is situated on the west shore of Taku arm about 10 miles below (north of) Golden Gate. Two claims, the Lakefront and Antimony, have been located here by Messrs. J. Johnson, and C. B. Dickson (Fig. 1) respectively.

The ore occurs in the form of bedded veins that conform in a general way to the stratification planes of the enclosing rocks, which here lie almost flat, and consist mainly of the dark, finely textured, clay-shale members of the Jura-Cretaceous, Laberge series.

[1] Report of Minister of Mines, British Columbia, 1904, p. G. 80.

The main vein is from 3 to 4 feet in thickness, and is composed chiefly of quartz and stibnite (antimony sulphide), with also some galena, and includes, as well, varying amounts of intercalated shale. In some places the entire 3 or 4 feet is composed of vein materials, but in others, beds of shale occur separating the layers of quartz, and constitute about one-half the entire material, which is, in a general way, regarded as the vein or ore body. The quartz is generally quite heavily mineralized.

In addition, a number of bedded veinlets, ranging in thickness from a fraction of an inch to 2 or 3 inches, occur within a few feet of the upper edge of this vein.

A drift about 15 feet in length constitutes the bulk of the development on this deposit.

CONTACT METAMORPHIC DEPOSITS.

General.

Contact metamorphic deposits of economic interest have been found in the Atlin district in only one locality, which is situted on Hoboe creek, near the upper end of Torres channel, an arm of Atlin lake (Fig. 1).

The valley of Hoboe creek has an average width of about half a mile, is flat, and contains numerous, swampy meadows, which are the result, to a great extent, of beaver dams at different points on the stream. Schists, quartzites, limestones, etc., of the lower Palæozoic (?) Mt. Stevens group apparently underlie a considerable portion of this valley, and, for a distance of approximately 2 miles from Torres channel, extend up its western slope as well. Adjoining these rocks on the west are the Coast Range granitic intrusives, which constitute the high, steep sided hills to the west and south. The contact metamorphic ore deposits are included in the Mt. Stevens rocks near their contact with the granitic intrusives.

Along this contact, the Laverdiere and the Callahan groups of claims have been located.

The Laverdiere Group.

The Laverdière group is owned by three brothers, Messrs. Nöel, Frank, and Thomas Laverdière, and consists of six claims, three of which were located in 1899 and have been Crown granted, and two fractions. In addition to the contact deposit which is here considered, two mineral veins have been discovered on this property, and are described above under gold-silver veins. The main workings on this property are situated on the western edge of the valley of Hoboe creek, 1½ to 2 miles from the mouth of the stream.

The Mt. Stevens rocks which outcrop along the western edge of the valley consist prevailingly of finely textured, chloritic and greenstone schists, and limestone. Cutting these, and lying to the west and southwest of them, are the Coast Range granitic intrusives, which are prevailingly light grey or pink, coarsely textured, granodiorites. The ores prevailingly occur in the older rocks and near their contact with the intrusives.

The ore deposit is at one point approximately 150 feet in thickness, and wherever a section of the rocks immediately below the granitic intrusives has been seen, at least 30 to 40 feet of ore material has been found; this consists mainly of magnetite, chalcopyrite, tetrahedrite (grey copper), malachite, cobalt bloom, and various altered gangue materials including considerable biotite. Typical samples of these ores were supplied to Mr. R. A. A. Johnston, mineralogist, of the Geological Survey, who states: 'These specimens consist of an association of magnetite, chalcopyrite, and occasional small amounts of tetrahedrite, with altered gangue material made up of mixed carbonates and silicates of indefinite composition. The more important minerals in these specimens are sometimes sufficiently well segregated to admit of

[1] Report of Minister of Mines, British Columbia, 1904, pp. G. 79, G. 80.

easy recognition, but in general they are so intimately mixed with each other, and with the gangue materials, that they can be separated only with very great difficulty; these mixtures are so intimate at times as to at first sight present a homogeneous aspect; this intimacy of mixture not only affects the appearances of the different constituent minerals but it also has the effect of greatly modifying the tarnish colours produced through oxidation; this applies particularly in the case of chalcopyrite, which tarnishes to a brownish colour and presents almost the appearance of some pyrrhotite.'

The best showing of ore is perhaps on the French claim, on which a cross-cut tunnel 188 feet long has been driven, of which more than 130 feet are in ore. Numerous faults, having displacements generally of only a few inches or a few feet, were encountered in the tunnel, with the result that in several places blocks of rocks were found adjoining others composed of ore.

The rocks that are altered and replaced appear to have been mainly the chloritic schists; the limestone has for the greater part suffered merely crystallization and marbleization. The ore extends up to within a few feet of the contact, which is about 50 feet in elevation above the valley. A few hundred feet up the valley from the French tunnel, the contact and its associated ore, by persisting in their southeastely strike, extend from the hillsides out into the valley-flat and are here lost to view, but probably again outcrop on the hills to the southeast.

The ore in the French tunnel assays from 1·65 per cent to 6 per cent copper, and it is thought that a considerable portion of it will average between 2 per cent and 4 per cent.

On the Holy Cross claim a tunnel 35 feet long has been driven, but has not yet reached the ore. Above here, however, a body 40 feet in thickness, composed almost entirely of granular magnetite, occurs. This iron ore contains a certain amount of chalcopyrite, and malachite, as well as cobalt bloom, which occurs disseminated through the ore in places, and also frequently coats weathered surfaces. The ore here, as on the adjoining French claim higher up the valley, extends up the hillside to within a few feet of the contact between the schistose and granitic rocks, which is about 55 feet above the valley. The ore in the Holy Cross tunnel does not contain as much copper as in the French tunnel, and does not, probably, average more than 1 per cent. All the ore on the Laverdiere group is reported to contain small amounts of silver and gold.

The Callahan Group.

The Callahan group (Fig. 1) is owned by Mrs. Callahan, and consists of six claims, which adjoin the Laverdiere group and extend in a northerly direction to the upper end of Torres channel, known as West bay. The contact between the Mt. Stevens' rocks and the Coast Range intrusives passes through these claims, but is in most places concealed by superficial materials, and by the forest growth; where it is exposed, however, ore occurs in its vicinity much resembling that on the Laverdière property. These contact deposits have not been developed, however, and the assessment work has been performed on various quartz veins, generally lens-shaped, that occur mainly in greenish schistose rocks, and are prevailingly only a few inches but in places are as much as 6 feet in thickness, and show generally only a small amount of pyrite. It is claimed that these veins contain also native gold.

COAL.

Sloko Lake Claims.

In 1908 Mr. Alex. McDonald was informed by Indians of the occurrence of float coal near the southeastern summit of Sloko mountains, and at a point to the north-east of and overlooking the lower (east) end of Sloko lake. Since then ten claims have been located in the vicinity, by Alex. McDonald, Norman McLeod, James Johnson, M. A. Dickson, J. Dunham, M. Wynn Johnson, David Gibb, E. Lambert, N. C. Wheeling, and Samuel Johnson. Seven of these claims are now owned or controlled by the Amalgamated Development Co., of Vancouver, B.C.

The rocks outcropping along the shores and on the hills overlooking the lower end of Sloko lake from the north are mainly lavas and tuffs belonging to the Wheaton River volcanics, and are prevailingly greyish to yellow in colour, except where stained by iron oxide. Occasional basaltic dykes pierce these materials, but do not comprise any considerable portion of the general formation. The volcanic flows and beds still lie nearly flat, and outcrop horizontally along the walls of Sloko Lake valley, giving rise to numerous successive benches or terraces forming broad steps up the mountain slopes. These rocks weather and decrepitate rapidly, giving rise to an abundance of talus, which in turn decomposes readily to form a fine ash-like material. The mountains are consequently, in most places, rugged and precipitous, and the scenery is wild and imposing.

The Wheaton River rocks extend to the east down the valley of Sloko river, the outlet of Sloko lake, for approximately 2 miles, where sedimentary rocks belonging to the Jura-Cretaceous Laberge series outcrop, and thence continue down the valley for several miles at least. The Laberge beds occur also on the mountain slopes on the north side of Sloko river, where they extend to an elevation of 2,550 feet above Sloko lake at their most northwesterly exposure, and 2½ miles in a northeasterly direction from the northeastern corner of the lake.[1] Here only a narrow tongue of these rocks has been stripped by erosion and weathering processes of their original cover of volcanics, and is still surrounded, and overlain on three sides, by flat-lying beds, which hide the remaining portions of the Laberge rocks to the north, east, and west.

The sedimentary beds, where exposed, strike about N 70° W, dip to the southwest at from 20° to 50°, and consist mainly of dark, finely textured shales and sandstones, but also include near the summit of the ridge some dark conglomerates that belong to the Tantalus conglomerates, and consist entirely of quartz, chert, and slate pebbles, generally firmly cemented together. All the important coal seams that have been found in northern British Columbia and southern Yukon occur associated with these Tantalus conglomerate beds.

The uppermost portion of this sedimentary area just described is, in most places, covered by several feet of weathered and decomposed material, which is derived from the surrounding and underlying volcanics and sediments, predominantly from the volcanics, and is in the form of sand, mud, and clay; this in places contains a certain amount of wash coal, which occasionally occurs in layers more or less mixed with other products of erosion and weathering, and near the summit of the ridge, pieces of lignitic coal and carbonized wood, as much as 6 inches thick, have been found. Some of the layers of detrital coal were at first thought to be coal seams in place, but the fallacy of this idea soon became apparent.

When visited in the latter part of September, 1910, the seams from which the float coal is derived had not been discovered, but a small amount of work should expose them. The pieces of coal found are lignitic in character, and would make a good fuel. The utilization of this coal, when found in place, will be difficult, owing to the fact that it is situated on a mountain top high above timber-line and in an almost inaccessible portion of the district. An attempt should be made to trace the seams, when uncovered, to the more accessible country to the east or southeast, in the valleys of Sloko river or its tributaries, where it might pay to mine the coal, if found in clean seams of sufficient thickness.

[1] The level of Sloko lake on September 25 was approximately 230 feet above that of the upper end of Atlin lake.

Other Coal.

Coal is to be expected wherever the Tantalus conglomerates occur, especially where any considerable thickness of these beds remains. The south side of the lower end of Sloko lake, and along Sloko river, are very probable localities that should be carefully prospected.

Tantalus conglomerates were found on an inconspicuous summit on the south side of Graham inlet, about 5 miles southwest of Taku Landing, but only about 30 feet of the bed remain, as the overlying portions have been removed by erosion; however, it is probable that more of the conglomerates occur farther to the south and southwest where the accompanying coal seams should also be found. This probability almost reaches a certainty, from the fact that small pieces of coal are reported to have been found during the past season in one of the creeks running into the north side of Graham inlet.

A piece of solid, firm coal, apparently bituminous in character, and weighing possibly 20 or 30 pounds, was brought to Atlin by prospectors, and placed on exhibition in the Gold Commissioner's office. This sample is reported to have been obtained from a 4 foot seam on Taku river, 12 miles above canoe navigation, and about 30 miles from Juneau.

PORTLAND CANAL DISTRICT.

(R. G. McConnell.)

The season of 1910 was spent in studying the geology and ore deposits of the Portland Canal district. I was assisted by Mr. A. O. Hayes in the geological examination, while Mr. Malloch collected data for a topographical map.

The work was greatly hampered by the lack of a suitable topographical map on which to lay down the geological boundaries, and further field work will be necessary before a correct geological map can be issued. A sketch map compiled as carefully as the existing conditions permitted has been prepared to accompany this report.

Previous Work.—While no work had previously been done by the Geological Survey in the district, three reports have been published by the British Columbia Bureau of Mines. Two of these, by Mr. H. Carmichael, Provincial Assayer, are included in the annual reports of the Bureau of Mines for 1906 and 1909 respectively, and one by Mr. W. F. Robertson, Provincial Mineralogist for British Columbia, was published during the past season as Bulletin No. 2, 1910.

Acknowledgments.—The writer is indebted to most of the mining men in the district for information and other courtesies, and especially to Mr. C. M. Dickie, president, Mr. Elmendorf, manager, and Mr. Sheridan, mine superintendent of the Portland Canal Mining Company; Mr. A. Erskine Smith, president, and Mr. Webster, mine superintendent of the Red Cliff Mining Company; Mr. A. D. McPhee, manager of the Red Cliff Extension and other mining companies; Mr. H. B. Williams, engineer for the Lordigordy Mining Company, etc.; Mr. Vaughan-Rhys, engineer for the Main Reef Mining Company, etc.; Mr. Tuomy, mine superintendent of the Stewart Mining and Development Company; Mr. Knobel, manager of the Pacific Coast Exploration Company; Mr. Smith, manager of the International Portland Mining Company; Mr. Baxter, mine superintendent of the Main Reef claim; Mr. James Lydden, part owner of the Old Chum and other claims; and Mr. Anderson of the Black Bear group.

SITUATION AND COMMUNICATION.

The district is situated in northern British Columbia, close to the Alaska boundary, at the head of Portland canal, one of the largest of the numerous fiords which indent the North Pacific coast. Portland canal cuts completely across the long granitic batholith which forms the central portion of the Coast range and reaches the mineralized sedimentary and intrusive rocks which border the batholith on the east. Bear river empties into the canal at its head, and the area examined includes the portion of the mineralized belt drained by that stream and its tributaries.

Portland canal is a large deep inlet, easily navigable by the largest steamers. Stewart, the distributing point for the district, is situated at its head, and several steamship lines maintain regular communication between it and Prince Rupert, Vancouver, and other coast towns.

A wagon road has been built by the Provincial Government, from Stewart up Bear River valley to Bitter creek, a distance of about 10 miles, and from it the principal showings are reached by trails constructed partly by the Government and partly by private companies. A railway up the valley is now being built.

DISCOVERY.

The metalliferous character of the Portland Canal mining district was first discovered by a party of prospectors in 1898, the year of the great Klondike rush. They were searching for placer deposits, but failing to find pay gravels turned their attention to prospecting for quartz. The Roosevelt and other claims on the North fork of Bitter creek were staked in 1899, and the Mountain Boy and American Girl on American creek in 1902. The Alaskan boundary at that time had not been defined, and the claims were first staked under United States laws, but were subsequently restaked and recorded in British Columbia. The Red Cliff, which could hardly escape the notice of prospectors as the croppings show up prominently on the mountain side, was first staked in 1898, and has lapsed and been restaked several times, the last time in 1908.

While some prospecting and staking were done year by year, little actual mining work was attempted until 1907, when the Portland Canal Mining Company commenced development work on the Little Joe and Lucky Seven claims on Glacier creek. The success met with drew the attention of miners to the district, and during the last three or four seasons, prospectors have swarmed over it, and little ground from Stewart far up Bear River valley, which shows any signs of mineralization, is now left unstaked. Only a few of the claims have been even roughly prospected, and on only two, the properties of the Portland Canal and the Red Cliff Mining Company, is development work much advanced. A number of companies, however, commenced systematic work during the past season.

TOPOGRAPHY.

The Portland Canal mining district is situated in the heart of the Coast range, in a region of intense glaciation, and its topography, while still bold and striking, has been toned down by moving ice, and much of the original ruggedness removed. It has been heavily glaciated up to a height of fully 5,500 feet[1] above the sea, and the mountain slopes, below this level, although usually very steep, often rising in sheer unscalable cliffs, are, as a rule, comparatively smooth, except where scored and broken by narrow cañons carved out, in post-glacial times, by streams plunging down from the perennial snow and ice fields above.

The district embraces a number of high mountain groups and mountain ridges, separated by the deep valleys of Bear river and its numerous tributaries, but usually coalescing around the heads of these streams.

The principal mountain divisions include the long, rather even ridge separating Bear river and its tributary American creek from the Salmon; a group of mountains between American creek and the upper part of Bear river; a range of high sharp peaks known as the Cambria range[1] bordering the upper part of Bitter creek; a broken ridgy group culminating in Mt. Gladstone between the north fork of Bitter creek and Bear river, and a group of high, snow covered, rather flat topped elevations between Bitter and Glacier creeks, for the highest point of which the name Mt. Dickie[2] is proposed.

The long ridge west of Bear river has a general elevation of about 5,000 feet, but is surmounted by occasional irregularly distributed rocky peaks, some of which attain a height of over 6,000 feet. One of the most prominent of these, situated nearly opposite the mouth of Bitter creek, is known as Mt. Dolly. The sharp-crested, angular-peaked Cambria range, the wildest portion of the district, rises in places to elevation of over 8,000 feet, and Mt. Otter, the highest point, to an elevation of 8,800

---

[2] Name proposed by miners interested in the vicinity.
[3] After the President of the Portland Canal Mining Company.

feet. Mt. Gladstone, the highest point in the range bordering the upper part of Bear river on the south, has an elevation of 6,800 feet, and Mt. Dickie, between Glacier and Bitter creeks, an elevation of nearly 6,600 feet. The snow covered mountain group of which Mt. Dickie forms the centre is exceedingly precipitous on the Bitter Creek side, but falls away in easier slopes towards Bear river and Glacier creek.

The dominant features of the mountain landscape, viewed from one of the higher elevations, are the steep valley slopes, the jagged peaks of the Cambria range, and the prevalence above an elevation of 4,500 feet of vast fields of snow and ice. These either terminate in long lines of ice cliffs from which huge masses are constantly falling, or form glaciers which descend the mountain slopes for some distance, and are then replaced by roaring torrents often deeply hidden in rocky cañons.

Drainage.—The district is drained entirely by Bear river and its tributaries. Bear river is a swift mountain stream about 18 miles in length. It heads with a branch of the Nass in a glacier, which flows northward to the Pass from a peak in the Cambria range, and is then diverted by the mountains bordering the Pass on the north, westward down Bear river and eastward down a branch of the Nass. The tongue flowing down Bear river has a length of about three-fourths of a mile. The one flowing towards the Nass is reported to be somewhat longer.

The Pass is comparatively low, the elevation at the foot of the glacier, measured with the aneroid, being approximately 1,370 feet, and the ice divide at the summit, 2,100 feet.

Bear river in the lower part of its course, below Bitter creek, is a wide, winding stream, flowing rapidly in a net work of channels around gravel bars and low islands, which are being constantly built up and destroyed. The valley is a deep, steep-sided, flat-bottomed typically ice worn trough, practically a continuation of the Portland Canal depression, partially filled up with gravel and silt.

Above Bitter creek, Bear river is more confined, and its valley, while still wide, becomes more irregular. Rough benches, covered in places with moraine material, occur along the sides, and occasional rocky spurs extend part way across it. Between American creek and the summit the valley bends to the east, becomes much narrower, and at one point passes into a cañon, known as the Bear River cañon. The valley bottom above the cañon is usually from 200 to 500 yards in width, and is lined in places with low gravel terraces. A small lake, filling the valley, interrupts the course of the stream a mile below the termination of the summit glacier.

The principal tributaries of Bear river are Glacier and Bitter creeks from the east, and American creek and an unnamed stream near its head from the north.

Glacier creek is a short, rapid stream, from 20 to 50 feet in width, formed by three glacier fed branches. The trunk stream has a length of 2½ miles, and is sunk in a deep narrow cañon throughout its whole course.

Bitter creek joins Bear river 8½ miles from its mouth, and is the largest stream entering it, probably carrying more water at ordinary seasons than the main river. It has a length of 6 miles to its main source in the Great Bromley glacier, and a fall averaging 100 feet to the mile. It is a wild stream, the swift current and boulder strewn channel making it practically one long rapid. The valley is narrow, except near the mouth and in the vicinity of the North Fork, and in places is badly blocked in the early part of the season by snow slides.

Four miles above Bitter creek, Bear river bends to the east, and is joined by a large branch from the north, known as American creek, the two forks being nearly equal in size. Only the lower portion of American creek was examined. It is longer than Bear river, and is fed by numerous glaciers, one of which, about 7 miles above its mouth, crosses and blocks the valley.

A fourth large tributary joins Bear river 1½ miles below the summit glacier. It is a short stream issuing from a large glacier, and flows more water than Bear river above the junction.

Besides the large tributaries referred to, the mountain sides are furrowed everywhere by a multitude of roaring torrents cascading down the steep slopes, and few places in the district are free from the sound of falling water.

Glaciers.—The uplands of the district, except on the steep slopes, are largely covered, above an elevation of from 4,500 to 5,000 feet, with permanent fields of ice and snow. These form numerous glaciers, which fill the upper part of most of the valleys of the district and creep down the mountain slopes for varying distances; few of them reaching the main valley bottoms and most of them terminating at elevations of from 2,500 to 4,000 feet above the sea.

The largest glacier in the district is the Bromley[1] glacier, at the head of Bitter creek. This is formed by several branches, originating in large snow fields situated east of the area examined. One branch sweeping southward, skirts the base of Mt. Trevor,[1] a beautiful snow covered peak rising high above the icy plain at its base, and is reported to head with a glacier descending Marmot river. Only the lower 5 miles of the glacier were mapped. In this stretch it has a width of from 4,000 to 5,000 feet, and fills the valley of Bitter creek from side to side. The slope is irregular and averages about 700 feet to the mile. The surface, while rough in places, especially near the sides, is not badly crevassed, and the glacier is easily ascended for several miles. The Bromley glacier descends to an elevation of less than 1,000 feet, the lowest level reached by any of the glaciers of the district.

Other prominent glaciers occur on the North fork of Glacier creek, the North Fork of Bitter creek, at the head of Bear river, and at numerous points along Bear river, and American creek.

All the large glaciers are receding slowly up their valleys. This is shown by fresh moraines, both terminal and lateral, left behind in the retreat, and by the absence of vegetation for some distance below the present terminations. The Bitter Creek valley below the Bromley glacier is bare for a distance of over half a mile.

FOREST.

All the valley bottoms of the Portland Canal district are well wooded, and the forest sweeps up the mountain slopes, except where cleared away by snow slides, to heights of from 3,500 to 4,500 feet, depending on the exposure. Stunted specimens of balsam and mountain hemlock were found at an elevation of 5,000 feet.

The principal tree in the valley bottoms and lower slopes of the mountains is a hemlock (*Ptsuga mertensiana*). It is a fair-sized tree, usually attaining a diameter of from 2 to 4 feet, and furnishes excellent mining timber. The Sitka spruce (*Picea Sitchensis*), which usually accompanies the hemlock, is a tall stately tree, some specimens seen measuring fully 6 feet across. The cottonwood (*Populus Trichocarpa*) and a large alder (*Alnus Oregona*), are well represented along the flats. The yellow cedar (*Chamaecyparis nootkatensis*) occurs in a few places in the district, but no specimens of the red cedar were seen. On the higher slopes the trees mentioned above are replaced by balsam (*Abies Amabilis*), and the mountain hemlock (*Ptsuga Heterophylla*).

The forest is protected from destructive fires by the humid climate, and the timber resources are sufficient to meet the requirement of the district for many years.

FAUNA.

Only a few species of animals thrive in the district. The mountain goat is abundant in places, and it, with the black bear, the siffleur, an occasional wolf, the

[1] Name proposed by mining men interested in Bitter creek.

marten, and mink are the principal representatives of mammalian life. The heavy winter snowfall is probably responsible for the absence of the deer and other species usually common along the coast.

CLIMATE.

The situation of the Portland Canal district on the west slope of the Coast range, though some distance inland, places it within the rainy belt, and the precipitation, while not so excessive as in the outer ranges, is still very high, probably averaging well over 100 inches per year. The best weather occurs as a rule in the late spring and early summer months. The past season was exceptional in this respect, dry weather continuing well into September. The precipitation falls as rain in the valleys from early in April until near the end of October, and as snow during the rest of the year. The temperature is equable, as the summers are cool and in the winter the thermometer seldom drops much below zero.

Heavy snow slides, due to the excessive winter snowfall and the steep slopes, are common throughout the district in the late winter and spring months. These usually follow the valleys, but in places plunge directly down the mountain sides, destroying the forest in their course. At some of the mines and prospects the slides are at times a serious menace.

WATER-POWER.

Large streams with steep grades, most of them fed from permanent ice and snow fields, are available for water-power in every part of the district. At the present time only Glacier creek is being utilized, although plants at several other points are projected.

General Geology.

The rocks and rock formations represented in the Portland Canal district are classified tentatively as follows, in order of relative age:—

1. Glacial deposits.
2. Basic dykes.
3. Felsitic dykes.
4. Coast Range granitic rocks.
5. Diorites (?).
6. Nass formation (tuffs, agglomerates, etc.).
7. Bear River formation (complex series of greenstones).
8. Bitter Creek formation (dark argillites).

No fossils were found in the district, and the age of the formations is uncertain. The last three are cut by granitic rocks and felsitic dykes, and are, therefore, older than the Coast Range batholith usually referred to late Jurassic.

BITTER CREEK FORMATION.

The Bitter Creek formation consists of a series of dark argillaceous rocks, well exposed on Glacier and Bitter creeks. It is the oldest formation in the district and economically the most important.

Distribution.—The Bitter Creek slates and slaty rocks are separated from the granitic rocks of the Coast Range batholith by the Bear River greenstone formation. They appear from beneath the greenstones on Glacier creek half a mile above its mouth, and are exposed in almost continuous sections to its head, except where cut by intrusives. They cover most of the region between Glacier and Bitter creek, and extend north of Bitter creek to Mt. Gladstone, near the limit of the area examined.

Rocks.—The Bitter Creek formation is very uniform in composition, consisting almost entirely of dark and dark grey, often iron-stained argillites. On Bitter creek and other places they have a striped appearance, due to the alternation of fine-grained, dark and coarse greyish layers. They are highly altered, and in places pass into lustrous, mica schists. Slaty cleavage is well developed in some sections, while in others the principal partings follow the original bedding planes.

The argillites include at rare intervals beds of dark grey, finely crystalline limestones, and occasional thin, greyish feldspathic bands, probably tufaceous in origin.

Structure.—The Bitter Creek argillities have a northwest-southeast strike, approximately parallel to the eastern edge of the Coast Range batholith, and dip in a southwesterly direction towards it. This applies both to the original bedding where observable, and to the subsequent slaty cleavage. The dips are low along the western edge of the area, but become steeper going eastward, and in the Mt. Gladstone ridge the inclination often approaches verticality.

Faulting on a small scale was observed in places, but no evidence of great breaks or overturns affecting the whole formation was obtained.

Economic Features.—The Bitter Creek argillities are traversed by numerous quartz veins or silicified zones, usually conforming very closely to the dip and strike of the enclosing rocks. Large, persistent veins, well mineralized in places with metallic sulphides, occur south and north of Glacier creek, on Bitter creek, and in other places. The veins often parallel felsitic dykes at a short distance, and are occasionally in contact with them.

BEAR RIVER FORMATION.

This name is applied to a series of altered greenstones lying east of the granitic mass of the Coast range and apparently overlying the Bitter Creek argillites.

Distribution.—The great ridge west of Bear river is formed almost entirely of the rocks of this formation, north of the granite contact. They also cross the Bear River valley and occur on the lower slopes of the elevations east of the valley. The rocks in the group of mountains between Bear river and American creek, and in the mountains bordering Bear river above the mouth of American creek, although differing in some respects, are included in it provisionally.

Rocks.—The rocks of the Bear River formation consist mostly of greenstones, differing greatly in character and often altered into schists. They probably represent an old volcanic complex. The principal rock in the ridge west of Bear river below American creek is a massive, rather fine-grained greenstone, usually destitute of phenocrysts. It resembles a diorite in hand specimens, but has not been examined microscopically, and probably consists partly at least of altered fine-grained tuffs. Dark, hard argillaceous rocks are associated with it in a few places, and coarse, altered agglomerates, holding faintly outlined fragments, occur occasionally in the higher slopes of the Bear River ridge.

Ascending Mt. Dolly opposite the mouth of Bitter creek, the fine-grained greenstones are largely replaced above an elevation of 4,000 feet by a variety sprinkled with feldspar crystals. This porphyritic variety is often reddish in colour and is traversed by numerous small, branching, reddish veinlets, not conspicuous in the compact green variety outcropping below.

Northward along the ridge the porphyritic variety becomes more important, and descends in places nearly to the level of the valley. It is irregular in its distribution, and often alternates with and passes gradually into the even-grained green variety.

In the mountains between American creek and Bear river the same varieties are represented, but the proportion of agglomerates is increased, and bands of dark slates, and slates and limestones occur at a few points. At the south end of Bear River cañon a greenstone variety with augite phenocrysts covers a considerable area.

The rocks of the Bear River formation are altered occasionally by silicification into cherts. Large cherty areas occur north of Lydden creek at an elevation of about 4,000 feet, and on the slopes of the mountains bounding Bear river on the south above the Bear River cañon. A red coloured mountain, east of the Bromley glacier 3 miles above its termination, is formed almost entirely of cherts. The cherts here are filled with iron pyrites in grains, and the conspicuous coloration is due to their surface decomposition. The definite classification of the original rocks in this area awaits further study, as they differ in some respects both from the Bear River and Bitter Creek formations. They are dark coloured but are coarser textured than the Bitter Creek argillites, and include fragmental bands.

Structure.—The Bear River formation, although known to be partly at least of fragmental origin, is practically massive throughout. It is schistose in a few places. especially in the valleys, but bedding or banding, except where infrequent dark argillaceous bands are included, is seldom observable. The original massive, and fine and coarse fragmental constituents, have been compacted and altered by the granitic invasion and the processes of mountain building into a massive formation, often nearly homogeneous except for slight differences in texture, through sections 3,000 feet to 4,000 feet in height.

Economic Features.—The Bear River formation is well mineralized. The deposits occur frequently in the form of lenses or irregular shaped areas, often of large size. The principal mineral in these is usually pyrite, occasionally pyrrhotite. The iron sulphides are accompanied by subordinate and varying amounts of chalcopyrite, blende, and galena. The gold and silver values are often important.

Veins filled with quartz, and fissured zones with the country rock partially replaced by various sulphides are also common.

NASS FORMATION.

The Nass formation overlies the massive greenstones of the Bear River formation. It consists of red, green, grey and dark tufts, agglomerates, slates, and shales, all well bedded, with occasional massive porphyritic bands, probably representing flows. It has a limited distribution in the district, occurring only near the summit of the ridge separating Bear river and American creek from the Salmon. Two areas were seen, one of limited extent south of Lydden creek, and the other exposed only on points projecting through the snow which covers the ridge north of Lydden Creek valley. Outside the immediate Portland Canal district its areal extent must be considerable. It occurs, resting on the Bear River greenstones and dipping northwestward at a moderate angle, in the summits of the mountains north of the Bear River-Nass divide, and eastward towards the Nass; and the drift brought down by the Bromley, Bear River summit, and Salmon River glaciers, and scattered along the valleys, consists mostly of the rocks of this formation.

No mineral deposits of importance have so far been discovered in the rocks of the Nass formation in the district.

DIORITES (?).

A fine-grained greenstone, resembling a diorite in hand specimens, intrudes the slates of the Bitter Creek formation in a rounded area about 1½ miles in diameter at the head of Glacier creek. A second area, also intruding slates, was traced from the glacier at the head of the North fork of Bitter creek, southward in a generally narrowing band across Hartley gulch to the Bromley glacier.

The rocks in these areas resemble some of the greenstones of the Bear River formation, and may possibly be of the same age. They are badly altered, too much so, in the few sections examined, for specific determination, but are nowhere crushed into schists.

The Glacier Creek occurrence is cut by numerous moderate sized veins, mostly siliceous in character but occasionally containing a calcite or siderite filling. They are well mineralized in places with pyrite, galena, blende, chalcopyrite, tetrahedrite, stibnite, and other minerals. Promising veins also occur in the area east of Bitter creek, especially in the vicinity of Hartley gulch.

GRANITIC ROCKS.

The eastern edge of the Coast Range granitic batholith crosses the western angle of the district examined, and granitic rocks form the mountains bordering the lower portion of Bear river on the west. The boundary of the batholith has a general northwest southeast direction, but is irregular in detail. Near the mouth of Bear river it bends southward, forming a large spur, which crosses Bear River valley and extends for some distance into the mountains east of the valley.

Granitic outliers in the form of rounded areas and long dyke like masses are common throughout the district. A long area, over half a mile wide in places, was traced from Mt. Dickie northwesterly down the valley of Bitter creek, and across the great ridge bounding Bear river on the west to the Salmon River valley. On Goose creek, and at the head of Lydden creek, this area is represented in part by a succession of wide parallel dykes. Numerous smaller areas occur in the ridge west of Bitter creek, in the mountains between Glacier and Bitter creek, and north of the lower part of Bitter creek.

The granitic rocks vary widely in mineral composition. In the main area, the principal rock is a greyish, medium grained granodiorite, with biotite as the principal dark mineral. Two of the outlying areas are gabbroic in character, and varieties occur ranging from this basic type through quartz diorites, acid granites, and quartz porphyries, to an acid siliceous rock scarcely distinguishable in hand specimens from a quartzite. Quartz porphyries, with numerous rounded quartz grains and occasionally some feldspar phenocrysts scattered through a felsitic ground-mass, are common both in dikes and areas.

The granitic rocks, while fractured and mineralized at a few points, are not so important economically as the Bitter Creek and Bear River formation.

FELSITIC DYKES.

The grey felsitic dykes which are formed everywhere in the district cutting the Bear River, Bitter Creek, and Nass formations are generally connected with the granitic rocks, and were intruded during, or possibly in some cases immediately after the granitic invasion. They generally follow more or less closely the bedding or cleavage planes of the sedimentaries, but in places cut directly across them. They are usually large, often 30 feet or more in thickness, and traceable for long distances. On Bitter creek, especially along the southwest side of the Bromley glacier, a succession of large grey dykes, alternating with the dark argillites of the Bitter Creek formation and running nearly horizontally along the steep valley walls, forms a conspicuous feature of the landscape.

The dyke rocks are usually medium grained, and occur both in a granular and porphyritic condition. In composition they resemble the granitic batholithic rocks, but are probably more acid, as the dark ferro-magnesian minerals are seldom present in quantity. A light coloured quartz porphyry is a common variety.

The felsitic dykes are often paralleled at a short distance by mineral veins, and occasionally are in contact with them.

BASIC DYKES.

The youngest rocks in the district consist of a widespread system of dark greyish, brownish-weathering basic dykes. These cut all the older formations, up to and including the various granitic varieties. They are smaller than the felsitic dykes, seldom exceeding 6 feet in width, and are also finer grained and darker coloured. They have not been studied microscopically, but probably, judging from hand specimens, mostly belong to the diabase group.

The basic dykes are not mineralized, except by scattered grains of iron pyrite, and were intruded after the main era of mineralization. In many instances they cut directly across veins and ore bodies without noticeable effect on either themselves or the deposit intruded.

GLACIAL DEPOSITS.

Below Bitter river the accumulations of the Glacial period in Bear River valley are buried beneath alluvial gravels, silts, and sands. Above Bitter creek the main valleys are generally floored with boulder clays and loose morainic material. The deposits are very irregular in thickness, and in places have been destroyed and carried away by the rapid streams. Clay beds cover an area about a mile in length above Bitter Creek valley. They were evidently laid down in a glacial lake, formed by the extension of the Bitter Creek glacier across Bear River valley.

On the mountain slopes occasional moraines, formed during halts in the recession of the great glacier, occur up to a height of 5,000 feet, while scattered erratics were found up to an elevation of 6,000 feet.

Economic Geology.

The Portland Canal district is remarkable for the widespread character of the mineralization it has undergone. This is manifested not only by the number of concentrated metalliferous deposits of varying sizes scattered throughout the region, even though these are so numerous that practically the whole district has been staked, but also by changes in and additions to the principal rock formations themselves. Secondary iron pyrite is everywhere present, and silicification on an unusually large scale has taken place. Large areas—in one instance a whole mountain mass—have been altered by this process into hard cherty rocks.

The district is situated immediately east of the great group of granitic rocks which form the central portion of the Coast range, and its mineralization is doubtless due to this fact. During the granitic invasion, the neighbouring rocks, both sedimentary and intrusive, were intruded by dykes, crushed and broken and rendered permeable to emanations, probably mostly in the form of siliceous waters from the cooling magma. These were either originally charged with the various metals, or leached them out in their passage through the various rocks encountered and deposited them when heat and pressure lessened.

The whole district is probably underlaid in depth by granitic rocks, as dykes and stocks are numerous everywhere.

CLASSIFICATION.

The deposits of the district may be generally grouped into two classes:—

1. Veins (mostly quartz).
2. Irregular, replacement deposits.

Quartz Veins.—The quartz veins occur mostly in the Bitter Creek argillites, but in some instances were found traversing the massive Bear River greenstones. In the argillites they follow, in most cases, long zones of fissuring and crushing, often of considerable width, which while enlarging and pinching at intervals along the strike, are on the whole fairly regular. The walls are straight and well-defined in places, in others ragged and irregular. The quartz filling varies greatly in purity in different veins and along different portions of the same vein. Fragments of the broken country rock are almost invariably present in some quantity, and in places the vein consists of alternating bands of quartz and argillite, or of a brecciated mass of argillite cemented together by quartz. In some instances the line of the vein is marked only by stringers and lenses of quartz distributed irregularly through the argillites.

The veins, with few exceptions, have a general northerly trend, approximately parallel to the direction of the eastern edge of the neighbouring granitic batholith and to the strike of the enclosing argillites. The dip is usually westward towards the granite at angles varying from 20° to nearly vertical.

While most of the veins are comparatively small, usually from 2 to 4 feet in width, a number are exceedingly strong and very persistent. The most notable of these is the vein on which the Portland Canal Company's mine is situated, south of Glacier creek. This vein, while it cannot be continuously followed, as some stretches are concealed and others are inaccessible, is traceable by a succession of outcrops, some of considerable length, all following the same general direction for a distance of over 2 miles, and probably extends across Glacier creek to the Sunbeam claim, a total distance of nearly 4 miles. The quartz filling may be interrupted in places, but it is practically certain that the line of disturbance is continuous. In places several parallel veins are present. The width of the vein is commensurate with its length, ranging from 10 feet to over 60 feet, and probably averaging 20 feet in the outcrops seen. The strike of the vein is northerly, and the dip is westerly at low angles, usually about 30°.

North of Glacier creek, the O.K., Portland Wonder, George E, and other claims are situated on veins following a line of strong fissuring, traceable for over a mile. On the George E, four well-defined veins, the largest 27 feet in width, occur in the fissured zone. These veins are usually considered to be a continuation of the vein, or series of veins south of Glacier creek, but this, while probable, is not altogether certain, as the outcrops are separated by a concealed interval about half a mile in length. The dips in the veins north of Glacier creek are also somewhat steeper, and the direction is more easterly.

Other large quartz veins occur on Bitter creek south of the Bromley glacier.

The principal metallic minerals in the large quartz veins are pyrite carrying gold values, silver bearing galena, zinc blende, and occasionally notable quantities of native silver. Pyrite is always the most abundant mineral present, and in portions of the veins is often the only one. Where it occurs in masses it is usually associated with subordinate quantities of galena, and some blende.

While practically only a beginning has so far been made in the exploration of the large quartz veins, enough has been done to show that the distribution of the metallic contents is extremely irregular. The veins are seldom entirely barren, and small bunches of ore are common, but concentrations large enough and rich enough to be of commercial value are rare. One such deposit is now being worked by the Portland Canal Mining Company, and others may be discovered as exploration proceeds. Several promising portions of the veins are now being investigated.

Small and medium sized veins, that is, veins ranging from a few inches to 6 feet in width, and occasionally even wider, are very common in the Bitter Creek slates, in the dioritic area at the head of Glacier creek, and also occur, though less frequently, in the Bear River greenstones, and in the granite. Some of these veins are very persistent, one on the Middle fork of Glacier creek having been traced across three claims, and one on Hartley gulch for over 1,000 feet. Few of them have been explored sufficiently to determine their extent.

The gangue in the smaller veins is more varied than in the larger ones. Quartz is nearly always present, and a few of the veins consist entirely of that mineral. Others have calcite as the principal gangue, or a mixture of calcite and quartz, and occasionally the filling consists mostly of siderite.

The metallic content also show greater variation. In the dioritic area at the head of Glacier creek tetrahedrite in grains, bunches, and small lenses occurs in some of the veins, associated with galena, pyrite, blende, and stibnite. Lenses and stringers of nearly solid galena occur in veins at Bear River cañon, and at points east of American creek. Chalcopyrite, in bunches and lenses, usually accompanied by pyrite, blende, and galena, also occurs in a few croppings.

The small veins, like the larger ones, are, as a rule, irregularly mineralized, shoots of ore, usually short, alternating with barren or comparatively barren stretches, and the bunchy character of the mineralization has already led to some disappointments. Very few of the veins, however, have had any considerable amount of work done on them, and a large number, some with promising outcrops of good ore, still await investigation.

Replacement Deposits.—In the massive and slightly schistose greenstones of the Bear River formation, the ore deposits occur characteristically in irregular, often ill-defined masses. A number of red patches, due to the oxidation of these masses, are plainly visible from the valley in the mountain slopes bordering Bear river and American creek. The shapes are very variable, some are wide and blunt, others rounded or elliptical, and a few are elongated, resembling wide irregular veins. In some of their features these mineralized areas resemble contact metamorphic deposits, but the characteristic contact metamorphic minerals, such as garnet, epidote, augite, etc., which invariably accompany such deposits, are never present in quantity, and are usually altogether absent. Garnet, mostly in disseminated crystals, was seen at only two of the croppings visited.

The gangue in these deposits is mostly the more or less altered country rock, although some quartz is usually present, and in places there is a considerable development of this mineral. Calcite and barite also occur, but are less common.

The deposits probably always occur in connexion with lines of fissuring, or, as suggested by their irregular outlines, with broken areas, but this is not always evident. In some of them the relationship is plain, as they are bounded on one, or sometimes on both sides by fissures, and for portions of their courses, especially where the replacement is nearly complete, resemble and practically are veins. Traced farther, the space between the so-called walls becomes less well mineralized, and often passes into ordinary country rock. Transitions occur from this vein like type, through occurrences partially bounded by walls, to others wholly lacking in definite boundaries other than those afforded by the gradual disappearance of the replacing minerals.

The metallic minerals in the replacement deposits are generally similar to those in the veins, except that pyrrhotite is occasionally present in place of pyrite. The proportion of chalcopyrite is probably greater on the whole, and the proportion of galena less.

Pyrite, often carrying significant gold values, is usually the principal mineral present. The pyrrhotite is always, as far as known, low grade. The associated minerals are chalcopyrite and galena in varying quantities, and usually a little blende. The chalcopyrite at the Red Cliff ore body, the only member of this class of deposits on which much development work has been done, is distributed in grains, bunches, and interbanded with pyrite through the whole mass of the lode, and forms a considerable percentage of it. In most of the occurrences examined the copper and lead sulphides are present only in portions of the pyritized area, and in some are apparently absent altogether.

The ultimate value of these large mineralized areas cannot safely be predicted, a number of them are inviting enough to warrant exploration, while others are hopelessly low grade, on the surface at least.

Mineralogy.

The following list includes the most important minerals so far identified:—

Gold.—While no specimens containing free gold were collected by the writer, it is reported, on good grounds, to occur in a quartz vein crossing the Ruby claim now being developed by the Portland Bear River Mining Company. The vein in places assays high in gold. Free gold is also stated to occur in a yellowish quartz vein, from 4 feet to 10 feet in width, on Gold Bar No. 1 claim, south of Bitter creek, but was not positively identified.

Native Silver.—Native silver in small blebs and plates enclosed in quartz, and in thin flakes and scales along partings, occurs in places in the workings of the Portland Canal Mining Company, the Stewart Mining and Development Company, on the O.K. claim, and in other places. There is reason to believe that the silver is, partly at least, an original constituent of the ores. It often occurs in solid quartz, associated with iron and other sulphides which have undergone no change of any kind.

Iron Pyrite.—This is the most abundant mineral in the district. It occurs in some quantity, and is usually the principal mineral present in all the showings, both in the argillites and greenstones. It also occurs in grains disseminated through most of the rocks of the district. Its gold content is usually important, and in places high assays for gold have been obtained from it. The silver value is also important in places.

Pyrrhotite.—Pyrrhotite occurs in veins and large irregular masses in the greenstones, but is seldom found in veins cutting the argillites. Its tenor in gold is usually low.

Arsenopyrite.—Arsenical pyrites occurs in some of the veins, but is not common.

Chalcopyrite.—This mineral is widely distributed in the district, and at the Red Cliff mine constitutes a considerable proportion of the lode. It occurs in veins and lenses in the greenstones, in veins in the granite, and occasionally in veins cutting the argillites. Except at the Red Cliff no large body has so far been found.

Bornite.—Bornite is reported to occur on the Rangoon, a claim not examined by the writer.

Malachite and Azurite.—The copper carbonates are conspicuous in some of the deposits as stains and incrustations, but do not occur anywhere in quantity.

Galena.—Lead sulphide is one of the important minerals of the district. It is found in some quantity in most of the deposits, its usual associates being pyrite, zinc blende, and occasionally chalcopyrite. Veins or narrow lenses of nearly solid galena, a few inches in thickness, occur in the Bonanza, Independence, and a number of other claims. Most of these appear to be short.

The galena, besides its lead content, always holds appreciable values in silver. The tenor is variable, ranging from a few ounces to over 100 ounces per ton.

Sphalerite.—Zinc blende is widely distributed in the district, accompanying iron pyrite and galena. The percentage present is usually small, but in some instances, notably on the Ajax, is considerable. The discovery of workable zinc deposits is not improbable.

Stibnite.—This mineral is not common. Specimens were obtained from the Silver King claim and it is also reported to occur in the Mountain Boy.

Tetrahedrite.—This rich silver mineral, commonly known as grey copper, occurs in grains, bunches, and small lenses, in some of the veins cutting the greenstone area at the head of Glacier creek. The principal occurrences are now being investigated.

Argentite.—Argentite is reported to occur at a number of points, but was not positively identified. Specimens shown as argentite proved on examination to be thin plates of tarnished native silver.

Anthraxolite.—This dark carbonaceous mineral occurs in small quantities in a quartz vein on Bitter creek, and also on a claim in the Salmon River district.

GANGUE MINERALS.

Quartz.—Quartz is the common gangue mineral of the district, and in the slates is often the only one present. It occurs in numerous veins in all the formations of the district, and also, though less prominently, in the irregular replacement deposits characteristic of the Bear River formation. Large areas of country rock have also been silicified.

In the veins the quartz filling is often marked by long lines of interlocking crystals, and in places a concentric arrangement of the crystals around fragments of country rock, and occasionally around metallic grains is a prominent feature.

Calcite.—Coarse crystalline calcite occurs in some quantity in most of the deposits, and in a few of the smaller veins is the principal vein filling.

Siderite.—Siderite is not common as a gangue mineral, but occurs as the principal filling in a vein traversing the Silver King and Evening Sun claims on the Middle fork of Salmon creek.

Barite.—Veins of nearly pure barite a few inches in width occur on the Waratah claim, high up on the slopes of Mount Dolly. It also occurs as a gangue mineral in the Mountain Boy lode on American creek, and in other showings in the vicinity.

Garnet.—Garnet is rare in the camp, occurring, so far as known, only in small quantities on two claims, both in the Bear River greenstones.

Chlorite.—A bright green chloritic mineral is a conspicuous constituent of the veins on the George E, O.K., and other claims north of Glacier creek. It occurs in blotches and narrow bands up to half an inch in width, following lines of quartz crystals. The bands are occasionally straight for short distances, but usually follow wavy courses, and in many cases circle round fragments of slate and other impurities enclosed in the quartz vein filling.

This mineral is usually spoken of in the camp as a silver chloride, but is referred by Mr. R. A. A. Johnston, who examined a number of typical specimens collected by the writer, to the chlorite group. It appears to be an original constituent of the veins.

Chlorite, sericite, and other micaceous minerals occur largely as decomposition products in the replacement deposits of the Bear River greenstones.

Hornblende.—Secondary hornblende occurs in a few places in the deposits in the Bear River greenstone, but is not prominent.

Main Features of Some of the Principal Mines and Prospects.

CLAIMS ON GLACIER CREEK.

Portland Canal Mining Company.

This Company, under the management of Mr. W. J. Elmendorf, M.E., has been engaged for some time in exploring a group of claims near Glacier creek, and has succeeded in finding and partially outlining what is at present the most important known ore body in the camp.

Situation.—The Lucky Seven and Little Joe, the two claims most developed, are situated south of Glacier creek about 2 miles east of Bear river. The country slopes steeply up from Bear river and Glacier creek, and at the workings (lower tunnel) has an elevation of 2,453 feet above sea-level.

Geology.—The Glacier Creek basin is occupied principally by the dark coloured Bitter Creek argillites, described on a previous page. Near the mouth of the creek they are replaced by the Bear River greenstones, and between the South and North forks are intruded by an important diorite mass. The argillities are seldom contorted or crumpled except in the vicinity of the vein, and have a fairly regular westerly dip. The general strike is a few degrees west of north.

Vein.—The vein explored forms part of a long fissured and silicified zone traceable for over 2 miles, which follows the upper part of Glacier creek on the east and continues up the South branch. At the workings the fissured zone has a width in places of over 30 feet. It is irregularly silicified, and consists of quartz often filled with metallic sulphides and usually holding fragments of slate, alternating with partially silicified and unaltered slates, and brecciated slates cemented by quartz. Usually there is a persistent central quartz mass from 2 to 6 feet in width, bordered on both sides by small quartz lenses and veinlets which diminish in size and frequency outwards. The boundaries are occasionally definite walls, but similar walls often occur in the interior of the vein, and simply mark subordinate lines of fissuring. Ordinarily the limits are known only by the disappearance of the quartz. Following the strike the proportion of quartz in the vein varies greatly. The amount present is doubtless a measure of the completeness of the fissuring and shattering suffered by the slates in any particular part and the relative ease with which they were infiltrated and replaced by the ore-bearing solutions.

The dip of the vein is westerly, and is comparatively low, somewhat less than 30°. The strike is about 25° west of north. Both dip and strike conform closely to that of the enclosing argillites.

Workings.—The vein outcrops on a steep hill side, and has been opened up by three tunnels driven along the strike of the vein. The drifts wind considerably, a witness to the difficulty experienced in following the ore in the wide, gently dipping lead.

The upper or No. 1 tunnel has a length of 190 feet. It follows a practically continuous ore body for a distance of 100 feet, beyond which the sulphides which carry the values occur in a condition too disseminated to constitute commercial ore.

No. 2 tunnel is situated 110 feet easterly along the vein from No. 1, and has a length measured along its curving course of 180 feet. A narrow band of ore was followed from the portal for a distance of 30 feet. A low grade stretch of 30 feet succeeds this, beyond which good ore was encountered and followed for 60 feet. A second waste stretch 30 feet in length occurs at this point, after which ore reappears, and continues to the present breast of the tunnel, a distance of about 35 feet.

No. 3 tunnel, 170 feet northeasterly along the vein from No. 2, is much the longest of the three, but shows the least ore. It has a total length, following the bends, of nearly 500 feet. Owing to the contour of the surface, the vein outcrops considerably east of the probable extension downwards of the ore bodies found in the upper tunnels, and no ore is exposed for the first 140 feet, and no large continuous body until near the end. The last 40 feet, and the face, were in ore at the time of my visit, and the vein for some distance before reaching the ore body contains disseminated sulphides in considerable quantities. Ore also occurs in a short cross-cut to the south 150 feet from the portal, and in a second cross-cut to the east 120 feet farther on. The extent of these ore bodies is still unknown.

No. 3 tunnel is connected with No. 2 by an upraise 65 feet in length, on a slope of 45°, and an upraise from No. 2 to No. 1 was under construction when the mine was examined.

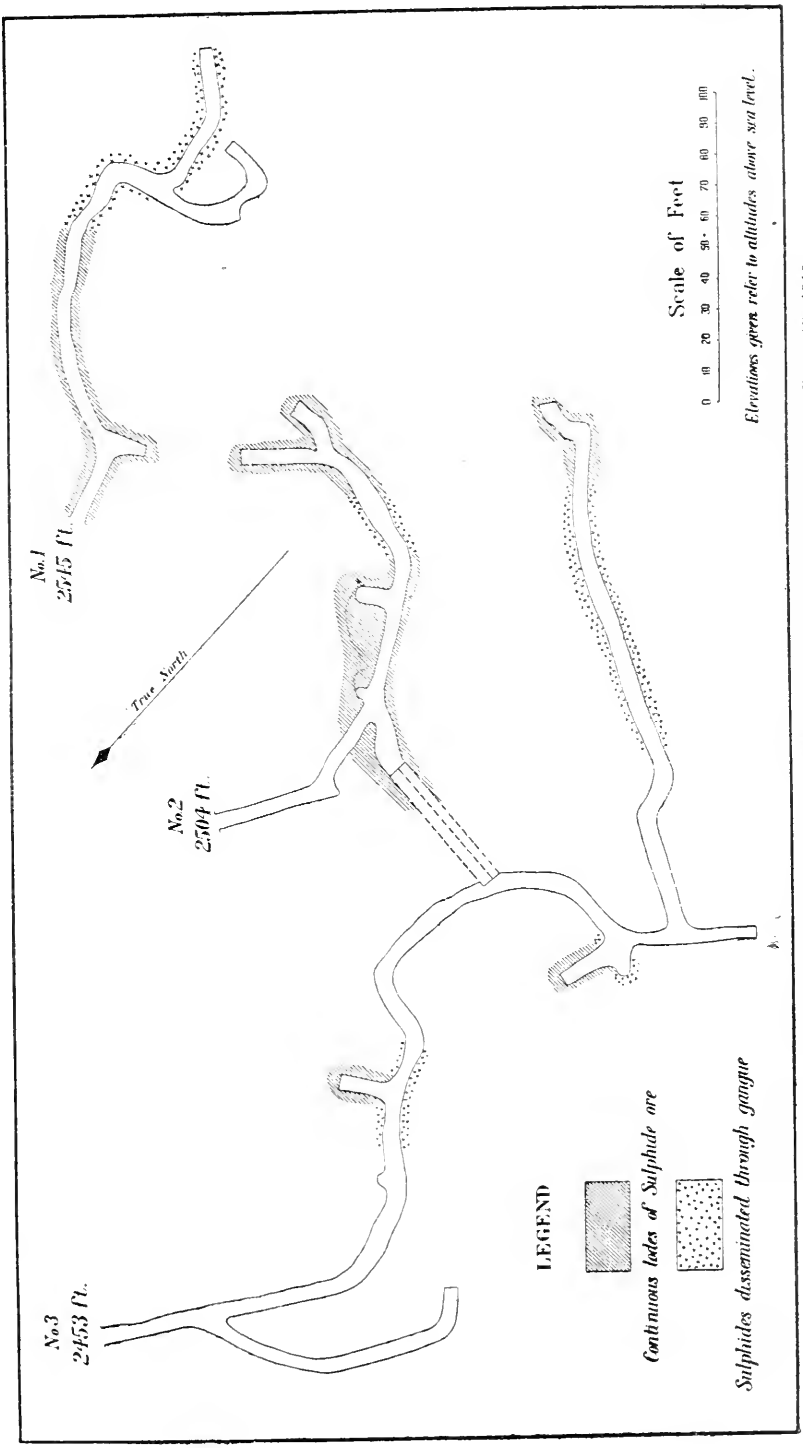


Fig. 4.—Plan of Workings of Portland Canal Mine, from Surveys by Management—Sept. 15, 1910.

Ores.—The Portland Canal ores consist mainly of auriferous pyrite, associated with varying but much smaller quantities of silver bearing galena, some blende, and in portions of the vein a little native silver, most of which appears to be primary. The galena at times is interbanded with the pyrite, but as a rule is scattered somewhat irregularly through it in grains and small bunches. The sulphides, while occasionally occurring in, almost solid masses, are usually scattered more or less densely throught a siliceous, sometimes a slaty matrix. Fragments of slates are also frequently enclosed in the ore. The values are mainly in the sulphides, and when the proportion of sulphides present drops below a certain point, difficult to estimate but probably somewhere between 10 per cent and 20 per cent, the vein ceases to be profitable.

The ore shows little oxidation and secondary minerals are uncommon.

Ore Bodies.—The ore body or bodies—as probably more than one is present—extend beyond the present development work, and are still imperfectly outlined. The ore occurs in flattened masses, usually from 2 feet to 6 feet, but occasionally 8 or 10 feet in thickness, and probably averaging about 4 feet. The masses never occupy the full width of the vein, and while fairly regular in their extension, occasionally jump along cross fissures to higher or lower positions in it.

In No. 1 tunnel a practically continuous ore body has been followed for 100 feet. The two lower tunnels enter and penetrate for some distance near their ends, what is considered, and probably is, an extension downward of the same sulphide mass. This would indicate an ore body at least 200 feet in length, following the dip of the vein, with both ends still unknown, and a known width at one point of 100 feet. Open-cuts in the croppings of the vein above No. 1 tunnel, all showing bands of ore from 2 to 4 feet in thickness, indicate an extension of the ore body, or at least of similar ores, upwards along the dip of the vein for a further minimum distance of 250 feet. The extension downward below No. 3 tunnel can only be ascertained by further development work.

In No. 2 tunnel a second important sulphide mass, 60 feet in length and over 8 feet thick in the central portion, was encountered. It is separated in the tunnel level from what may be considered the main ore body by a sparingly mineralized stretch of 30 feet, but may be connected with it above. It is exposed in the upper part of the upraise from No. 3 tunnel, but soon leaves it, as its dip is less than the slope of the raise. The two ore bodies found in cross-cuts from No. 3 tunnel, referred to above, may represent its downward extension, but the connexion has not been traced.

It is still an open question whether the various bodies of ore exposed in the workings form a continuous irregular mass with low grade patches, or consist of a number of separate ore bodies in close proximity. While many thousands of tons of ore are unquestionably present, any even approximate measurement of the amount is impossible until development work is more advanced.

Values.—The mine has been well sampled by the management and the values are fairly well known. They are in gold, silver, and lead, and usually aggregate from $11 to $12 per ton. The gold usually varies from 0·12 to 0·30 ounces, the silver from 5 to 25 ounces, and the lead from 3 per cent to 12 per cent per ton.

The following results of the sampling, selected from a large number of assays, are fairly typical of the general run of the ore:—

	Gold.	Silver.	Lead.
	oz.	ozs.	per cent.
Face of No. 2 tunnel, Sept. 4, width 5 feet	0·16	6·6	13
Slope in No. 2 tunnel, width 6 feet..	0·16	9·00	6
Face of No. 3 tunnel..	0·24	15·2	3·9
A sample of waste from No. 2 tunnel gave..	0·02	1·46	nil

The following assays by Mr. J. H. Marston, assayer for the Company, are interesting as showing the tenor of the different sulphides in the precious metals. The material used was as pure as could be obtained:—

	Gold.	Silver.
	oz.	ozs.
Blende	0·10	5·20
"	0·10	3·00
Pyrite	0·30	13·50
"	0·30	20·00
Galena	0·10	85·00

Equipment.—Preparations are now almost completed for working the mine in an economical manner. An aerial tramway, used both to bring the ore down and supplies and other material up, has been constructed from No. 3 tunnel to the valley of Bear river, where a mill to concentrate the ore and separate the lead and iron sulphides has been erected. Glacier creek near by furnishes an excellent water-power, and this is used to operate the mill, and will also be used for the electric lighting and compressor plants in course of installation at the time of my visit.

The following description of the mine equipment was kindly furnished by Mr. W. J. Elmendorf, engineer and general manager.

Portland Canal Mining Company, Limited. Head Office, Duncan, B.C.

'The concentrating mill of the Company is located at Glacier creek, about 3½ miles north from Stewart. The mine is reached by a trail about 3 miles in length from that point, and is about 2,250 feet above tide-water.

'Water-power for the operation of the mill and air compressing plant is taken from Glacier creek by a flume 3 feet by 4 feet inside measurement and about 1,100 feet in length. Water rights to the amount of 2,000 miners inches are held by the Company.

'*Concentrating Mill.*—This is advantageously located on a hill-side millsite, and has a nominal capacity of 50 tons daily. The crushing machinery consists of a Sturtevant crusher, 2 pairs of Allis-Chalmers rolls and a slow speed Lane Chilean mill. The concentrating machinery includes four 4 compartment Abeling jigs, 1 each Wilfley and Overstrom tables, and 2 suspended type Allis-Chalmers 6 foot vanners. Settling tanks are provided for the slimes. The sizing is done by three trommels of the new sprocket driven type, and a very complete system of hydraulic classifiers. Especial attention is paid to the careful sizing of the ore.

'A short conveyer belt carries the ore from the crusher to the storage bin, which in turn feeds the first set of rolls by means of a revolving feeder.

'The ore is supplied to the mill by a covered chute, and this, with the two ore bins in the mill, furnishes a storage capacity of about 400 tons.

'Power is supplied by a 6 foot and 3 foot Pelton wheel working under a head of 100 feet. The larger wheel can be used to drive all the mill machinery, but the smaller can be connected with the jigs and tables in order to ensure constant speed for these machines. Its principal use is to drive the generator for the electric lighting of all the buildings.

'The conveying, crushing, and screening machines are ample for a mill of double the present capacity, and were installed with the contingency of an increase in the concentrating machines in view. Just what these will be, and in what number, will be determined by the behaviour of the present installation.

'Large bins for the concentrates are provided, and these fill from pipes and launders, thus avoiding the handling of any of the mill products, the middlings and tailings also being distributed automatically.

'The aerial tramway which connects the mine with the mill is of the Bleichert type, and was made by the Trenton Iron Works. It is 1⅜ miles in length, and of a 17 per cent grade. About 900 pounds of ore can be loaded into each bucket, of which there are 26. A round trip is made in a little less than an hour, and the power for operation is furnished by gravity alone, the loaded buckets on one side bringing the empties and whatever mine supplies may be needed up on the other.

'The air compressor is a D-2 type Canadian Rand compound machine of 520 cubic feet free air per minute capacity. This is installed at the mill, and is direct driven by a 6 foot Pelton wheel. The air is conveyed to the mine by a 4 inch pipe line.

'An office, assay-office, and boarding house have recently been completed at a cost of about $7,000. These buildings are commodious and comfortable, a bath and many other conveniences being included in the men's quarters.

'The Company has expended more than $150,000 in development and improvements in the past two years.'

Jumbo, Ben Bolt, Etc.

The fissured, silicified zone on which the Portland Canal mine is situated extends up Glacier creek, and a number of claims, including the Jumbo, Ben Bolt, Chicago Nos. 1 and 2, and others have been located on it. These claims are now under bond to the Pacific Coast Exploration Company, and preparations are being made to explore them. A trail to the Jumbo was built during the past season, a bunk house and other buildings erected, and the Company late in the season was in a position to begin mining.

The vein on the Jumbo and Ben Bolt, the two claims at the southern end of the group, is exposed in a series of quartz cliffs, continuously traceable for a distance of 2,000 feet. The vein here is very strong, portions of it having an estimated thickness of fully 75 feet. It consists, as usual, of quartz holding fragments of slate, brecciated slates cemented by quartz, and silicified slates. Partially altered greenstone dykes, evidently apophyses from an intrusive mass which outcrops a short distance to the east, also occur in it in places.

The workings consist of some open-cuts along the base of the line of quartz cliffs.

The mineralization is irregular, and in most of the vein consists only of disseminated grains of pyrite. In a few places masses of pyrite, holding some galena and zinc blende, several feet in thickness, are exposed. The extent of these is now being investigated.

On Chicago No. 1 and No. 2 the vein, where exposed, has a thickness of from 20 to 25 feet, and is fairly well mineralized with pyrite, intermingled with a little galena. It looks promising in places, and deserves attention. The workings consist only of a short tunnel, and a couple of open-cuts.

Gipsy.

This claim is in the group owned by the Portland Canal Mining Company. It contains a vein about 3 feet in width, which is supposed to be a branch from the main zone of mineralization, but has not been actually traced into it. Its direction is nearly east and west, and the dip is southerly at an angle of 60°.

The Gipsy lead, while narrow, is traced for several hundred feet, and carries good values in places at least. The ore, mostly pyrite, galena, and blende in a quartz matrix, taken from a shaft sunk on the vein, assayed over an ounce in gold and 10 ounces in silver.

CLAIMS NORTH OF GLACIER CREEK.

O. K. Fraction.

The O. K. Fraction is situated on the western end of a fissured zone traversing the Bitter Creek argillites, traceable from Glacier creek eastward through a number of claims, and generally considered to be an extension of the Portland Canal lead. On the O. K. ground two quartz veins 60 feet apart are present, and quartz stringers occur in the country between. The main vein strikes 10° east of north, and dips to the west at angles of from 45° to 70°. In places it is a well-defined quartz vein from 2 feet to 6 feet in width, while in others the quartz is intermixed with considerable slate.

The workings, which consist of a tunnel driven along or near the lead for a distance of over 150 feet, show no commercial ore. Native silver occurs in the croppings of the vein at several points.

Little Wonder.

This claim adjoins the O. K. Fraction on the east, and is being explored by the Portland Wonder Mining Company. The fissured zone from the O. K. passes into and crosses it. The workings consist of a shaft, a cross-cut tunnel 150 feet in length to the lead, and a drift of 150 feet along it. Some sulphide ore carrying good values occurs in the shaft, and bunches were also encountered in the drift. The management intend extending the drift 300 feet farther in order to undercut a portion of the vein said to carry good gold values in the surface showing.

Stewart Mining and Development Company.

This Company owns a group of claims stretched along a continuation of the same fissured zone outcropping on the O. K. and Little Wonder. A large amount of exploratory work has been done on the George E., one of the claims in the group, and several of the others have been prospected by surface cuts.

The argillites in the vicinity of the lead are much disturbed and dip steeply to the west. They are traversed by a number of dykes belonging both to the felsitic pre-mineralization and the basic post-mineralization series. In crossing the felsitic dykes the leads become restricted, and at times are represented only by stringers of quartz.

The fissured and crushed zone on the George E. has a width of over 350 feet, and includes four well-defined and nearly parallel quartz leads, one on the western and the other three on the eastern side of a deep narrow cañon which crosses the claim. The workings are situated in the bottom of the cañon, and consist of a cross-cut tunnel to the east, which cuts the three leads on the eastern side of the cañon known as Nos. 1, 2, and 3 veins, at distances of 50 feet, 140 feet, and 300 feet, and drifts along the leads of 60 feet, 120 feet, and 200 feet respectively. No. 4 vein on the western side of the cañon outcrops in the valley, and has been drifted along for some distance.

The veins have a general direction of N 12° E, and dip to the west at angles varying from 40° on the western or No. 4 vein to 80° in the eastern or No. 3 vein. Nos. 1 and 2 veins have dips of 55° and 45° respectively.

The eastern or No. 3 vein is the largest of the group, having a width in the tunnel of 27 feet. On the surface 200 feet above, its width is reduced to 7 feet. It consists of quartz, sometimes nearly pure but usually holding fragments of or alternating with the broken country rock. Some calcite is also present. No. 1 vein has a width of about 4 feet, No. 2 of 6 feet, and No. 4 of 8 feet.

The portions of the vein explored are all lightly mineralized, mostly with iron pyrite in grains and bunches, occasionally a little galena, some blende, and native silver. Specimens often yield high assays in silver and gold, but in general samples the values are low, seldom much exceeding $4 per ton. The veins look inviting and fully warrant the expenditure incurred, even if the persevering efforts of the management have not yet been attended with success.

The Main Reef.

The Main Reef claim is situated some distance north of the Stewart group, near the junction of the argillites with the Bear River greenstones. The vein explored is narrow, in places practically a single, well-defined line of fissuring, bordered by crushed slates. It overlies a large, westerly dipping granitic dyke, which forms the foot-wall of the vein in portions of its course, and in others is separated from it by a few feet of argillite.

The vein or fissure has a general direction of N 10° E, but curves slightly along its course, and it has a westerly dip of from 30° to 50°. It has been explored by a drift for a distance of 240 feet. Near the mouth a small ore shoot up to 30 inches in width and about 40 feet in length was encountered, and light mineralization continues to the face. Near the end of the drift small bunches of galena in a calcite gangue occur in the fractured slates.

The ore consists of pyrite, galena, and blende in a calcite gangue. Four tons of picked ore, shipped, yielded:—

Gold, 0·7 ounce; silver, 20·94 ounces; lead, 23 per cent.

Several other showings on the claims have been prospected, one situated at the base of the same large felsitic dyke which underlies the main lead. This consists of 4 to 5 feet of silicified slates, mineralized with pyrite, blende, and some galena and chalcopyrite.

Tyee.

The Tyee is situated on the Main Reef trail from Bear river at an elevation of 300 feet above the valley. The argillites here are cut by a granitic stock, and the showing occurs in fractured granite. The development work consists of a shaft, filled with water at the time of my visit, and an open-cut 40 feet to the north. Three feet of shattered and partially silicified granite, holding considerable pyrite and occasional bunches of chalcopyrite, are exposed in the cut.

Silver Bow Group.

These claims are situated on the upper waters of Maude gulch, a tributary of Glacier creek. The argillites here are interbanded with altered greenstones, which are probably intrusive into them. The principal showing seen occurs in Maude gulch, at an elevation of 2,850 feet, and follows one of the greenstone bands. The lead is a strong one, the massive greenstone being fractured and irregularly silicified and mineralized for a width of 10 to 15 feet in places. Pyrite in small lenses, bands, and scattered grains is the principal mineral present. Associated with it are small quantities of blende, galena, and tetrahedrite. The lead is traceable along the creek for fully 700 feet. The workings consist of a couple of shafts, and some open-cuts.

Some work was done on this lead during the past season by the Silver Bow Mining Company under bond, but the values obtained did not come up to expectations, and the bond is reported to have been thrown up.

A galena showing on the west branch of Maude gulch was also investigated by the same Company. It occurs in argillites, and consists of a narrow vein of galena and blende, about 6 inches thick, where widest. It proved to have little permanence.

Northern Belle.

This claim is situated west of the glacier from which the North fork of Glacier creek issues, at an elevation of 3·175 feet. Only a little stripping has been done. This exposes an oxidized lead 5 to 6 feet in width, made up of quartz and slate, and mineralized with pyrite and smaller quantities of chalcopyrite. The latter often occurs in small solid masses several inches across. The lead has an east-west strike, and dips to the south at an angle of 40°. It is exposed for a distance of 50 feet.

CLAIMS IN BASIC INTRUSIVE AREA AT THE HEAD OF GLACIER CREEK.

Columbia and Evening Sun.

These two claims, one south and the other north of the Middle fork of Glacier creek, are being explored by the Lordigordy Mining Company. A vein, usually narrow, but sometimes 6 feet to 8 feet in width, striking about N 30° E, occurs in both claims, and is supposed to be continuous, but is concealed where it crosses the creek, and for some distance on either side. The vein is usually rather sparingly mineralized, but contains occasional narrow shoots, up to 8 inches in width, of rich ore made up of fine and coarse-grained galena, running high in silver, tetrahedrite, blende, and pyrite. Two of these shoots, one on the Columbia at an elevation of 450 feet above the creek, and the other on the Evening Sun at an elevation of 600 feet, are now being investigated. The vein filling consists mostly of siderite and calcspar, usually intermixed with more or less of the crushed and schistose country rock. Small shipments of high grade ore have been made from the claims.

Silver King.

This claim, owned by Andrew Nelson, adjoins the Evening Sun on the northeast, and the vein on the latter has been traced into it for a distance of 300 feet. The vein has been drifted at several points. It is irregularly mineralized, most of it sparingly, but a couple of small shoots of ore are exposed in the workings. The minerals present include galena, blende, stibnite, tetrahedrite, and pyrite. The principal gangue mineral is siderite.

Katherine Claims.

This claim is situated near the glacier at the head of the North fork of Glacier creek, at an elevation of 3,400 feet. It is one of a group owned by the Rush Portland Mining Company. A vein from 1 to 3 feet in width occurs on the claim, and has been followed by a drift 87 feet in length at the time of my visit. Open-cuts exposed the vein for a further distance of over 100 feet in a southeasterly direction, and it is also traceable from the portal of the drift northwesterly for some distance. The gangue is siliceous, and the metallic minerals present include ordinary and arsenical pyrites, galena, blende, and tetrahedrite. The principal values are in silver.

Ajax.

This claim, situated on the east side of the South fork of Glacier creek, about 700 feet above the valley bottom, is being examined by the Pacific Coast Exploration Company. An oxidized zone, striking nearly east and west, and dipping to the north, about 25 feet wide, occurs on the claim. A portion of the zone, near the hanging wall, from 5 to 6 feet in width, is well mineralized with pyrite, zinc blende, and some galena. The showing is being explored by a drift, only in 30 feet at the time of my visit.

Excelsior.

This claim was visited by Mr. Malloch, who furnishes the following description:—

The Excelsior claim is situated on the spur between the Middle and the South forks of Glacier creek, and the main showings occur within a few hundred feet of the ice field which feeds the glacier descending to the head of the South fork. Two veins occur about 100 feet apart and striking approximately north and south. The eastern vein is about 2 feet in width and is well mineralized with galena, zinc blende, and subordinate amounts of grey copper in a gangue of siderite. Specimens from the capping are reported to have assayed 300 ounces of silver to the ton. This vein dips at about 65° to the west. The second vein strikes more to the northeast and southwest than the first and the dip is nearly vertical. The maximum width observed was 18 inches. The same minerals are present, but there is rather more zinc blende and less galena. Some shallow pits had been sunk on the veins, but comparatively thick deposits of morainic material would have to be removed before the continuation of the veins for any considerable distance in either direction could be demonstrated. Numerous quartz veins were seen on this claim, striking generally east and west, but except for a few copper stains no indications of economic minerals were observed.

CLAIMS ON BITTER CREEK.

Black Bear Group.

These claims are situated southwest of the Bromley glacier, the source of Bitter creek, 2¾ miles above the snout of the glacier, and 10 miles above the mouth of Bitter creek. They were the cause of considerable excitement for a while last season, owing to the spreading of exaggerated accounts in regard to the size and richness of the leads which cross them.

The rocks along the southwest side of the Bromley glacier consist mainly of the dark grey Bitter Creek argillites. They are less altered than on Glacier creek, are often striped and include occasional tufaceous bands. They strike nearly north and south, and dip regularly to the west at angles of from 38° to 40°.

A prominent feature of the geology is the number of large greyish felsitic dykes which alternate with the dark argillites. They run nearly horizontally along the bare steep mountain slopes and look like a succession of sills. They conform, as a rule, very closely to the dip and strike of the argillites, but occasionally cut across them at a considerable angle. The series of brownish weathering, dark, basic, post-metalliferous dykes are also well represented.

The leads consist of crushed and silicified zones of various sizes up to 15 or 20 feet in width, which, like the dykes, follow closely the dip and strike of the argillites. The principal croppings occur on Gold Bluff No. 2 claim, at a height of 600 feet above the glacier, and about 3,700 feet above the sea. The lead at the point examined consists of about 15 feet of quartz and silicified argillites, holding considerable iron pyrite in places. A red zone, usually inaccessible and in places concealed by wide slides, outcrops at intervals along the mountain side, at about the same height, for a distance of half a mile or more, and probably represents the extension of the lead. A number of smaller showings occur at various other points in the vicinity, some of which are sparingly mineralized with chalcopyrite and galena in addition to the pyrite.

The pyrite in the main lead where examined is gold bearing, but the values are too low to constitute it a commercial ore under present circumstances. It is, however, only accessible at one or two points, and it is possible that in other portions of its course better values may be present. No exploratory work has been done on it. Good looking float occurs in some abundance along the foot of the slopes, but the source of this has so far not been determined.

Old Chum Group.

These claims are situated about a mile up Hartley gulch, a steep mountain torrent which joins Bitter creek from the east, three-fourths of a mile above the termination of the Bromley glacier. The principal showings occur on Old Chum No. 2 claim, and consist of three fissured and mineralized zones in a space of 130 feet, traversing slates in a direction a few degrees south of east. The centre lead is about 4 feet wide, and is made up of quartz and decomposed and reddened slates. The slates bordering it are broken and pyritized for some distance. It contains galena in grains and bunches, and iron pyrite. The pure galena carries 80 ounces in silver and $2 in gold per ton. The south lead is seamed with quartz stringers for a width of 15 feet, and mineralized with iron and a little chalcopyrite and blende. The north lead is about 6 feet wide, and minaralized chiefly with pyrite. The workings consist only of some surface cuts insufficient to indicate the extent or importance of the deposits.

L. L. and H. Group.

The claims in this group are situated on the side of Hartley gulch a short distance below the Old Chum group. The argillites here are intruded by greenstones, and are contorted and broken in places. The principal showings occur on the Union Jack and Famous claims, and consist of three nearly parallel lines of fissuring, one of which, the centre one, is traceable along the precipitous slopes which border the valley for a distance of about 1,000 feet. The width of the fissured and partially silicified and altered zone varies from a few inches to 6 feet. The mineralization is irregular, and consists mostly of iron with some arsenical pyrites. Small quantities of galena and chalcopyrite are also present in places. The pyrite carries significant gold and small silver values. A coarse-grained variety yielded $8 in gold and $1.38 in silver per ton, and better returns have been obtained from selected samples.

The upper lead has a width of over 10 feet and carries considerable galena. It has not been traced out.

The claims have only been staked recently, and with the exception of a short cross-cut tunnel into the foot-wall of the upper lead no work has been done on them.

Roosevelt.

The Roosevelt is situated on the North fork of Bitter creek near the bottom of the valley, about a mile above its junction with the main stream. The Bitter Creek argillites, which form the country rock in the vicinity, are cut and disturbed by numerous dykes referable to three periods. The oldest set is much altered, and consists of greenstones, probably of the same age as the intrusive area at the head of Glacier creek. These are cut by large greyish felsitic or granitic dykes, and later by brownish-weathering basic dykes.

The main lead occurs below one of the greenstones dyke and has been followed by a drift for a distance of 70 feet. It consists of 5 feet of broken and silicified country rock, carrying some pyrite and chalcopyrite. The mineralization diminishes towards the end of the drift. A small lens of good chalcopyrite ore has also been uncovered above the dyke. A good trail to the claim was built during the summer, and a bunk house erected, but little mining work was attempted.

Bitter Creek Mining Company.

This Company owns a group of thirteen claims situated along a small stream which enters Bitter creek from the north, immediately below the North fork. Some work has been done on the Cupron and Swede-American No. 14. The latter is situated above the timber line, at an elevation of about 4,000 feet above the sea. A lead about 12 feet wide, which occurs on it, has been drifted for a distance of 45 feet. It consists of crushed and broken argillites, often partially decomposed, seamed with numerous irregular veins of quartz and calcite. The metallic minerals present are galena, blende, and iron pyrite. The pyrite is stated to carry good silver values. The lead is a strong one and seems worth following up, although no continuous body of commercial ore is exposed in the present workings.

The Cupron showing is situated lower down the creek at an elevation of 1,650 feet above sea-level. It outcrops in the creek bottom, and is exposed for a distance of 60 feet. The lead has a thickness of about 5 feet, and consists of a broken slate gangue, with bunches and stringers of quartz and calcite, well mineralized in places with chalcopyrite, galena, and pyrite. A cross-cut tunnel to intercept the lead in depth has been started but not completed.

Gold Bar No. 1.

This claim is situated south of Bitter creek about a mile above its mouth, and at an elevation of 1,000 feet above it. It contains a quartz vein, which follows the ragged contact between a granite area and the Bear River greenstones which it intrudes. The quartz vein has a width of from 4 to 10 feet, and is stripped at intervals for a distance of 150 feet. It contains some disseminated iron pyrites, and weathers to a yellowish colour. It is stated to carry fair gold values, but no assays were seen.

A second quartz vein, or a continuation of the first, outcrops on the Blue Belle No. 1 claim 400 feet to the south.

CLAIMS IN RIDGE WEST OF BEAR RIVER AND AMERICAN CREEK.

International Portland Mining Company.

This Company owns a group of eight claims situated on the ridge west of Bear river, opposite the mouth of Bitter creek. Three of the claims, the Mammoth, Dundee, and Ben Lomond, were prospected during the summer.

The Mammoth showing, as exposed in an open-cut 500 feet above Bear river, consists of a fissured zone about 18 feet wide, cutting an argillaceous band enclosed in the Bear River greenstones. At the south wall of the zone the slates are crushed and decomposed for a width of 3 feet, and mineralized somewhat sparingly with pyrite, galena, and blende. Good values are reported from this portion of the lead near the surface. A tunnel 50 feet lower down the slope follows the same crushed zone for a distance of 40 feet. The same minerals are present, but in smaller quantities.

The Dundee showing is situated some distance north of the Mammoth, at an elevation of 850 feet above Bear river. It occurs in the same argillaceous band as the Mammoth, and consists of the broken country rock, seamed for a width of about 10 feet with small irregular quartz veins. Pyrrhotite, pyrite, blende, and a little galena are present.

The Ben Lomond is situated much higher up the mountain slope, at an elevation of about 2,300 feet above Bear river. The country rock here is the Bear River greenstones, altered in places into a light coloured schist. Irregular areas of the greenstones are heavily charged with pyrite, and bright red and yellow patches due to its oxidation are traceable along the mountain side for over half a mile. Some quartz in bunches and veins occurs in the mineralized areas, and chalcopyrite has also been found in several places, but so far not in commercial quantities. Exploratory work was commenced late in the season, and consists only of surface cuts.

Red Cliff Mining Company.

This Company owns a group of six claims and some fractions, situated along Lydden creek. This stream cuts a deep gash in the Bear River ridge west of the forks of American and Bear creeks, then bending southward, flows for some distance before joining Bear river, parallel with it and in the same valley. The mountain ridge west of the valley rises in steep cliffy slopes at an angle of fully 55°, and on the bare sides the red oxidized zones and patches which first attracted the attention of the prospectors are clearly outlined.

The country rock in the vicinity consists altogether of the Bear River greenstones, here a dark green, even-grained, massive appearing rock, without recognizable phenocrysts. It is considerably altered, and in the lower tunnel lines of schistosity have developed in places. It is cut by granitic dykes, and by later brownish-weathering basic dykes, neither of which have any evident connexion with the mineralization.

The Red Cliff claim, on which nearly all the development work has been done, is situated near the southern end of the tier of claims, and while west of Lydden creek is practically in the Bear River valley and easily accessible. The principal croppings occur near the base of the mountain, commencing 60 feet above Lydden creek and about 900 feet above sea-level, and consist of lenses of sulphide ore slightly oxidized on the surface and clearly traceable up the mountain slope for a distance of about 400 feet. The surface outcrops show two main lenses striking in a southwesterly direction, and separated by a barren stretch 100 feet in length measured along the slope. The lower lens has a width of from 5 to 25 feet, and the upper of 3 to 8 feet.

A tunnel has been driven into the lower lens, proving the ore body for a distance of about 70 feet. The full length is not known, as the tunnel bends to the right and leaves it. At the portal the ore body has a width of 5 feet, and 50 feet in, a minimum width of 15 feet, with the left wall still concealed. The drift cuts the lens 120 feet below the highest part exposed on the surface.

The upper lens has not been worked. It is narrower than the lower one, and contains a smaller proportion of chalcopyrite. Other smaller lenses occur in the vicinity.

The lenses or ore bodies are irregular in outline, and are only occasionally bounded by definite fissured walls. While probably deposited along zones of weakness, this is not evident either on the surface or in the workings. Fissures occur in their vicinity, some crossing and apparently younger than the ore body, but are not more numerous or better marked than in places showing little mineralization.

The gangue matter is mostly the altered country rock, usually silicified to some extent, and seamed in places with small irregular quartz veins. Some calcite is also present. The metallic minerals are chiefly pyrite and chalcopyrite, with a little zinc blende. The chalcopyrite occurs in grains, small solid bunches, and in narrow bands alternating with the pyrite; and both the pyrite and chalcopyrite contain varying gold, and small silver values.

About 200 tons of ore have been taken from the workings. The copper tenor of this is estimated at from 4 per cent to 5 per cent, and the total values in copper, gold, and silver at about $20 per ton.

During the past season the principal work in the Red Cliff mine consisted in driving a long tunnel designed to undercut the ore body at a depth of 280 feet below the upper workings. The tunnel passes below Lydden creek at a depth of 60 feet, and when completed will have a length of about 1,300 feet. Reports received since leaving the camp state that ore has been reached at about the estimated distance.

The mine is equipped with a 10 drill air compressor, two 60 horse-power boilers, and an electric lighting plant. A power plant on Lydden creek is projected.

A number of other showings, some seemingly important although little or no work has so far been done in them, occur in the tier of claims owned by the Red Cliff Mining Company. Ascending Lydden creek a large patch, reddened irregularly and fully 100 feet across, occurs at the top of a steep talus slope near the junction of the Red Cliff and Little Pat claims. The mineralization is more scattered than in the Red Cliff showing, and consists mostly of pyrite, with some chalcopyrite in spots. The average values are not known. Farther up Lydden Creek cañon an outcrop of ore on the Montrose claim has excited considerable interest on account of the high gold values it contains. The exposure, as seen in the cliff rising up from the valley bottom, has a length of 35 feet, and a minimum width of 15 feet, and consists of the country rock more or less completely replaced with quartz and pyrite. Some galena and copper carbonates occur along the inner wall. Assays of over $100 per ton in gold have been obtained from the pyrite in this ore body. Other wide croppings occur farther up the valley in the same line, and also on the opposite side of the cañon a short distance lower down.

Ouray and Big Casino.

Exploratory work on these claims was commenced last season by the Big Casino Mining Company. They are situated on the same mountain as the Red Cliff, but farther up Lydden creek and at a much greater elevation, the altitude at the Big Casino workings, as registered by the aneroid, being 3,140 feet above sea-level. A zigzag pack trail up the steep mountain to the showings was completed during the summer.

The Ouray showing occurs in a fissured zone, about 15 feet wide where best seen, traversing the Bear River greenstones in a southeasterly direction, and dipping to the northeast. The lead has been stripped for a distance of 200 feet. It consists of the fissured country rock, sparingly silicified and mineralized with galena, pyrite, and some chalcopyrite in scattered grains and bunches.

The Big Casino showing has a width of 35 feet, and has been stripped for 60 feet. It contains considerable quartz, and is mineralized with pyrite, chalcopyrite, and bunches of galena. A drift along the lead had just been started at the time of my visit.

Initial Group.

This is situated south of Big Casino group on the same mountain, but towards the Goose Creek slope, at an elevation of 3,135 feet. A band of granitic rocks and quartz porphyries runs northwesterly from Bitter creek up Goose creek and across to the Salmon river, and the main showing occurs near the northern junction of this with the Bear River greenstones. The showing consists of two mineralized zones, one 6 to 12 feet in width, and the other up to 25 feet in width, separated by a felsitic dyke. The leads strike N 30° W, dip towards the granitic belt, and are irregularly mineralized with pyrite, chalcopyrite, and galena. Very little work has been done on them.

Red Cliff Extension.

The Red Cliff extension is situated high up on the slopes of the mountain north of Lydden creek, at an altitude of 3,500 feet above the sea. The rocks here, as at the Red Cliff, are the Bear River greenstones. Higher up on the mountain they are overlaid by the tuffs and agglomerates of the Nass formation. The greenstones are traversed by a zone of fissuring running nearly east and west. This has been opened up by two surface cuts about 100 feet apart, and 100 feet lower down the slope an exploratory drift along the lead has been started. The lower cut exposes a small lens of good chalcopyrite ore. At the upper cut the fissured country rock is largely replaced, for a width of 12 feet, with quartz, often red and jaspery, and calcite, and carries some pyrites, and small quantities of galena and chalcopyrite.

Mountain Boy.

This claim is one of the oldest in the district, having been staked in 1902. It forms one of a group now under bond to the Pacific Coast Exploration Company, and is situated in the lower slopes of the mountain ridge, bordering American creek in the west, about 4 miles above its junction with Bear river. The rocks here, while referred to the Bear River formation, are more porphyritic than usual, and are often reddened irregularly. They are slightly schistose in places.

The showing occurs at the top of a steep talus slope, at a height of about 1,000 feet above the valley bottom and 2,200 above the sea, and is a somewhat imposing one, as the fissured and broken country rock for a width of about 25 feet is almost completely replaced by a mass of quartz, calcite, and barite, which projects along the surface in a pinnacled cliff. The lead strikes nearly east and west, and dips to the south at an angle of 50°. Traced up the steep hill it soon becomes less well defined, and the proportions of secondary minerals present gradually diminish. The extension of the lead downwards towards the valley is buried beneath slide material.

The Pacific Coast Exploration Company was occupied most of the season in the necessary preliminary work of trail building, erecting winter quarters, etc., and had not commenced actual mining at the time of my examination. The old workings consist of a tunnel about 100 feet long, which starts on the lead, but soon leaves it and then bends gradually round to the left in an effort to pick it up again. It affords little information.

The metallic minerals present consist mostly of zinc blende, galena, pyrite, and chalcopyrite distributed somewhat sparingly in grains, veinlets, and small bunches through a mixed gangue of quartz, calcite, and partially altered country rock. The deposit, as a whole, is low grade so far as explored, although fair assays, mostly in silver, are reported from portions of it. Some good ore occurs along a cross fissure which cuts the lead 75 feet above the portal of the tunnel.

Several parallel zones of mineralization, all somewhat similar to the one just described, occur in the vicinity.

CLAIMS IN MOUNTAINS BETWEEN BEAR RIVER AND AMERICAN CREEK.

Bonanza.

The Bonanza claim is situated between Bear and American creeks, about a mile above the junction, and at an elevation of 400 feet above it. The showing occurs in a band of slates enclosed in the Bear River greenstones, and consists of a narrow vein made up of brecciated slate and quartz, holding a small seam of nearly solid galena from 2 to 5 inches in thickness. The galena seam is exposed on the surface, and in a pit sunk on it for a distance of 40 feet. An open-cut, 75 feet farther north-northwest along its strike, shows the lead, but it is here less well mineralized.

The galena occurs in a coarse, cubical condition and is associated with a little chalcopyrite, blende, and pyrite. The pure galena is stated to give values of $90 in lead and silver.

Catchem.

The Catchem claim is situated east of American creek, about 2½ miles above its forks with Bear river, and the showing on it is very similar to that on the Bonanza. The country rocks consist of a band of argillites and tuffs in the Bear River greenstones. Some of the beds contain considerable lime in small lenses following the bedding planes. These weather readily, and on exposed surfaces the rock has a honeycombed appearance.

The lead or fractured zone has a width of 5 or 6 feet, and contains on the hanging wall a seam of nearly pure, mostly fine-grained galena up to 6 or 8 inches in thickness. This is followed by 2 feet of broken country rock, carrying some galena in small stringers and bunches. The workings are insufficient to define the extent of the deposit either in strike or depth. A long tunnel to undercut the lead at some depth has been started but not completed. Assays of the ore show from 45 ounces to 107 ounces in silver per ton, while one exceptional specimen is said to have run several hundred ounces.

Ruby No. 2.

This claim was not seen by the writer, but was examined by Mr. Hayes. It is situated on the Bear River slope of the ridge between Bear river and American creek, at an elevation of about 2,700 feet above the sea. The rocks in the vicinity consist mostly of the greenstone agglomerates of the Bear River formation with some included slaty bands. A quartz vein from 7 inches to 2 feet in width, and traced by surface stripping for 250 feet, occurs on the claim. The quartz contains considerable iron pyrite, and in places assays high in gold, returns of several ounces per ton having been obtained from selected specimens. The vein is now being investigated by the Portland Bear River Mining Company.

CLAIMS ON BEAR RIVER ABOVE AMERICAN CREEK.

Independence.

This claim is situated in the Bear River cañon, a constricted portion of Bear River valley, a mile and a half above the American Creek forks, and was explored during the past season under bond by the Bear River Cañon Mining Company. The showing occurs in a band of slates, tuffs, and limestones enclosed in the Bear River greenstones. These are traversed in a nearly north and south direction by a well marked line of fissuring which follows closely the strike of the rocks. The fissure has been drifted on for a distance of 140 feet. A lens of nearly solid galena, with some blende about 8 inches in thickness which outcropped on the surface, was cut through in a distance of 20 feet. A second lens, consisting mostly of blende with some galena, was encountered at 50 feet and followed for 12 feet, and beyond that the fissure proved barren. A shaft at the mouth of the tunnel followed the galena lens down to a depth of 15 feet when it disappeared.

Similar narrow lenses of galena ore, on what seems to be the same line of fissuring, occur north of Bear river on the Victor claim, but have not been investigated.

Bear River Mining Company.

This Company was engaged during the season in prospecting a group of claims situated south of Bear river, some distance above the Bear River cañon. The country rocks consist mostly of fragmental greenstones often silicified over large areas, and are referred to the Bear River formation. Reddish oxidized zones and patches, some of considerable extent, are numerous in the vicinity. One of these on the New York claim was opened up by a short drift. It consisted mostly of pyrrhotite distributed irregularly through the country rock, and associated in places with a little chalcopyrite. The mineralized mass has a width of over 30 feet. Its length was not determined. A second mineralized mass fully 30 feet wide occurs in the London claim; iron pyrite is the principal mineral present. The gangue, mostly the altered country rock, contains garnets in disseminated crystals.

Float chalcopyrite ore occurs in some quantity in the wash of a glacial stream which descends from the mountains, a short distance east of the London claim. The region at the head of the stream is exceedingly precipitous and difficult to explore, and the source of the ore has not been definitely determined.

THE SALMON RIVER DISTRICT.

Before leaving the Portland Canal district, a couple of days were spent on the Salmon river, where promising discoveries of ore were reported, in company with Mr. H. B. Williams, M.E., manager of the Salmon Glacier Mining Company, one of the companies operating there.

Transportation into this district at present is by no means easy. A rough boggy horse trail has been cut up the valley for a distance of 8 or 9 miles, from which point supplies and other materials needed are packed on men's backs to the foot of the Salmon River glacier, a distance of about 4 miles, along the glacier for several miles, then up the steep mountain side to the various camps.

Salmon river parallels Bear river on the north, the two streams being separated by a long mountain ridge, and empties into Portland canal near its head. It is a swift, branching stream, usually from 75 to 100 feet in width where confined, and a length to the glacier at its head, measured along the valley, of about 12 miles. Its grade averages 40 feet to the mile. An important tributary heading in or passing through several large lakes joins it from the east 9 miles above its mouth.

The glacier at the head of Salmon river is a large one, its width averaging over a mile. Salmon river heads with a branch of the Nass, and the glacier extends across the summit and flows for some distance down a tributary of the latter, its total length probably exceeding 12 miles. Its principal feeder is a large ice stream, which joins it almost at right angles, from the west, at the summit.

The Salmon River valley, like Bear River valley, is, in the lower 10 miles of its course, a wide, straight, flat bottomed glacial trough, partially filled with alluvial gravels, sands, and silts. Above the forks a long spur projects into the valley from the west, beyond which the flats resume and continue to the moraines at the foot of the glacier.

Rocks.—The rocks exposed along the Salmon River valley up to the foot of the glacier consist mainly of the granites and granodiorites of the Coast Range batholith. These are replaced east of a line running diagonally across the valley near the foot of the glacier by greyish green rocks, sometimes massive but usually in a more or less schistose condition, the lines of schistosity striking nearly north and south and dipping to the west. They resemble the more schistose varieties of the Bear River formation, and may represent an altered phase of that formation. A narrow band of crystalline limestone is included at one point.

A wide band of dark, almost black argillites crosses the valley of the East fork about 3 miles above its mouth. The argillites are younger looking than the greenstone schists, and apparently overlie them, but the relationship was not clear in the exposures seen.

Granitic dykes and stocks are numerous along the valley east of the main batholith, and a series of later post-metalliferous basic dykes similar to those in the Bear River valley are also well represented.

Mineralization.—The showings seen occur altogether in the greenstone schists, and consist mainly of reddish coloured oxidized zones and areas, some well-defined and with a regular trend, and others very hazy in outline. A series of these oxidized patches some 100 feet or more across, was followed along the valley, east of the glacier and at an elevation of about 1,000 feet above it, for a distance of over 2 miles, and they are reported to extend up the valley for several miles farther. Well marked lines of fissuring occasionally traverse, or partially or wholly bound the mineralized areas, and, in a few instances, they have the regularity of veins, but in most cases the boundaries are marked only by a sudden or gradual cessation of the mineralization.

The oxidation is shallow, the unaltered sulphides usually being found immediately beneath the surface.

The metallic minerals in the showings consist largely of pyrite, associated in places with galena, chalcopyrite, and blende. The principal values are in silver, gold, and lead, no large copper deposits having so far been found. The silver tenor of the galena is reported at about 50 ounces per ton, and $19 in gold per ton has been obtained from the pyrite.

The principal gangue is the altered country rock usually more or less silicified but seldom entirely replaced. Some calcite is also occasionally present.

Workings.—During the past season some exploratory work, mostly surface cuts, was done on a few claims by the Salmon River Glacier Mining Company and the Golden Crown Mining Company. The work, while too limited to afford conclusive results, has proved the existence of several ore concentrations certainly worth further exploration.

The Salmon River Glacier Mining Company hold four claims situated on a hummocky ridge bordering the Salmon River glacier on the east, at an elevation of about 1,300 feet above the glacier, and 3,400 above the sea. The showings consist of mineralized zones traversing the greenstone schists, which form the country rock in an approximately north and south direction. The zones are well mineralized and carry pay values in places, at least, but the persistence of these values along the strike and in depth still remains to be demonstrated.

Several of the zones were trenched across and sampled during the season by Mr. H. B. Williams, engineer and manager for the Company. A cut on the Martha Ellen claim sampled for 29 feet yielded, according to Mr. Williams, 0·34 ounces gold, 2·1 ounces silver, 3·6 per cent lead, and 0·2 per cent copper. A second cut in the same claim 49 feet in length, sampled for 10 feet, yielded 0·45 ounce gold, 13·8 ounces silver, 27·6 per cent lead, and 1·1 per cent copper. A cut on the Glacier claims yielded along a 10 foot stretch 0·26 ounces gold, 4·0 ounces silver, and 11·2 per cent lead. These values are about equal to those in the ores mined by the Portland Canal Mining Company.

Farther southeast along the mineralized belt are the claims, over 30 in number, held by the Golden Crown Mining Company. Some preliminary work has been done on the Rambler, Buena Vista, Province, Big Missouri, and a few others. A well-defined vein occurs on the Rambler, the filling consisting of quartz and the brecciated country rock mineralized with pyrite and some galena. On the Buena Vista a red oxidized hill top has been drifted for a distance of 36 feet. The minerals present consist of pyrite, with some galena and blende and occasional specks of chalcopyrite. A general sample along the tunnel is stated by the management to have yielded $16 per ton in gold, silver, and lead. The extent of the deposit is still unknown. At the Big Missouri, the cliffy hillside is reddened and irregularly mineralized, mostly with pyrite, for a width of several hundred feet. The face of the hill has been stripped for 100 feet and a tunnel driven in 35 feet. The tunnel passes through 8 feet of good looking ore, beyond which it penetrates oxidized and pyritized schists. The ore minerals are pyrite, chalcopyrite, galena, and blende. Veinlets and bunches of calcite, and some quartz occur in the gangue. A tunnel has been started lower down the slope to explore the deposit in depth.

The Portland No. 2 claim is situated farther down the glacier near the south-eastern end of the known mineralized belt and is being opened up by the Portland, Salmon River syndicate. A strong lead striking S 20° E, and dipping to the east at a high angle, occurs on the claim. The lead is bordered on the east by a felsitic dyke altered and sparingly mineralized near the contact, and on the west by green schists, and has a width on the surface at one point where cut across, of 14 feet. A section across the bottom of the cut shows 8 feet of nearly solid galena, followed by 6 feet of mineralized and silicified country rock passing near the dyke into nearly pure quartz. The galena, according to Mr. Williams' sampling, assays from 25 per cent to 45 per cent in lead, from 13 ounces to 16 ounces in silver, and from $1.20 to $2.10 in gold. A general sample from the silicified portion of the vein yielded $1.10 in gold, 6 ounces in silver, and 5½ per cent lead.

The galena is only exposed in the cut. It narrows above, and the workings are not sufficient to determine whether it occurs in a large bunch or short lens in the lead, or persists for some distance along it. The lead at a second cut 150 feet to the south shows little galena, but contains fair gold and silver values, a general sample yielding 0·38 ounces in gold and 3·2 ounces in silver per ton. Preparations are now being made to drift along the lead from a point 300 feet south of the main galena showing. The country falls rapidly in that direction, and the drift at the showing will have a depth of 150 feet.

TOPOGRAPHIC WORK IN THE PORTLAND CANAL DISTRICT.

NORTHERN BRITISH COLUMBIA.

(G. S. Malloch.)

Topographic work in connexion with the geological survey of the Portland Canal district, by Mr. R. G. McConnell, was begun early in June, and continued until near the end of September. Signals erected by the Canada-Alaska Boundary Commission were used as a base for a system of triangulation extended so as to control a large part of the valleys of Bear river and its tributaries. Thirteen dozen photographs were secured from the triangulation points to record the main features of the topography, and compass and telemeter surveys were run of the wagon road, trails, and some of the streams in the thickly wooded portions of the valley where their positions could not be determined by means of the photographs. An endeavour was made to fix the positions of all mines, tunnels, and important prospects, but the latter were so scattered, and their number was so large that it was found another season's work would be necessary to secure data for an adequate mining map of the district. The area in Canadian territory at the head of the Salmon river, and the valley of Marmot river, remains to be done, as well as the upper parts of the valleys of Bear river and its two principal tributaries, American and Bitter creeks. A sketch map of the district has been prepared for publication in the Summary Report. It is based on the traverses without photographic control, but it is hoped that the distances between points will prove roughly correct. The prospects are indicated by crosses, and the salient topographic features by broken contours.

The writer's thanks are due to many mine foremen and prospectors who often went to a great deal of trouble to point out prospects on their properties, and evinced a desire to help the work in any way possible.

Mr. S. D. Robinson proved an efficient and painstaking assistant.

SKEENA RIVER DISTRICT.

(W. W. Leach.)

During the past season work was confined chiefly to the vicinity of the Bulkley valley; the greater part of the time being spent in connecting up the work of past seasons—both geological and topographical—with the idea of collecting sufficient information to complete a map now under compilation. This map will include the greater part of the Bulkley valley from Hazelton to a point about 20 miles north of Aldermere, as well as parts of the adjoining country.

Great activity has been evidenced in prospecting this district, and it is hoped that, on the completion of the Grand Trunk Pacific railway, which traverses the valley, many mines, both coal and metalliferous, will be opened up.

A few days were spent in the vicinity of Kitsalas, where a hurried examination was made of some of the mineral properties there.

Every facility for the examination of the various properties was extended to the writer by the respective managers and owners.

Field work was carried on from the end of May until the end of September. It consisted chiefly of more or less detailed examinations of the most important properties, and an attempt to correlate the geological features of the various isolated districts examined in previous years.

The main topographical work done was the connecting up of the transit triangulation of past seasons, and this again with the British Columbia land surveys and the railway survey. The triangulation was supplemented by panoramic sketches from all stations occupied. Pace and compass traverses were run on practically all the travelled trails in the district.

Material aid in the work was rendered by Mr. S. E. Slipper, who acted as assistant.

LOCATION AND AREA.

The Bulkley river is the most important tributary of the Skeena, entering that river from the southeast about 150 miles from its mouth. The town of Hazelton, the present commercial headquarters of the district, is situated at the junction of the two rivers, at the head of river navigation of the Skeena, which is carried on with considerable difficulty by a number of small stern-wheel steamboats. From Hazelton, a fair wagon road extends up the Bulkley valley to Aldermere (56 miles) and beyond, from which many trails branch off on either side. The area under examination includes the valley of the Bulkley for a distance of about 75 miles from its mouth, and extends back from the river for from 15 to 35 miles on both sides.

The village of Kitsalas is situated at the foot of the cañon of the same name, on the Skeena river about 60 miles below Hazelton.

PREVIOUS WORK.

Dr. Dawson in his report on 'An Exploration from Port Simpson to Edmonton' (Report of Progress 1879-80) briefly reviewed the geology of part of this district; while Mr. Wm. Fleet Robertson, Provincial Mineralogist for British Columbia, visited the mineral properties of the Telkwa in 1905 (Report of Minister of Mines for British Columbia, for 1905). Apart from these reports, nothing has been written concerning the geology of this country with the exception of the summary reports, 1906-1909, and the preliminary report on Telkwa river and vicinity by the writer.

SUMMARY AND CONCLUSIONS.

In general, the geology of the new districts visited this year, shows little variation from that of the neighbouring localities described in previous summary reports.

Rocks of the Hazelton (Porphyrite) group in all cases predominate in areal distribution, while a number of new areas (in most cases small) of the Bulkley eruptives were noted. Only one new area of the coal-bearing Skeena series was examined; it contains a number of coal seams; but it is doubtful if their quality is sufficiently good or the seams large enough to permit of coal-mining on a commercial scale.

A small area of Tertiary sediments was noted on Driftwood creek, being the first occurrence of these rocks seen in the district. They contain seams of lignitic coal which have been prospected to a certain extent during the past season; the results obtained, however, do not give much promise that they will be of value.

A number of coal claims have been staked, and a little work done on some black carbonaceous shales, containing streaks of coal, which occur low down in the Hazelton group, and outcrop at intervals for 30 miles along the lower reaches of the Bulkley river. It seems highly improbable that workable coal seams will be found in these shales.

As noted in previous reports the chief mineral deposits occur near the contact between rocks of the Hazelton group and the Bulkley eruptives, either in, or alongside of dykes from the latter, in fissures around the peripheries of the intrusive masses, or in sheared and crushed zones in the eruptives themselves. It seems clear, therefore, that it is in the immediate vicinity of these intrusive rocks that prospecting should be most thoroughly carried on.

Few new discoveries of note were examined during the past season, but prospectors are penetrating farther into the mountains every year, and vague reports were heard of the finding of new mineral bearing localities; notably on the Rochers Déboulés mountains, the headwaters of the Suskwa river, and Babine lake.

The silver-lead claims on Ninemile and Fourmile mountains, near Hazelton, were the centre of activity of the district, the various properties being energetically prospected and some development work being done.

A trial shipment of about 5 tons of ore was made from the Lead King, while the Silver Cup and Sunrise mines had jointly about 15 tons sacked and ready for shipment.

GENERAL CHARACTER OF THE DISTRICT.

The country is on the whole mountainous, although it is intersected by many comparatively wide and fertile valleys: such as those of the Bulkley, Kispiox river, and parts of the Skeena river and of Babine lake. The greater part of the district examined is drained by the Bulkley river, the largest tributary to the Skeena, which ocupies a wide valley with many open or slightly timbered areas, which are rapidly being settled. To the south and west, the watershed between the Bulkley and the Kitseguecla and Zymoetz rivers consists of the Rochers Déboulés mountains and the Hudson Bay mountains respectively; both of these are large isolated blocks of mountains, reaching elevations of from 7,500 to 8,000 feet, and are cut off on all sides by low valleys.

To the east and north, the Babine range divides the waters of the Bulkley from those of Babine lake. This range reaches its greatest height to the northeast of Hazelton, the highest peaks attaining elevations of 8,000 feet. About 10 miles above Hazelton the Suskwa river enters from the east, taking its rise in a comparatively low pass (3,500 feet). Southeast of the Suskwa the Babine range reaches heights of from 6,000 to 7,000 feet; until in the neighbourhood of Moricetown (30 miles from Hazelton), a region of much lower timbered ridges is met with, gradually rising again to culminate in a group of high, rugged peaks, in which head Twobridge, Driftwood, and Cañon creeks—the chief tributaries of the Bulkley from the east—north of the Suskwa. From this point southeast the range gradually diminishes both in height and width.

The valleys of the Skeena and the Bulkley, and of the lower portions of the Suskwa and Telkwa rivers are, for the most part, terraced, and the rivers have in many cases cut through the ancient valley floors forming secondary, deep, cañon-like channels. This is particularly noticeable on the Bulkley, which flows in a cañon for nearly 30 miles from its mouth, with a total fall of about 1,000 feet in this distance.

The country is, on the whole, well wooded, the principal trees being spruce, poplar, jack-pine, balsam, and birch with a little hemlock and cedar.

General Geology.

TABLE OF FORMATIONS.

1. Quaternary.............Glacial deposits.
2. Tertiary................. Sandstone, conglomerate, (Oligocene?) shale and coal.
3. Tertiary?............... Bulkley eruptives.
4. Lower Cretaceous........ Skeena series (coal-bearing).
5. Jurassic................. Hazelton group.

DESCRIPTION OF FORMATIONS.

Hazelton Group.—These rocks were originally named by Dr. Dawson the 'Porphyrite Group'; but this name was abandoned last year as being somewhat misleading. Where originally met with by Dr. Dawson, in the François Lake district and on the Skeena near Kitselas, they consisted almost exclusively of porphyrites; whereas in the vicinity of Hazelton, tuffs, sandstones, and shales, are extensively developed.

Generally speaking, it may be said that to the south, this formation is built up almost entirely of flow rocks, chiefly andesites, massive, and with characteristic dark red and green colours. At the top of the series, a few thin beds of fossiliferous sandstones and shales appear, a number of fossils from which have been determined to be of Jurassic or early Cretaceous age. These are overlain directly by the coal-bearing Skeena series, so that in the Telkwa River district little difficulty was encountered in separating these two formations in the field. On travelling northwards, however, it was found that these flows gradually thinned out, and were replaced by a considerable thickness of tuffs and tufaceous sandstones, although a few of the andesite beds extended as far north as Hazelton. Locally, these tufaceous beds are known as sandstones, and where altered near the contact with intrusive masses, as quartzites. A number of thin sections of these rocks were examined microscopically by Dr. G. A. Young, and in all cases were found to be of volcanic origin.

The best section available of these tufaceous rocks is to be found in the cañon of the Bulkley, from Hazelton to Moricetown, where, although the strata are highly folded and faulted, it is hoped that a fair estimate of their minimum thickness may be obtained.

Well down in the series, and intercalated with beds of purely volcanic material, a series of sediments occur which do not exceed 150 feet in thickness, but which are of importance, inasmuch as several beds of black carbonaceous shale, with thin streaks of coal contained therein, have been mistaken for coal, and many coal claims located on them. From the evidence on hand it seems improbable that workable coal seams occur in these shales. Typical exposures of these rocks can be seen in the Bulkley cañon near the mouth of Mud creek, and about 2 miles above the mouth of Boulder creek. A few fossils were collected from these beds, but they were so imperfectly preserved that it was found impossible to identify them. The similarity of these sediments to those of the coal-bearing Skeena series, and the great amount of disturbance that the strata have been subjected to, entails very careful study before an opinion can be expressed as to the horizon of any given outcrop.

In the Babine range, at the headwaters of Driftwood cañon, and Twobridge creeks, the rocks of the Hazelton group consist chiefly of dark reddish, and greenish andesites, very similar to those seen on the Telkwa river, with this difference, however, that in the Babine they show, nearly everywhere, a certain amount of schistosity, whereas on the Telkwa they are always massive. This schistosity is also very apparent on the Bulkley river, in the neighbourhood of the mouth of Twobridge creek.

Roughly speaking, rocks of the Hazelton group underlie about four-fifths of the area under consideration, and, with the exception of the above mentioned shales and sandstones, are, as a rule, readily distinguishable from the other formations present.

From the Morice river northward to the vicinity of Moricetown they consist almost entirely of thick beds of massive, fine-grained andesites (usually either dark red or green in colour), but with some beds of tuff. From Moricetown to Hazelton the tufaceous beds predominate; which are generally rather fine-grained, and hard, and show well-defined bedding. They are usually light in colour with prevailing greenish tints.

Skeena Series.—This series is of great economic importance, inasmuch as all the known coal of commercial value is contained therein. The strata consist essentially of rather soft, thin-bedded shales and sandstones, the former, in places, carrying many clay-ironstone nodules and holding a number of coal seams. At the base of the series there is usually found a bed of coarse, crumbly conglomerate, but this, though fairly persistent, is not always present.

Owing to the disconnected nature of the exposures and the seeming lack of continuity of the beds, a complete section of these rocks has never been obtained. It seems probable, however, that their total maximum thickness is in the neighbourhood of from 600 feet to 800 feet. A number of fossils (chiefly plants) collected at various times, have been determined by Mr. Lawrence Lambe and Mr. W. J. Wilson, and show the age of these beds to be lower Cretaceous, and about equivalent to the Kootenay series of the Crowsnest pass.

The Skeena series is apparently conformable with the Hazelton group, and the line between them must be rather arbitrarily drawn, the coarse conglomerate already mentioned being regarded as the base of the Skeena series.

These beds occur in a number of comparatively small patches in various widely-separated localities, being folded in with the harder, underlying volcanics. These small isolated areas seem to be remnants of one or more large fields, which, owing to favourable circumstances, have escaped denudation. It is only in the valleys and low country that these rocks are now to be found, erosion having completely removed them from the higher ridges and mountains. The most important coal-bearing areas are situated on the Telkwa river and the headwaters of the Morice, which have been described in previous reports. Other important localities where they have been noted are on the Shegunia and Kispiox rivers. The only new area examined this season is situated on the Bulkley river near the mouth of Boulder creek, about 21 miles above Hazelton, where the beds occur in the form of a shallow, synclinal basin, with a number of minor undulations, the river cutting across it diagonally. The greatest width of this trough is probably not more than 1½ miles, with a length of about 4½ miles. The only outcrops occur in the banks of the river so that it is a matter of some difficulty to define the boundaries definitely. To the north the coal-bearing beds are cut off by a granitic intrusion, while at the southern extremity there is a faulted contact with rocks of the Hazelton group. A number of small coal seams have been uncovered here and a little prospecting has been undertaken.

Bulkley Eruptives.—These rocks, consisting chiefly of granodiorites and diorite porphyrites, have evidently played an important part in the deposition of the various mineral deposits in the district, since it is in the immediate neighbourhood of these intrusive masses that all the principal ore bodies have been discovered.

Numerous areas of these eruptive rocks are found at various points in the district, almost invariably accompanied by more or less mineralization near their contacts with the intruded volcanics. Among others examined during the past season is a comparitively small but important area situated on the headwaters of Tuchi river: a stream rising in the Babine mountains, and following easterly to Babine lake. It is near and along the contact of this granitic mass with tufaceous rocks and argillites of the Hazelton group that the claims of the Babine Bonanza Mining and Milling Company, as well as many others, are situated. Other important areas occur on the Bulkley river near Gramaphone creek, in the Babine mountains at the head of Sharp creek, and in the Rochers Déboulés mountains at the head of Boulder and Porphyry creeks; as well as the areas mentioned in previous summary reports on the Telkwa river, and on Ninemile, Sixmile, and Twentymile mountains. The rocks of this group vary greatly in texture and appearance, but are, as a rule, rather coarse grained, porphyritic, and grey in colour, although in a few localities pink colours prevail.

Nothing definite is known of the age of these rocks except that they are younger than the Skeena series; dykes from them cutting the coal measures at a number of places. They are here provisionally classified as Tertiary.

Tertiary Sediments.—On Driftwood creek (which enters the Bulkley about 45 miles above Hazelton), 2 or 3 miles above the Hazelton-Aldermere road crossing, a small area of soft conglomerates, sandstones, and shales occurs. Some of these beds contain many plant impressions, often well preserved, a number of which have been identified by Mr. W. J. Wilson as 'clearly belonging to the Tertiary formation, and being very common in the Oligocene.'

A number of seams of lignitic coal have been found in these beds, but where stripped, they are so banded with shales that it seems unlikely that they can be profitably mined.

The country in this neighbourhood being very heavily drift-covered, it was found impossible to trace the boundaries of this basin with any degree of accuracy, but its total extent is probably not more than 4 by 2 miles. The strata are usually very soft and readily-weathering, and the sandstones and conglomerates are very light in colour. In places, along Driftwood creek, the coal has evidently been burned, with the result that the clay shale, interbedded with the coal, has been baked to a hard, white, brick-like material, although at times very finely laminated.

Though unconformable with the underlying volcanics, these beds have been very highly flexed and faulted in places, although where the coal seams have been prospected the strata are nearly horizontal.

Economic Geology.

The Bulkley eruptives appear to have been the main factor in the deposition of mineral deposits in this district. All the important mineral-bearing localities are situated near the contact of these eruptives with rocks of the Hazelton group, either in or alongside of dykes radiating from the main masses, in fissures in the volcanics near the contact, or in sheared zones in the intrusive rocks themselves.

The coal seams have also been affected to a considerable degree by these rocks, as the quality of the coal appears to depend to a great extent on contiguity to these eruptive areas, becoming more anthracitic in character as they are approached. The seams have also, in places, been cut by dykes, often accompanied by faulting which will undoubtedly complicate future mining operations.

GROUPS OF DEPOSITS.

The copper and copper-silver deposits of the Telkwa river and the silver-lead properties of Hudson Bay mountain, have been briefly described in previous summary reports, and no new information is at hand this year in regard to them.

Prospecting has been actively carried on at the various silver-lead properties on Ninemile and Fourmile mountains, near Hazelton. It is expected that when adequate transportation facilities are obtainable on the completion of the Grand Trunk Pacific railway from Prince Rupert to this district, that several properties will be in a position to commence ore shipments.

Prospectors have been energetically at work in the Babine and Rochers Déboules mountains, and about the head of Suskwa river and Babine lake, as well as in many other localities, but nothing definite is yet known as to the results obtained.

Coal prospecting has been carried on with much activity, during the whole season, from the Morice river to the Kispiox valley, and many new locations have been made.

DESCRIPTION OF PROSPECTS.

The Babine-Bonanza Mining and Milling Co.—This property (better known as Cronin's mine) is situated in the Babine mountains near the headwaters of a branch of Tuchi river, a tributary of Babine lake, and not far from the sources of Driftwood creek. The locality is somewhat difficult of access by the present trail up Driftwood creek, as the summit at the head of that stream is high and rugged and passable with loaded pack animals only for a short season. It is expected, however, that a more favourable route, with no adverse grades, can be found by way of the Tuchi river and Babine lake.

The ore occurs at or near the contact of an area of pinkish granite porphyry, with a series of altered black argillites and tuffs of the Hazelton group. Along the contact the porphyry is much decomposed, and nearly everywhere more or less mineralized. It would appear that there are two classes of ore deposits on this property; the first, on which most of the work has been done, occurring in a sheared zone in the porphyry, and the second along the contact where the porphyry has in part been replaced by secondary minerals.

The ore consists essentially of crystalline galena and zinc blende in a gangue of quartz and brecciated porphyry; it also contains small quantities of iron, copper, and arsenical pyrites. No information is available as to the values contained in the ore.

The principal work done is a tunnel, driven along a sheared zone in the granite porphyry, with the intention of cutting an ore shoot exposed on the surface at the top of the hill, about 250 feet above the level of the tunnel. What is probably the continuation of this ore shoot, was cut about 350 feet from the entry, and showed 3·4 feet of good ore, consisting of galena and zinc blende in a quartz gangue, striking N 65 E, and dipping about 70° NW. A short way beyond this point the ore is cut off by faulting, the tunnel having been driven in barren ground a further distance of about 125 feet, and a cross-cut driven to the southeast for about 115 feet, without finding the ore. An upraise was driven on the ore for about 30 feet, where the vein was again found to be faulted.

On the surface a considerable amount of prospecting work has been done, consisting of open-cuts and several small shafts. An incline shaft sunk on the dip of the vein, in what is probably the same shoot as that found in the tunnel, shows about 3 feet of ore, but the vein is somewhat irregular. The whole width of the vein is fairly heavily mineralized with galena and zinc blende in a gangue of quartz and altered country rock, both walls consisting of granite-porphyry, and the foot-wall being heavily slickensided. The shaft is about 40 feet deep on the dip of the vein, which here is about 60° north.

About 450 feet to the southwest a vertical shaft has been sunk to a depth of about 20 feet. Although within a few feet of the contact, this shaft is entirely in the porphyry, and shows about 2 feet of ore: consisting of galena, pyrites, arsenopyrites, and much zinc blende, in a gangue of brecciated porphyry and quartz. Alongside of this shaft and adjoining it a slope has been sunk on the contact between the granite-porphyry and the black argillites, the foot-wall being porphyry and the hanging wall argillite. The dip is here 70°, and the ore about 4½ feet wide and similar to that in the shaft. This slope is about 28 feet deep on the dip of the ore.

It does not seem probable that the ore body here has any connexion with that found in the tunnel, but is rather a separate contact deposit. Continuing in a southwesterly direction along the contact, a number of open-cuts and shallow shafts show ore more or less continuously for a distance of about 1,500 feet.

Ste. Anne and St. Eugene Mineral Claims.—These claims, the property of John McKendrick and partners, are situated in the Babine mountains near the headwaters of Cañon creek, but on the Babine Lake side of the divide, and at an elevation of about 5,000 feet above sea-level.

The ore occurs in a well defined vein in an intrusive area of what is probably a granodiorite, but which has not yet been microscopically examined. These granitic rocks cut the volcanics of the Hazelton group, and consist chiefly of green and red andesites and breccias. The vein occurs near the contact of the two formations.

The ore consists of white and rusty quartz, with tetrahedrite and galena, which occur, as a rule, more or less concentrated in bands parallel to the walls of the vein. The writer was unable to obtain any definite information in regard to the assay value of the ore.

With the exception of a few open-cuts, the only development work done on this property consists of a tunnel 50 feet in length, driven on the vein, which, in the face of the tunnel, has a width of 4·4 feet.

Last Chance and Little Wonder Claims.—Last Chance and Little Wonder mineral claims, owned by Brewer Bros., are situated at the head of the south fork of Boulder creek, a stream which flows into the Bulkley river about 21 miles above Hazelton. An important area of granitic rocks occurs in this neighbourhood, extending southwards to the north fork of Moricetown-Twomile creek, and northwards to the head of Mud creek; cutting the red and green andesites of the Hazelton group.

The claims are located in the granitic rocks, but quite close to their contact with the volcanics, the mineral being deposited along a crushed and sheared zone. The only work seen consisted of a couple of open-cuts which exposed about 16 feet of ore consisting of pyrites, a considerable admixture of tennantite, and some chalcopyrite, in a gangue composed of quartz and decomposed granitic country rock. Many small seams and lenses of quartz are in evidence, usually in bands parallel to the walls, and frequently showing comb structure with many exceptionally large quartz crystals developed. The walls are not clearly defined, but merge gradually into the granitic wall rock, which is much decomposed for some distance on each side of the ore body.

The strike of the lode is about southwest and the dip 45° northwest.

The writer was unable to obtain any information in regard to the values contained in this ore.

Silver Cup Mines Limited.—A brief description of the claims of this Company, which are situated on Ninemile mountain, near Hazelton, was given in the Summary Report of 1909. Since then, a considerable amount of work has been done on the property, and about 15 tons of ore sacked, ready for shipment for a smelter test.

Three tunnels have been driven, in each case on the vein, which show a total difference in elevation of at least 1,000 feet. The upper tunnel is about 200 feet in length and shows some ore all the way, while the second tunnel, about 150 feet below the first, has been driven a distance of 65 feet in ore averaging about 2½ feet in width.

The lower tunnel had only been started at the time of the writer's visit, and had not at that time reached solid rock.

Sunrise Group.—This group, situated on Ninemile mountain, was also described in last year's Summary Report, and since then has been actively prospected. The main vein occurs in a granitic (granodiorite) intrusion; the ore, consisting of galena with a little stibnite and zinc blende, being deposited in a sheared zone. The vein has been stripped for about 150 feet on a very steep hillside and shows about 3 feet of quartz, and disseminated galena, and from 6 to 15 inches of solid galena. The sheared zone containing the ore is from 10 to 25 feet in width, and is generally more or less mineralized; and it is possible that part of it at least will prove of shipping quality.

A short tunnel was being driven to cut the vein below the lower end of the stripping, but at the time of the writer's visit had not yet reached the ore, in a distance of 30 feet.

About 16 tons of picked ore was sacked and ready for shipment before the close of navigation on the Skeena.

Silver Pick Group.—This group of three claims is also situated on Ninemile mountain, to the east of the Sunrise group. The ore occurs in a number of roughly parallel veins, in highly altered tufaceous rocks of the Hazelton group, and near their contact with the main granitic intrusion of Ninemile mountain. It appears probable that the ore deposition has taken place along the bedding planes of the tuffs, the original country rock having been replaced in part by quartz and ore. With the exception of a little surface stripping, no work has been done on these claims. Four veins, varying from 2 feet to 3 feet in width, have been exposed, all of which are very similar in appearance, the ore consisting of disseminated galena with a little zinc blende and stibnite in a quartzose gangue. The writer was informed that a number of assays obtained by the owners showed returns of from $19 to $125 in combined silver and lead values.

COAL.

Morice River Areas.—On the Morice River waters three known areas of coal lands, situated respectively on the main Morice, on the Clarkford and on Goldstream (a tributary to the latter), have been energetically prospected by Messrs. Jefferson and Dockrill. These areas have been described in previous reports. Two diamond drills, one operated by hand power and the other by steam, were in service most of the season; unfortunately a forest fire damaged the larger machine, necessitating, for some time, a cessation of operations.

The writer was unable to get any details of the results attained, but was assured by Mr. Dockrill that in the Goldstream basin a large area of excellent coal had been proved.

Grand Trunk Pacific Railway Company's Coal Lands.—Considerable prospecting has been carried on by this Company during the past season on their coal locations situated on the Telkwa river and its tributaries, Mud and Goat creeks.

A number of short tunnels were run on the seams outcropping on Mud creek. The first of these (No. 1) was driven near the northeastern edge of the synclinal trough in which the coal measures lie. At the point of entry, on the southeast bank of Mud creek, the seam was nearly horizontal, but on driving, it was found to have a light southwesterly dip which, at 118 feet from the entry, brought the coal to the surface again. The seam is 3·9 feet in thickness, and is overlaid by 3 feet of shale followed by 3 feet of coal. The lower bench appeared to be good, clean, firm coal, and an average sample taken from near the face of the tunnel gave the following analysis:—

	Per Cent.
Moisture	2·35
Volatile combustible matter	27·72
Fixed carbon	60·65
Ash	9·28

Coke firm and coherent.

No. 2 tunnel, also driven from the southeast bank of Mud creek, but about 400 yards above No. 1 tunnel, opened up a 4 foot seam of coal for a distance of 140 feet. The coal here, however, is rather severely disturbed and much crushed.

On Goat creek an attempt was made to sink a slope on a 9 foot seam of what appears at the surface to be good, clean coal. The slope was started near the level of the creek, but had to be abandoned on account of flooding.

Two diamond drills had been ordered by this Company, but up to the middle of September had not started operations, although at that time it was hoped to begin work within a few days.

The Ashman Coal Mines Limited.—This Company holds twelve sections of land as local locations on the Bulkley river between Boulder creek and Moricetown-Two-mile creek. This area is underlaid by rocks of the Hazelton group, consisting chiefly of tufaceous sandstones, tuffs, and some andesitic flows. There are, however, several beds of shaly sandstones and carbonaceous shales with thin irregular streaks of coal, and it is due to the presence of an 11 foot bed of carbonaceous shale and its resemblance to coal that these lands were located. The bed in question outcrops in the deep, cañon-like channel of the Bulkley, near the mouth of Swamp creek (a small tributary of the Bulkley entering that stream about 23 miles above Hazelton), where it strikes S 18° W with a dip of 60° NW. It is about 11 feet in thickness, has been stripped at several places, and a short tunnel driven on it from near the level of the river. The following analyses, by the Mines Branch, Department of Mines, from average samples taken at different times, will show that this can hardly be classed as a true coal; but rather as a carbonaceous shale:—

—	No. 1.	No. 2.	No. 3.
Moisture	1·91	1·73	2·04
Volatile combustible matter	10·79	12·38	10·40
Fixed carbon	20·50	37·98	23·86
Ash	66·80	47·91	63·70

All the rocks of the Hazelton group, from this point to Moricetown, are much folded, and many faults may be seen.

The Grand Trunk British Columbia Coal Company, Limited.—The property of this Company, consisting of twelve claims, is situated on the Bulkley river about 20 miles above Hazelton. The coal beds of the Skeena series are here found in a rather shallow but fairly regular basin, with a total length of about 4½ miles, and a maximum width of probably not more than 1½ miles.

A number of small coal seams were stripped some years ago at the northwestern extremity of the basin, when a total of eleven seams were uncovered, ranging from 12 to 40 inches in thickness, and included in about 500 feet of sandstones and shales. The following analyses from two of the best looking of these seams proved disappointing, the percentage of ash being very high:—

	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
No. 1—15 inch seam	1·02	25·70	52·96	20·32
No. 2—18 inch seam	1·39	25·56	50·06	22·99

Coke in both cases firm and coherent.

Near the centre of the basin the Company has stripped six seams, varying from 12 to 38 inches in thickness, and probably representing in part the above-mentioned seams. The strata at this point are very regular, the strike being S 40° E, and the dip 30° to the northeast.

The following analyses, by the Mines Branch, of samples from three different seams, show an unduly high percentage of ash:—

	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
No. 1—20 inch seam	1·12	23·70	51·72	23.46
No. 2—38 inch seam	2·15	22·03	43·66	32·16
No. 3—20 inch seam	1·36	25·18	55·41	18 05

Coke in Nos. 1 and 2 firm and coherent.

Coke in No. 3 coherent, but tender.

This coal differs considerably in appearance from that of the Telkwa river. It is very hard, is finely laminated, and shows a very distinct cleavage at right angles to the bedding planes.

Driftwood Creek Coal.—This area of coal bearing rocks has been known for a number of years, but it was during the past season only that any claims have been located thereon. The coal seams occur in a comparatively small patch of Tertiary sediments—probably not more than 4 by 2 miles in extent—although its boundaries have not been closely defined: On part of the area the coal has been burned, baking the interbedded clay shales to a whitish brick-like material.

The Tertiary rocks are found outcropping in the valley of Driftwood creek, about 2 to 3 miles above the crossing of the Hazelton-Aldermere wagon road. An open-cut in the bank of Driftwood creek shows this section.

	Feet.
1. Grey and carbonaceous shale and a little coal	5·00
2. Fairly clean coal	1·80
3. Coal and dark shale	4·40
4. Dark clay shale and a little coal	3·60

In Nos. 3 and 4 of this section, the coal and shales alternate in very narrow beds, never more than an inch or two in thickness, the shales themselves being usually highly carbonaceous.

The analyses here given are from the 1·8 feet of clean coal (No. 2), and from an average sample from 6·2 feet of combined coal and shale (Nos. 2 and 3):—

	Moisture.	Vol. Comb.	Fixed Carbon.	Ash.
No. 1—1·8 feet fairly clean coal	7·90	36·64	42·06	13·40
No. 2—6·2 feet banded coal and shale	7·39	31·88	28·07	32·66

In No. 1 the coke was non-coherent, while in No. 2 it was coherent but tender.

The above analyses show the coal to be of lignitic character. In picked specimens it is hard and bright, with a conchoidal fracture, but it is extremely doubtful whether a workable thickness of coal clean enough for market purposes will be found here. Several small seams varying from a few inches to one foot were noted below this one.

KITSALAS DISTRICT.

On returning down the Skeena river to Prince Rupert a short stay was made at Kitsalas village, situated at the foot of the cañon of the same name and about 60 miles below Hazelton. From Kitsalas a fair trail leads up Gold creek to its head, then descending into the valley of the Zymoetz river it continues up a branch of that stream to the Telkwa pass, from which point it follows the Telkwa river down to Aldermere on the Bulkley.

Near the Gold Creek-Zymoetz River divide, a number of claims have been staked, but very little development work has so far been attempted.

The geological conditions here are very similar to those of the upper Telkwa river, the predominant rocks belonging to the Hazelton group, and consisting chiefly of red and green andesites with some breccias and tuffs. These rocks are cut by several granitic intrusions (probably Tertiary), but it is possible that all the granitic rocks to be seen here are not contemporaneous, some of them at least being most probably referable to the older Cascade Crystalline series of Dawson, denudation having removed the overlying volcanics in places. The similarity of these two series of granitic rocks, however, would necessitate a much closer study of them than could be made this year, in the short time available, before any definite classification could be undertaken.

The 'Avon group' of three claims, owned by Messrs. Olesen, Burns, and Lowery, is situated near the head of Gold creek. The country rock is a green andesite, lying nearly horizontal and much altered in places. The ore occurs in what appears to be a dyke from an intrusive granitic mass to the east, the dyke having a width of 40 feet and striking S 25° E with a dip of 70° NE. The ore consists of chalcocite, bornite, chalcopyrite, pyrites, blende, and copper carbonates, in a gangue of altered dyke rock, garnets, quartz, epidote, and calcite, and occurs scattered throughout the dyke, but seemingly more or less concentrated in the neighbourhood of the walls.

The Wells Group.—The 'Wells group' is situated on the Zymoetz River slope near the head of Gold creek, at an elevation of about 4,600 feet above sea-level. The country rock here consists of red and green andesitic flows, which strike about N 30° E and dip 50° to the southeast. The ore occurs along the walls of, and in places disseminated through, a dyke about 30 feet in width, which has a strike of N 30° W and a dip of 60° to the southwest. The mineralization appears heavier along the southwest wall, but the whole of the dyke rock has been more or less replaced with ore. A width of about 2 feet along the southwest wall shows considerable quantities of chalcocite and copper carbonates in a gangue of calcite, quartz, and decomposed dyke rock.

GEOLOGY OF THE VICTORIA AND SAANICH QUADRANGLES, VANCOUVER ISLAND, B.C.

(Charles H. Clapp.)

The greater part of the field season of 1910 was spent in a detailed geological examination of a district in the vicinity of Victoria, Vancouver island, B.C. The topographic maps prepared by R. H. Chapman in 1909 were used as field maps. These maps consist of two fifteen minute sheets, the Victoria and the Saanich quadranges, mapped on a scale of 1:48,000 (1 inch=4,000 feet) with 20 foot contours. The total land area represented is about 150 square miles, and includes the south-eastern part of Vancouver island, the region adjacent to the city of Victoria, the Saanich peninsula, and the southern part of Saltspring island, and several smaller islands in Haro straits. The detailed geological work on the Victoria and Saanich quadrangles was completed by the middle of September. The rest of that month, and the first part of October, were spent applying the results reached during the detailed work to the geology of the whole southern end of Vancouver island, over which reconnaissances had been made during the seasons of 1908 and 1909.

I was very ably assisted in the detailed work, and in part of the reconnaissance work by Mr. John D. MacKenzie and Mr. Alexander G. Haultain.

PREVIOUS WORK.

Very little detailed geological work had been done in the Victoria and Saanich quadrangles. In the seventies, Selwyn, Richardson, and Dawson made reconnaissances in the neighbourhood of Victoria. In 1908 I made a general reconnaissance over the southeastern part of Vancouver island, including virtually the entire area mapped during the present field season, the results being published in the Summary Report for 1908.

SUMMARY AND CONCLUSIONS.

The larger part of the Victoria and Saanich quadrangles is underlain by crystalline rocks. These belong to two, or possibly three groups. The older groups consist of metamorphosed basic volcanic rocks, with intercalated lenses of crystalline limestone. They have not only been folded, faulted, and dynamo metamorphosed, but also contact metamorphosed by the younger group, which consists of intrusive plutonic rocks. The larger part of the metamorphic rocks belong to the Vancouver group, and are lower Jurassic, and in part probably Triassic in age. Some of the volcanic rocks near Victoria and Esquimalt are more metamorphosed than the greater part of the Vancouver group, and may be Palæozoic in age.

The intrusive batholithic rocks may be divided into three principal types, which were erupted in a definite sequence as follows: diorite gneiss, quartz diorite gneiss, and granodiorite and quartz diorite. The two older types have been greatly dynamo metamorphosed, and also somewhat contact metamorphosed by the later granodiorite intrusions. As a whole the batholithic rocks belong to one general period of eruption, and are correlated with the upper Jurassic, Coast Range batholith.

Unconformable on the old crystalline rocks occur the upper Cretaceous sediments. These sediments, which belong to the Nanaimo formation, occur in the northern and eastern part of the Saanich quadrangle in two synclinal basins.

The larger part of the area is covered by superficial deposits of glacial origin. They have, however, been worked over by post-glacial rivers and marine agencies so that the deposits are now usually stratified.

The mineral resources of the quadrangles are confined to non-metallic deposits, lime, cement, clay, sand, gravel, and crushed stone.

General Character of the District.

TOPOGRAPHY.

The relief of the area represented by the Victoria and Saanich sheets is generally low, ranging from sea-level to 1,940 feet on Saltspring island, and to 1,440 feet, the top of Mt. Wark, on Vancouver island. The average elevation in the eastern part of the area is from 200 to 300 feet above sea-level, and in the Highland district, in the west central part of the area, is from 600 to 1,000 feet above sea-level. The higher elevations are knob-like hills, which rise several hundred feet above the general level.

A peculiar feature of the relief is the long ridges of stratified sand, gravel, and clay which occur in the eastern part of the Saanich peninsula, and on James and Sidney islands. They are in certain cases 2 miles long, 100 to 200 feet high, and esker-like in form.

Although the relief is low, there are no plains of any great extent. The Colwood plain, and the basins underlain by stratified clays and sands in the neighbourhood of Victoria and Sidney, are relatively flat, but are only 2 miles or less in width.

There are no large rivers in the area, but there are many small creeks, the greater number of which are dry during the summer months. Small lakes are numerous in the southern and western districts, and occur chiefly in wide, pre-Glacial valleys, with drift divides. In detail the valleys are irregular, but in general they have either a north-south or a northwest-southeast trend.

The coast line of Vancouver island is very irregular, and there are a large number of relatively small islands near the main island. Steep, wave-cut cliffs of sand and gravel, up to 200 feet high, occur, usually with attendant sandspits and bars.

In the eastern part of the area, in pre-Glacial time, the erosion cycle, initiated by the uplift of a peneplain developed by a Tertiary erosion cycle, reached old age, and the only elevations remaining at present are rounded, monadnock-like hills. In the Highland district, however, the Tertiary peneplain although maturely dissected is still represented by flat-topped and ridge-like hills, which are interrupted by rather narrow but deep valleys. It appears as if the whole area at some time subsequent to the mature dissection of the Tertiary peneplain was depressed, thus forming the drowned coast line of the present day.

The topography was greatly modified during the Glacial period; the monadnock-like hills were rounded, the valleys deepened and widened, thus changing the drowned valleys to typical fiords, and the country was covered by a heavy mantle of drift. The glacial drift was worked over by post-Glacial rivers and deposited in lakes and marine basins. It is probable that an elevation of comparatively recent date brought the stratified sands and gravels above sea-level.

CLIMATE AND VEGETATION.

The temperature of the region is remarkably uniform throughout the year, averaging about 55° F in summer and 40° F in winter. The rainfall is much less than in other portions of the north Pacific coast, owing to the occurrence of high mountains on all sides. It averages less than 35 inches. The greater part of the rain falls in the winter months, while the summer is very dry.

The region was once heavily forested, but the forest trees, largely conifers, have been cut over a large part of the area. Fruit, especially berries of various kinds, is the chief agricultural product. The higher and more rocky parts of the area are still covered with the dense timber and thick underbrush so characteristic of Vancouver island and the north Pacific coast.

MEANS OF ACCESS.

The area has many wagon roads, and is traversed by two railways, the Esquimalt and Nanaimo, and the Victoria and Sydney. An electric tramway has been projected along the Saanich peninsula. The roads, and the large amount of cleared land, make the area very accessible, and as rock outcrops are abundant, the geology may be done with a minimum amount of physical labour. The elucidation of the geology of the area is important, since it is representative of the geology of the whole island, and in fact of the coast region of British Columbia.

General Geology.

TABLE OF FORMATIONS.

Superficial deposits	Pleistocene and Recent.
Nanaimo formation	Upper Cretaceous.
Dyke and batholithic intrusives	Upper Jurassic.
Porphyrites	
Granodiorite and quartz diorite	
Quartz diorite and diorite gneisses	
Vancouver group	Lower Jurassic and probably Triassic; and may include upper Palæozoic.

GENERAL DESCRIPTION OF FORMATIONS.

Vancouver Group.—The larger part of the volcanic rocks of the Saanich and Victoria quadrangles, with their associated limestones, notably those on the Saanich peninsula and neighbouring islands, undoubtedly belong to the Vancouver group. A belt of limestone lenses may be traced from Saanich inlet northwest to Cowichan lake, where a large number of fossils were collected in 1909[1], and which have been identified by Professor H. W. Shimer and myself. The species are all new, but the fauna is very definitely assigned to the lower Jurassic. In another lens of limestone, in the same belt, near the forks of Robertson river, 6 miles south of Cowichan lake, remnants of fossils were found, which appear to be similar to, or identical with, those identified. The structural relations of all the limestones in the belt are similar, and the volcanic rocks with which they occur are virtually continuous, so that it is almost certain that the limestones and volcanics of the belt are at least of the same general age, that is lower Jurassic.

The only important lens of limestone belonging to this belt, in the Saanich quadrangle, occurs near Tod inlet. The limestone is a compact, bluish grey marble, altered more or less by constant metamorphism, and is quarried and utilized for the manufacture of Portland cement by the Vancouver Portland Cement Company. Another much smaller deposit of limestone occurs on the shore of Cordova bay.

The associated volcanics are metamorphosed fragmental and flow rocks, basaltic and andesitic in composition. In places they have been silicified by contact metamorphism. They are commonly green weathering, greatly fractured, and often seamed with quartz and epidote stringers. Red weathering rocks, usually the fragmental types, are also characteristic.

The principal area of the volcanic rocks extends from the Saanich inlet, where the belt is over 2½ miles wide, to Cordova bay, where the belt is over 3 miles wide,

[1] Summary Report, 1909. Geological Survey, Canada, p. 87.

although in the neighbourhood of Elk lake it narrows to less than a mile. Along the south shore of Shoal harbour there is another area of meta-volcanics, which probably forms a continuous belt extending to the southern end of Sidney island.

In the vicinity of Victoria there is a group of limestones and associated volcanic rocks, which although structurally similar to those described above are more altered and metamorphosed, and may be older. The limestones vary from white, coarsely crystalline marble to bluish compact marble, the more coarsely crystalline varieties predominating. Where unsilicified they are very pure, varying from 90 to 100 per cent $CaCo_3$. They occur in lens-like masses, chiefly in the vicinity of Esquimalt harbour, although one very small lens occurs on the north shore of Victoria harbour. The largest limestone mass, which extends from the west shore of Esquimalt harbour to the Colwood plain, is only a mile and a half long by a fourth of a mile wide. The other lenses are much smaller, from half a mile in length to mere inclusions in the volcanic rocks.

The volcanic rocks, originally andesites and basalts, have been converted by contact and dynamo metamorphism into silicified and epidotic rocks, or more rarely to typical greenstones. There are two principal areas of these volcanic rocks, one, pinching out to the west, extends from Gonzales point west to Clover point and north to Oak bay; the other, which is the larger, occurs in the vicinity of Esquimalt harbour, extending as far north as Thetis lake and westward to Colwood plain. Another much smaller area occurs at Knockan hill, and other very small masses occur in the intrusive plutonic rocks.

The volcanic rocks of the Vancouver group are intrusive into the limestones, sending dykes into them, and brecciating them along the contact. In a large sense, however, the limestones are considered as contemporaneous with the volcanic rocks. Both rocks have been intruded by the plutonic rocks of the upper Jurassic batholiths.

While it is most probable that all the volcanic rocks and associated limestones are Mesozoic in age, and belong to the Vancouver group, it is possible that more metamorphosed types are Palæozoic. If this were true they would belong to the Victoria group.[1] It has been shown, however, by the detailed work of the past season, that the larger part of the rocks which were thought in 1908 and 1909 to belong to the Victoria group are either members of the Vancouver group, or metamorphosed plutonic rocks. It seems best, therefore, until definite evidence of the Palæozoic age of some of the rocks has been found, to consider them all as belonging to the Vancouver group.

Exposed on the southern end of Saltspring island, and extending across Russell and Portland islands to Moresby island, are a series of schists and interbedded volcanic rocks. The schists, which are chiefly quartz, chlorite schists, are largely of volcanic origin, but some fairly typical slates and greywacks, undoubtedly sedimentary, are present. The rocks of volcanic and of sedimentary origin could not be separated in the mapping, and so are grouped together and mapped as a single unit. These rocks were first met with, in 1908, on Mt. Sicker, and have been traced eastward to Saltspring island. They have been called the Mt. Sicker formation,[2] and are one of the formations making up the Vancouver group.

Intrusive into the Mt. Sicker formation are large irregular bodies of andesite and diorite porphyrite, which though they may be related to the batholithic rocks, intrusive into the Mt. Sicker formation, are apparently related to the volcanic members of the formation itself.

On Albert head occur volcanic rocks of diabasic habit, which form part of the belt extending to the west coast, and which have been called the Metchosin volcanics.[3]

---

[1] C. H. Clapp, Summary Report, 1909, Geological Survey, Canada, p. 87.
[2] C. H. Clapp, Summary Report, 1908, Geological Survey, Canada, p. 56.
[3] C. H. Clapp, Summary Report, 1909, Geological Survey, Canada, p. 89.

The rocks of Albert head include flow rocks, amygdaloids and porphyries, dyke rocks, and tuffs and agglomerates. The fragmental varieties are largely stratified and the fragments water-worn. The rocks are far less altered than any of the other volcanic rocks of the region, and though provisionally assigned to the Vancouver group, are apparently younger. No evidence as to their age is given by their structural relations, as these are obscured by the thick deposit of sand and gravel of the Colwood delta. To the west of the area they are known to be separated from the Leech River slates to the north by a profound and extensive fault.

Dyke and Batholithic Intrusives.—Intrusive into all of the above formations, with the exception of the Metchosin volcanics, are large masses of plutonic rocks and their accompanying dykes. The plutonics were erupted during one general period of batholithic intrusion, but in detail may be divided into three types which were erupted in a definite sequence. The three groups are, in order of their eruption, diorite gneiss, quartz diorite gneiss, and granodiorite and quartz diorite. As indicated by their names, the first two types have been greatly dynamo-metamorphosed, and have been converted into gneisses. Although the granodiorite and quartz diorite are somewhat gneissic in structure, they are not typical gneisses. All of the above rocks have been considerably altered and fractured.

The diorite gneiss and quartz diorite gneiss are very intimately related, and form virtually a single batholith. The batholith extends from the southern end of Saanich inlet, in the neighbourhood of Mt. Wark, southeast across the Highland, Lake, and Victoria districts to the east shore of Vancouver island; and the diorite gneiss also occurs on Chatham and Discovery islands. The older type, the diorite gneiss, is fairly uniform, and is composed chiefly of plagioclase feldspar and hornblende, with more or less biotite. It ranges from fine to coarse grained, and is typically medium to coarse grained. The composition varies, sometimes the feldspar and at other times the hornblende predominates, and it also passes into hornblende gneisses or amphibolites. Although relatively large masses of typical diorite gneiss occur, as on Mt. Wark and north of Cadboro bay, it is nearly everywhere cut by numerous apophyses of quartz diorite and quartz-feldspar gneisses. Often a complex of the diorite and quartz diorite gneisses has been formed, in which the two types can not be mapped separately.

The quartz diorite gneiss forms long lenticular masses which are intrusive into the diorite gneiss, so that a series of alternating irregular belts of the two rocks is formed. The series has a strike of N 50° to 60° W.

The gneisses have not only been dynamo-metamorphosed but also contact-metamorphosed, the metamorphism having greatly affected the quartz diorite. In its recrystallization the light and the dark coloured minerals have been segregated in zones, from less than an inch up to several feet in width; so that the formation has a characteristic banded appearance. These banded rocks were thought by Dawson,[1] and in 1908 by the writer[2], to be partly metamorphosed sedimentary and volcanic rocks, but the microscopic study and detailed field work have shown conclusively their igneous and plutonic origin.

The larger part of the Saanich peninsula is underlain by a fairly uniform body of granodiorite, growing more basic in places and grading into a quartz diorite. This body of granodiorite is relatively unmetamorphosed, and is quite distinct from the gneissic rocks to the south, although it is very similar in composition to the quartz diorite gneiss. It is separated from the Wark and Victoria gneisses by a belt of volcanic rocks, but some of the aplite and other salic granitic apophyses in the gneisses are doubtless referable to the Saanich batholith. Another granodiorite stock occurs at the southern end of the Esquimalt peninsula. It is clearly intrusive into the diorite gneiss, the contact being marked by an extensive shatter breccia.

---

[1] G. M. Dawson, Geological Record of the Rocky Mts., in Canada. Bull. Geol. Soc. Am Vol. 12, 1901, p. 72.

[2] C. H. Clapp, Summary Report, 1908, Geol. Survey, Canada, p. 55.

Associated with the plutonic rocks, notably with the Saanich batholith, are andesitic dyke rocks and other porphyrites, which are holocrystalline and range from basic to very acid, quartz-bearing varieties. They are irregular in composition, and are confined in their occurrence to the contact zones.

All the batholithic rocks belong to the same general period of intrusion. They are known to be intrusive into lower Jurassic rocks, and the upper Cretaceous measures rest unconformably upon them. They are, therefore, correlated, with considerable certainty, with the Coast Range batholith of British Columbia, which is upper Jurassic in age.

Nanaimo Formation.—The unmetamorphosed sedimentary rocks of the southern part of Vancouver island, which are referable entirely, or in large part, to the Cretaceous, have been grouped together, since they have not yet been definitely subdivided, and have been called the Cowichan group.[1] The rocks belonging to the Cowichan group, which occur in the Saanich quadrangle, probably all belong to one formation, or at least one series, which has been named and described by Richardson, Whiteaves, and Dawson as the Nanaimo series.[2] The rocks consist of conglomerates, sandstones, and shales, the sandstones greatly predominating. With them occur a few thin seams and lenses of a fair grade of bituminous coal.

The greater part of the Nanaimo formation occurs in the Cowichan basin, as defined by Richardson.[3] The rocks of this basin occur in a close folded syncline overturned to the south, so that the beds have a general dip to the north. The strike ranges from N 45° to 90° W. Several smaller folds occur in the major syncline. The north boundary of the basin is a thrust fault, and many smaller faults occur. The rocks of the syncline occur on the southern end of Saltspring island, and extend across the northern end of the Saanich peninsula to Bare and Low islands to the east of Sidney island, and are exposed on several small islands off the east coast of Vancouver island.

On Saltspring, Russell, Portland, and Moresby islands occur relatively small sedimentary areas, which belong to the Nanaimo formation, and which occur in the Nanaimo basin. The southwest shore of Pender island consists of thick bedded coarse conglomerates, which also belong to the Nanaimo basin.

Superficial Deposits.—A very large part of the area is covered by unconsolidated superficial deposits of various kinds, which are, however, almost entirely referable to the glacial period. Unmodified glacial till is comparatively rare below an elevation of 250 feet above sea-level. Above that level it occurs on Saltspring island, and in the Highland and Lake districts. As it occurs on steep slopes it has been more or less modified by sliding, and the removal of the finer material. Unmodified drift also occurs below 250 feet, resting unconformably on stratified drift.

The superficial deposits consist chiefly of stratified gravel, sand, and clay, and are principally fluviatile, lacustrine, and marine deposits. The material which was thus deposited was, however, derived from glacial till. The most extensive are probably lake or estuarine deposits and consist of stratified yellow and greyish blue clay, overlain to a considerable extent by sand and thin beds of gravel, with rounded glacial boulders up to 10 feet in diameter irregularly scattered through the deposit. The country underlain by these deposits is flat or gently undulating, and is generally covered by thick loamy soil, and forms, therefore, good farming land.

Undoubted river deposits of sand and gravel occur, with delta structure, and well developed terraces. The best example is Colwood plain, which is a delta deposit,

---

[1] C. H. Clapp, Summary Report, 1909, Geol. Survey, Canada, p. 89.

[2] James Richardson, Report on the Coal Fields of Nanaimo, Comox, Cowichan, Burrard Inlet, and Sooke, B.C. Geol. Survey, Canada, Rept. of Progress, 1876-77, pp. 160-192.
J. F. Whiteaves. Mesozoic Fossils, Vol. I, Part II, Geol. Survey, Canada, 1879, pp. 93-96.
G. M. Dawson. The Nanaimo group. Am. Journ. Sci. Vol. 39, 1890, pp. 180-183.

[3] James Richardson, Geol. Survey, Canada. Rept. of Progress, 1876-77, pp. 187-188.

built up by a very large, post-glacial river. In the south Saanich district, and on James and Sidney islands are four parallel, esker-like ridges, 100 to 200 feet high, one-fourth of a mile wide, and which have a trend of about N 15° W. The two western ridges apparently extend, although not continuously, across Lake district to the eastern part of Victoria district. The origin of these ridges is at present obscure.

Another peculiar type of deposit occurs to the south (the lee side) of the knob-like hills north of Victoria. They are esker-like in shape and form long trains extending south from the hills, in the case of the Mt. Douglas train, for over a mile. They are composed of stratified sands and gravel, the sand predominating, and are cross-bedded and apparently have been deposited by flowing water.

Recent alluvial deposits occur in small depressions and in the river valleys. Along the shore, especially in the vicinity of the wave-cut cliffs of stratified sand and gravel, large sand bars have been built, some of which form barrier beaches, behind which occur lagoons and salt marshes.

Economic Geology.

The mineral deposits of economic value are entirely non-metallic; the products derived from them include lime and cement, brick and tile, sand and gravel, and crushed stone. More or less prospecting for metals has been carried on, chiefly for gold and copper.

GOLD AND COPPER.

The deposits which have been prospected for gold are chiefly the quartz-feldspar veins which accompanied the intrusion of the batholith rocks, and are not likely to carry gold in commercial quantities. Quartz veins such as occur in the Leech River slates to the west, and which are known to be gold-bearing, do not occur. Small veins carrying pyrite and chalcopyrite occur in the sheared zones of the meta-volcanics which illustrate the occurrence of copper ores in other parts of the island,[1] but which are not of themselves important. In the Mt. Sicker schists, on Saltspring and Moresby islands, pyrite and chalcopyrite occur, impregnating shear zones. In the Highland and Esquimalt districts, near the contacts of the plutonic rocks with the limestones and meta-volcanics of the Victoria and Vancouver groups, occasional contact deposits have been developed. They are similar in their occurrence to those to the west, described last year, but none of them are of commercial importance, on account of their small size and irregularity. An interesting feature of these deposits is the development of garnet in a contact metamorphosed volcanic rock.

COAL.

The occurrence of small seams and lenses of coal in the measures of the Nanaimo formation has attracted very considerable attention, chiefly on account of their proximity to the productive coal seams of the Nanaimo and Comox districts. One or two attempts have been made to mine the exposed seams, and some diamond drill boring has been carried on, as yet without successful results. The conditions are not very favourable; though the measures are well exposed along the shores of the various islands, no thick or extensive seams are known to occur; the measures are thick, fully 6,000 feet and more, probably 10,000 feet; they have been folded and faulted to such an extent that the dips are high, and the known coal seams occur near the base of the formation, so that the coal horizons probably occur chiefly at great depths.

LIME AND CEMENT.

The limestones of the Victoria and Vancouver groups yield excellent material for the manufacture of lime and cement since they are almost pure calcium carbonate.

[1] See Summary Report, 1909. Geol. Survey, Canada, pp. 91-94.

The stratified glacial clays are suitable to mix with the limestone for the manufacture of Portland cement. At the present time there is one Portland cement plant in operation at Tod inlet, the limestone and clay both being obtained from the adjoining property.

Lime is manufactured on the west shore of Esquimalt harbour, by the Rosebank Lime Co. and by Thomas Atkins. The Silica Brick and Lime Co., situated about a mile west of Esquimalt harbour, on the Esquimalt and Nanaimo railway, manufactures lime, hydrated lime, and sand-lime brick.

SAND AND GRAVEL.

Sand and gravel, for concrete filling and similar purposes, is quarried extensively in the district. The British Columbia Sand and Gravel Co., and the Royal Bay Sand and Gravel Co., operate two banks on the Colwood shore of the Royal roads, the material of the Colwood delta being quarried. The gravel and sand are mined with an hydraulic giant, and then washed and screened. Sand and gravel are also obtained from the esker-like trains to the south of Mt. Tolmie, and from a sand and gravel ridge in northeast Victoria.

CLAY.

The stratified glacial clays are used for common brick and drain-tile at Victoria, Sidney, and Sidney island. At Sidney island the stiff-mud process is used, but at all the other plants the wet-mud process is used for the manufacture of the brick, although at Victoria drain-tile is moulded in an auger machine. No high grade clays are known to occur in the district. The shales of the Nanaimo formation are almost invariably sandy, and are not suitable for other wares than brick and drain-tile.

STONE.

No building stone is quarried at the present time in the area. The older crystalline rocks, even the Saanich granodiorite, are too badly fractured and sheared to yield good building stone. Some of the sandstones of the Nanaimo formation would furnish material of a fair quality, but sandstone of better grade, and more readily quarried, occurs farther to the north and west, and supplies the present demand.

Crushed stone is obtained from the Metchosin volcanics on Albert head by the British Columbia Trap Rock Company. The rock is a somewhat altered basalt of an ophitic or diabasic texture, and furnishes a rock of excellent quality for crushed stone for concrete, road metal, and similar purposes.

TOPOGRAPHIC WORK ON VANCOUVER ISLAND.

(R. H. Chapman.)

Field operations on Vancouver island were begun about the middle of May. One party was organized under K. G. Chipman, and the survey of the Sooke sheet—a rectangle extending between latitudes 48° and 48° 30′ and longitudes 123° 30′ and 124°—was begun.

This sheet includes the full width of the strait of Juan de Fuca, and will show the International Boundary and part of the shore line of the State of Washington.

The same party continued work northward surveying the Duncan sheet, which is bounded by the parallels 48° 30′ and 49° of latitude, and meridians 123° 30′ and 124° of longitude.

Later, a second party under S. A. Wookey was organized, and co-operated in this work.

This sheet shows the eastern shore line of Vancouver island from the head of Finlayson Arm of Saanich inlet to Oyster harbour at Ladysmith, and includes parts of Saltspring and Galiano islands, and the smaller islands of the vicinity.

The field scale of the Sooke and Duncan sheets is 1 to 96000—for publication at about 2 miles to 1 inch; with topography shown by contours at an interval of 100 feet.

About June 1, a party under B. R. McKay was established near Ladysmith, and later a party under T. A. McElhanney; and the surveying of the Nanaimo sheet was begun.

This sheet covers an area bounded by parallels 49° and 49° 15′, and meridians 123° 45′ and 124°. It includes the flat areas of sedimentary rocks, with which the coal of this field occurs, as well as some of the volcanics appearing in the foot-hills. Nanaimo and Northfield and the coast line from Oyster harbour to a point about 10 miles northwest of Nanaimo, are shown, together with the larger (western) part of Gabriola island and the smaller adjacent islands.

This sheet, which joins a portion of the northern edge of the Duncan sheet, was surveyed at a field scale of 1 to 48000, and will be published at about 1 mile to 1 inch. The topography is shown in great detail by contours at 20 foot interval.

All the mapping was prosecuted by the plane-table intersection and traverse methods, essentially the same as used the preceding year. A land area of about 1,000 square miles was mapped.

Very carefully run lines of levels were extended along the Esquimalt and Nanaimo railway, from Langford lake to Ladysmith, thus giving a tie between the datum at Victoria and that at Nanaimo, both of which were used in 1909. Standard bench marks—copper discs or iron pipe—were placed at short intervals on these lines, and were also placed along the lines run during the season of 1909.

This work was done with all the care and precision of the previous work.

Triangulation was extended from stations established in 1909 to points in the vicinity of Buttles and Great Central lakes and Effingham inlet. This work which is available for the extension of the topographic maps, was accomplished with the same refinement as that of the preceding year, and was again done by S. C. McLean.

All the work was greatly retarded by forest fires and smoke, and latterly by heavy and continuous rains.

The field work closed early in December. Efficient service was rendered by the following assistants: F. S. Falconer, R. E. McBeth, K. H. Smith, R. H. Jarvis, F. Bowman, A. U. Meikel and A. G. Haultain.

PARTS OF THE SIMILKAMEEN AND TULAMEEN DISTRICTS.

(Charles Camsell.)

During the season of 1909 geological field work was begun in the Tulameen district on a sheet covering about 160 square miles. About two-thirds of this work was completed in that season, leaving the remaining third to be finished in 1910.

During the season of 1910 nearly two months were spent on the Tulameen sheet itself, and in the examination of such adjacent country as was necessary for the proper interpretation of the geology of that field. The work of compiling the geological data obtained on this sheet in the past two seasons is now in progress, and a final report will be prepared for publication in the immediate future. The essential structural and economic features of this field were outlined in the Summary Report for 1909, so that it will not be necessary here to give more than a mere statement of progress in mining development during the last year.

Besides the work on the Tulameen sheet a few days were spent at Hedley in obtaining information on the development that had taken place there since the completion of the author's report on that district. An examination was also made of certain asbestos deposits situated in the neighbourhood of Okanagan Falls on the east side of Okanagan valley.

A little work was done in the region lying between Tulameen and Nicola valley, and a plane-table and telemeter traverse was carried through along the wagon road between these two points.

The field party consisted of four persons, including J. D. Galloway and W. S. McCann as assistants.

PROGRESS OF MINING IN THE TULAMEEN DISTRICT.

Although most of the ore deposits of the Tulameen district are still in the prospect stage of development, the near approach of the Great Northern railway has within the last year given a slight stimulus to the mining industry, which had previously shown some sign of languishing. Among the various lode metal prospects, such as gold, silver, copper, and platinum, the development has not been great, and in the large majority of cases the work done has only been such assessment duty as is necessary to hold a mineral claim that is not Crown granted.

Placer mining operations received a decided reverse in the early spring, by the washing out for the third time of Lambert and Stewart's dam on Granite creek. Work had advanced so far on this lease that the owners fully expected to be able to mine some 600 feet of the creek bed during the summer. Three seasons had been spent in preparation, and about $10,000 expended on dam and flumes, and it was confidently expected that the gold and platinum obtained from the mining of this ground would have amply repaid them for their outlay.

A few Chinese miners were again placer mining on a part of the bed of the Tulameen river between the mouths of Eagle and Champion creeks. This particular portion of the stream bed has been worked over a great many times since the first discovery of gold on it. Within the last twelve years it has been mined at least eight times and the old cabins, gravel dumps, and abandoned machinery, show that it had already been worked over years before. Gold and platinum are obtained here in about equal proportions. The evidence suggests that the gold and platinum on the stream bed are replenished annually from some near-by source. What this source is has not yet been determined. There are no prominent gravel deposits directly above this point, but it is significant that it lies immediately below a sheared and broken zone formed in the bed-rock, on the contact of pyroxenite with green schists. The method of working is to divert the water by wing dams to one side of the stream bed, and mine the other by sluicing. The amount of gold and platinum actually recovered was not ascertained, but it appears to have been satisfactory to the miners.

Some placer mining is also carried on annually in Granite creek by a few individuals. Here attention is devoted largely to old channels in the creek valley.

The most important developments in the Tulameen district within the last year have been in coal mining operations. Virtually all the known coal in the Tulameen coal basin has been acquired by the Columbia Coal and Coke Company, and prospecting has been vigorously carried on throughout the year by this Company.

As outlined in the Summary Report for 1909, the rocks of the coal formation are of Oligocene age, and consist of sandstone, shale, conglomerate, and beds of coal. These rest conformably on volcanic rocks, while they are in part overlaid unconformably by a basaltic flow. That the latter is simply a surface flow capping the coal formation has been satisfactorily proved by sufficient evidence. Fissures through which this basalt rose to the surface were noted in two places in the cañon of Granite creek, and it is possible that one or more of these fissures may cut the coal formation itself.

The coal basin is synclinal in structure, with the main axis of the syncline running approximately N 50° W. The total area covered by the Oligocene sedimentary rocks is 3,700 acres. As near as can be estimated by following out the outcrop of the coal seams 3,254 acres of the basin are covered by coal. The lava covers 1,070 acres of the coal-bearing rocks.

Enough work has not yet been done to prove the total number of workable seams existing in the basin, but what work has been done is sufficient to prove that a thickness of 20 feet of coal would be a fair estimate.

Taking the usual estimate of 1000 tons of coal to the acre per foot of seam the basin contains about 65,000,000 tons of coal that can be extracted in mining.

The total thickness of coal as exposed in the workings on Granite creek approximates 50 feet, but a great part of this thickness is made up of narrow seams, separated by partings of clay or sandstone. As the beds are explored some of these partings may pinch out and leave a good workable seam.

Up to the end of August, 1910, over 2,500 feet of tunnelling, drifting, and raising had been done in exploration of the coal basin. Most of this had been carried out at two points—one on Granite creek on the south side of the basin, and the other at Collins gulch. It was found, however, that the outcrop of the coal seams approached nearer to the Tulameen river on Fraser gulch than at any other point in the basin, consequently all recent work has been concentrated there. It is the intention to mine the basin by tunnels driven in at this point. A drill hole is also being sunk through the formation at a point near the head of Fraser gulch. This point was selected on account of its being near the centre of the basin, where a hole would pierce all the strata.

Since returning from the field the important discovery has been made of the occurrence of diamonds in a sample of chromite taken from the peridotite of Olivine mountain situated about 7 miles west of Tulameen village. This is the first recorded discovery of diamonds in Canada either in the solid rock or in placer.

As described in the Summary Report for 1909 (page 109) the peridotite forms an elongated body about 2½ miles long and about a mile wide extending from the summit of Olivine mountain northward across the valley of the Tulameen river to Grasshopper ridge. The total area of this body is 2·8 square miles. It is surrounded on all sides by pyroxenite into which it passes by a gradual transition. These two rocks have been thrust through a series of interbedded volcanic rocks, limestones, and argillites, which are believed to be of Triassic age.

The peridotite contains only two constituent minerals, olivine and chromite, and is, therefore, the variety dunite. The chromite in which the diamonds were found is not evenly distributed through the rock mass, but occurs in short irregular vein-like segregations an inch or more in width, in irregular masses, or in small grains disseminated throughout the rock. In all cases it is doubtless a product of differentiation in the molten magma during cooling.

The peridotite in some places is altered to serpentine, but in many places it is quite fresh and shows little evidence of decomposition. It is of the same family of rocks as that to which belong the matrices of the South African and Arkansas diamonds, but it differs slightly from the foreign rock in constituent minerals and in the degree of alteration undergone. The origin of the rock in each instance is identical.

The South African diamonds are found in a decomposed serpentine which occupies circular or elliptical pipes, varying from 20 to 750 yards in diameter. The Arkansas diamonds are found in two isolated bodies of peridotite, the larger of which covers about 60 acres. In Africa, and to a certain extent in Arkansas, the diamonds are distributed fairly uniformly throughout the mass of the rock, so that an estimate can be made of the number of carats that a given area will yield. For example, in South Africa it is estimated that one cubic yard of rock yields about 5 carats, while in Arkansas 16 cubic feet of rock gives 0·21 carats.

Samples of chromite taken from the peridotite of Olivine mountain were submitted to Mr. R. A. A. Johnston, mineralogist of the Survey, to determine the nature of the chromium minerals. In the course of his examination Mr. Johnston secured some insoluble crystals which on subjecting to further tests he found to be diamonds. Platinum and gold were also identified in the residue.

Results previously obtained in the course of a search for the original source of the platinum of the Tulameen district showed that this mineral was often associated with the chromite in appreciable quantity, and Prof. J. F. Kemp in one sample obtained as much as half an ounce to the ton. The sample submitted to Mr. Johnston has yielded platinum at the rate of about one ounce to the ton. When seen under the microscope the platinum appears as small rounded pellets or as thin sheets having a bright metallic lustre. The chromite segregations, however, where they have been observed, are too small and too widely separated throughout the body of the rock to make the extraction of the platinum a profitable commercial venture.

The gold is in considerably less quantity than the platinum.

The diamonds so far obtained by the breaking down of the chromite in the laboratory are of small size, the largest being about the size of an ordinary pin's head. When examined under the microscope many of them are seen to be clear and bright, and apparently of excellent quality. Some have a faint yellowish colour. Other specimens are massive, opaque, and greyish black in colour and are presumably the variety carbonado.

All of the diamonds extracted have been found to be associated with the chromite of the peridotite, and not with the olivine. If this association holds true throughout the mass of the rock the diamonds will be found to be very unevenly distributed, and for that reason, if for no other, their extraction is a difficult problem. Again, the rock is so fresh and hard that the South African methods of extraction cannot be used here. Mechanical methods cannot for several reasons be advantageously employed, and chemical processes are slow and expensive. The discovery, therefore, of these diamonds in the solid rock of the Tulameen is of great scientific interest even if it does not prove to be of much commercial importance.

Placer deposits have been found in the streams which drain the peridotite, and in these it is to be expected that diamonds comparable in size and quality with those obtained in the laboratory will be found. These deposits may also contain stones of greater size, but in the placer mining for gold and platinum which has been carried on in these streams for a number of years, although stones of commercial size on the sluice boxes should have attracted the attention of miners, the discovery of a diamond has not yet been recorded.

The present discovery of diamonds in Canada is the first that the department has been able to verify. For many years officers of the Survey working in British Columbia have been on the lookout for precious stones, so that the discovery of diamonds has not been altogether unexpected. Some years ago the present Director of the Survey obtained some microscopic crystals which were believed to be diamonds and which gave positive results in all tests to which they could be submitted. At that time he advised the prospectors of British Columbia to be on the lookout for diamonds and expressed the belief that they might occasionally be found in the placers. The present discovery justifies that belief.

A few diamonds have beeen found in the glacial drift in Illinois and Ohio, and as much of the material of this drift has been derived from rocks in Canadian territory and carried southward by glacial action it is presumed that the diamonds also may have had their original source in Canada.

RECENT DEVELOPMENTS AT HEDLEY.

In December, 1909, trains began running regularly into Hedley from the east, over the tracks of the Victoria, Vancouver, and Eastern railway. The effect of this on the mining industry of the Similkameen has been more marked perhaps in other portions of the district than in the immediate vicinity of Hedley. Operations have been carried on more vigorously than formerly on the Sunnyside and Nickel Plate mines, but this is not due solely to the advent of the railway. The Kingston group has been bonded to a Boston company, and exploratory work is being done, but in the remaining part of the camp the exploitation of mineral claims is in virtually the same condition as it was on the completion of our field work there in the spring of 1909.

On August 13, 1909, the Yale Mining Co., owners of the Nickel Plate and Sunnyside mines, sold out to the Exploration Syndicate of New York, who are now operating these mines under the name of the Hedley Gold Mining Company. The Daly Reduction Company also went into the hands of the same people, but the old name is still retained.

Since the change a vigorous policy has been pursued both in the mines and reduction works, resulting in a greatly increased output.

For a detailed description of the geology and ore deposits of this region reference can be made to a recent publication by the present author.[1] For the sake of convenience, however, a brief statement of the geological conditions is here made. The stratified rocks of the district consist of interbedded limestones, argillites, quartzites, and volcanic materials of Palæozoic age, now much altered by igneous intrusion and dynamic action. Into these have been intruded a batholithic mass of granodiorite, and smaller bodies of an igneous complex made up of gabbro, diorite, and

[1] The Geology and Ore Deposits of the Hedley Mining District, Memoir No. 2, Geological Survey Branch, Department of Mines, Canada.

quartz diorite. The ore bodies are of contact metamorphic origin, and are situated on the contact of the altered limestone with apophyses of gabbro which are connected with the main bodies of that rock. The principal ore mineral in them is arsenopyrite, which occurs in a gangue of lime silicate minerals, and yields gold as the chief valuable metal.

At the mines the ore bodies, which a year and a half ago were thought by the former owners to be almost exhausted, have been proved to extend a considerable distance both in length and width. Two new ore bodies have been discovered, one on the Nickel Plate, and another on the Bulldog. A third ore body, lying under the foot-wall of the old Nickle Plate ore body, and formerly thought to consist entirely of low grade ore, has been prospected and found to contain a large quantity of ore, averaging about $12 to the ton.

On the Bulldog claim, which adjoins the Sunnyside on the south, a prospecting adit tunnel has been driven into the mountain at a point about 30 feet below the electric tramway, and not far from Sunnyside No. 1. At the time of examination the tunnel was in about 60 feet, and was largely in ore up to the face. The horizon of this ore body is apparently the same as that of Sunnyside No. 2, and the ore is of somewhat similar character, with perhaps a higher proportion of pyrrhotite to the arsenopyrite. The gangue is largely calcite, with some of the lime silicate minerals.

At Sunnyside No. 2 mine, which has been second only to the Nickel Plate as a producer of ore, the work has been largely stoping of ore, and diamond drilling. Prospecting of this mine has not extended the limits of previously known ore.

On Sunnyside No. 3, which is an incline dipping about 45° on a foot-wall of gabbro, a new level has been opened up, and the main entry driven 120 feet below the first level. On the first level a raise has been put up 112 feet to the north, and is in ore all the way.

Sunnyside No. 4 is also an incline, with a dip of 17° and a length of 420 feet. A drift has been run to the south in the mine and connexion made with Sunnyside No. 3 on the first level. Ore is being stoped from both these mines.

The Nickel Plate mine shows the greatest development. At the last examination, made in June, 1909, only one ore body was being worked in this mine, namely, that lying above the foot-wall of gabbro (andesite). Another ore body was known to lie beneath this foot-wall, but it was always considered to be of lower grade than could be profitably mined at the time.

During our recent examination at the end of July, it was found that the limits of the original ore body had been extended both along and across the strike, and in places about 20 feet of what was originally considered to be the hanging wall has been mined out. The so-called low grade ore body beneath the gabbro foot-wall has been prospected and found to contain some high grade ore, and a considerable quantity—amounting to thousands of tons—of other ore of approximately average grade.

Besides these two ore bodies, a third has been discovered in the lower, or No. 4, tunnel. All three ore bodies are being mined, and at the time of our examination about 18,000 tons of ore had been broken down and was lying in the stopes.

The lower, or No. 4, tunnel, which was originally driven to form the main entry to the mine, and later abandoned, is now being used, and an electric tramway laid into it. Connexion has been made underground from this tunnel to the old workings above, and it is proposed to take all the ore from the mine through this entry. Preparations are also being made to sink from this level.

Besides the developments in the mines there have been improvements in transportation and methods of treatment, resulting in an increase in the quantity of ore milled. Previous to 1910 the reduction works treated a maximum of 135 tons daily. This has been increased to 160 tons, largely by a change in the drop of the stamps from 6 inches and 106 per minute to 7½ inches and 99 per minute. With other improvements that are now being made it is estimated that the capacity of the mill will shortly be increased to 200 tons per day.

The changes in the mill will include the addition of a 100 ton tube mill for re-grinding, Bunker Hill screens for classifying, Deister tables for slime concentration, Merrill precipitating presses to replace the zinc boxes, and Oliver filter presses for dewatering the slime residue.

The power plant also is being improved and increased. All the machinery was formerly operated directly by water-power, but electric motors are now being installed everywhere. A 360 K. W. Westinghouse generator has been installed in the main power house. This is connected at one end of the shaft with a 400 horse-power condensing steam engine, and at the other with a 500 horse-power Doble impulse wheel, so that the plant can be operated either by steam or water-power. By the addition of three new return tubular boilers the steam boiler capacity has been increased from 250 to 700 horse-power.

In spite of all the changes that are being made there has been no interruption of the regular milling operations, and with the increase in the steam boiler capacity there will be no necessity in the future to close down during part of the winter, as was so often done when water was the only motive power. Up to the end of 1908 the total tonnage of ore treated was 153,013. The following table shows the monthly tonnage since that date:—

	1909. Tons.	1910. Tons.	
January	....	2,718	
February	....	3,052	
March	....	1,919	
April	1,588	3,921	
May	3,831	4,305	
June	3 389	4,574	
July	3,695	4,549	
August	3,873	4,347	
September	3,700	4,360	
October	3,944	4,300	estimated.
November	3,691		
December	3,392		
	31,103	38,045	

Within the last two years the average grade of the ore milled has decreased from $14 per ton to $12 per ton. The extraction has, however, gradually increased, until at the present time it is 93 per cent of the assay value of the ore.

Extraction of gold from the ores of the Nickel Plate and Sunnyside mines began in June, 1904. From that time up to September, 1910, or in a little more than six years, these mines have produced gold to the value of $2,741,277.28.

Since the completion of the field work for the report on the Hedley mining district in September, 1908, some development has taken place in the district, and this development has a bearing on the theory advanced in that report for the origin of the ore bodies. The ores are therein stated to be the result of contact metamorphism, and the theory attributes their origin to the intrusion through beds of limestone of gabbro dykes—locally called andesite—emanating from a main central stock. This intrusion produced the primary ores. Secondary enrichment was also supposed to have taken place in the surface zone by downward moving waters, effecting concentration where dams had been formed by impervious cross-cutting dykes.

Recent development has done much to confirm the theory that the intrusion of the gabbro was the primary cause of ore deposition, and where new ore bodies have been found, they have always proved to be associated with the white gabbro. It is also true, however, that many bodies of gabbro have been intruded into the limestones without forming ore bodies of commercial magnitude.

The theory of secondary enrichment in the surface zone through downward moving waters is not of such general application as the other. While this theory has been found to be true in a few cases, these cases are not in the majority, and one would not be justified in attempting to draw any general conclusions from them. The majority of the ore bodies now being worked do not show any evidence of secondary surface enrichment and appear to contain only the primary ores, which are the result of contact metamorphism. This may be taken as a reason for encouragement to mine owners, for it indicates that secondary enrichment is not necessary for the formation of commercial ore bodies in this camp. It suggests at the same time that ore bodies will be found to persist to depths greater than was first supposed. Both of these factors go to lengthen the probable life of the existing mines, while they tend to increase the probable number of yet undiscovered ore bodies occurring in this camp.

It is true that the average grade of the ore now mined has decreased slightly with the working out of those ore bodies that were near the surface and did show evidence of secondary enrichment, but this decrease has been so slight that there is still a considerable margin of profit in the mining of these ores. The grade of the ore now mined averages about $12, while the cost of extraction is in the neighbourhood of $5 per ton.

The lowering of the grade of the ore with depth has been accompanied by a slight change in its character. The gold now mined is finer and is more intimately mixed with the arsenopyrite, and is not so readily extracted by amalgamation. This change, however, has been met by various changes in the treatment, and so successfully has this been done that a higher percentage of the assay value of the ore is now recovered than was formerly done with the more easily reduced surface ores.

In view of the fact that the surface zone has been passed through, and no great change in treatment has become necessary to meet the change in character of the ore, it is not likely that any radical change, such as the smelting of the ores, will ever have to be resorted to in the future as depth in the mine increases.

THE OCCURRENCE OF ASBESTOS AT OKANAGAN FALLS.

Asbestos is reported to have been discovered at this place in 1898, by G. Maynard, but until the last year nothing had been done to demonstrate its quality, or the area covered by the asbestos bearing rocks. In the spring of 1910, fourteen mineral claims were staked to cover the ground, the owners being Messrs. Ritchie, Hislop, Maynard, and Bailey.

The claims are situated on the east side of Okanagan valley, and on the south side of Shuttleworth creek, which flows into the Okanagan river below Okanagan falls. The claims extend up the slope of the valley, from an elevation of 400 to 2,000 feet above the level of Dog lake.

The sides of the valley slope up gradually but irregularly. The lower part is level land, on which fruit farming is being carried on. The upper parts are rocky, and broken into irregular hills and hollows.

The rocks in which the asbestos occurs belong to the Shuswap series, and this series extends up and down the eastern side of Okanagan valley, and for an unknown distance inland to the east. Patches of Tertiary volcanic rocks are found resting here and there on the rocks of the Shuswap series, and on the west side of the valley they attain a great development.

The rocks of the Shuswap series here consist of granite and diorite gneisses, mica, hornblende, and talc schists, limestones, narrow beds of pyroxenite, and some serpentine. In general the planes of schistosity and gneissic structure are parallel to the planes of stratification in the limestone, the strike being east and west, and the dip at low angles to the north.

The serpentine is the result of an alteration of an impure peridotite, of which a little yet remains in the unaltered state. One, and perhaps two bands are known to occur near the top of the valley slope, but neither of them appear to be as much as 100 feet in width.

The asbestos is found in veins running through the serpentine. These veins vary in width from a fraction of an inch up to 14 inches, and are exposed in a few places by open-cuts to a depth of 4 to 10 feet.

The larger veins appear to show some movement of the walls after the formation of the asbestos, for the middle of the vein shows a break, the fibre not being continuous across the whole width of the vein. The fibre is coarse and sometimes brittle, and though it can be worked up into a soft fluffy mass it lacks toughness and tensile strength, and would not yield either of the higher grades of asbestos product.

The smaller veins, varying in width from $\frac{1}{8}$ to 1 inch, contain a slightly better grade of fibre, but the depth to which they have been exposed is not sufficient to fairly demonstrate the quality.

At present the deposits are handicapped by two things; one is their situation at an elevation of about 2,000 feet above the main Okanagan valley, and the other is the limited quantity of visible serpentine in which asbestos could form. The quality of such fibre as is now exposed is inferior, but it would be unfair to condemn the deposits from this standpoint alone, when so little depth has been attained in development.

SUMMIT CAMP AND VICINITY.

The group of mineral claims locally known as Summit Camp is situated on the divide between Sutter creek on the Tulameen slope and Dewdney creek on the Coquihalla slope. The distance from Tulameen village is about 24 miles, and the camp is connected with that point by a good pack trail running up the Tulameen valley.

Ore was first discovered at Summit Camp in the autumn of 1895, and more or less development of the claims has been done every year since that date. There are now nine surveyed and Crown granted mineral claims, besides fifteen or twenty others on which the annual assessment work is still done.

The country was all burnt over the year after the discovery of ore, and a great deal of valuable fir and spruce timber was destroyed. The elevation of the summit of the divide is estimated by aneroid as about 5,700 feet above sea-level. All of the mineral claims are over 4,000 feet above the sea, and some of the points in the neighbourhood reach an elevation of over 7,500 feet.

The rocks consist of argillites, limestones, quartzites, and breccias, cut through and intruded by igneous rocks of medium basic composition, in the form of dykes and sheets. In lithological characteristics they resemble strongly rocks in other parts of the district, which are classed as of Carboniferous age. They are, as a rule, thin bedded, and dip at high angles, having a general strike about N 20 W. Bordering these rocks on the east is a belt of Cretaceous rocks, but these are of no importance in connexion with metallic ore deposits.

The most pronounced planes of fracture have a strike of about N 80° E. The ore deposits are replacements, generally of limestone, in and along either side of these fracture planes. The ore minerals are galena, zinc blende, chalcopyrite and pyrite, in a gangue of quartz or unreplaced country rock. From the loose appearance of the well-formed quartz crystals in the fissures, and the incipient comb structure exhibited therein, these fissures appear to have been at one time open spaces. Ascending solutions carrying the sulphides have traversed these fissures and deposited the ores in them, at the same time replacing the wall rocks on either side for a distance of 2 or 3 feet. The fissures themselves are narrow and seldom more than 6 inches in width.

The middle portion of the ore body represents the original fissure. This portion is often completely filled with a solid mass of galena, blende, and some copper and iron sulphide. That portion of the deposit which represents the replaced wall rock contains more pyrite, and less galena and blende.

The deposits carry silver as the principal valuable metal, and though not of great size are fairly high grade. A 1,700 pound sample of picked ore was shipped to a smelter a few years ago from one of the claims owned by the Terre Haute Company, and this sample is reported to have yielded 215 ounces in silver, $12 in gold, and 4 per cent in copper. Lack of good transportation facilities has retarded the development of this camp.

During the early spring of 1910, some 20 coal claims were staked out on a belt of Cretaceous rocks lying directly east of Summit Camp, and between the main Tulameen river and its south fork. This belt, at the mouth of Sutter creek, is probably 3 miles wide, and strikes slightly east of south. It is probably continuous with a belt of Cretaceous rocks found on the International Boundary line between Pasayton and Roche rivers, and may also extend northward to connect with other Cretaceous rocks in the valley of the Fraser river.

On the west these rocks rest on the ore bearing rocks of Summit Camp, and on the east on a sheared and gneissic granite which is probably continuous with the Eagle granite of the Tulameen sheet. The basal formation of the Cretaceous on the west is a coarse conglomerate, containing water worn boulders of quartzite and argillite, as well as of plutonic and volcanic igneous rocks. This bed dips at a high angle to the east and rests unconformably on a volcanic andesite.

On the eastern border the basal bed is a volcanic breccia, above which is a hard conglomerate, having a dip of 50° to 70° to the southwest. Above the conglomerate beds on both sides of the belt are massive sandstones, and black, grey, and reddish argillites. The whole basin is clearly synclinal in structure, though it shows minor folds towards its centre.

The sandstones and argillites are cut by dykes of granite, and syenite porphyries and andesite. Faults are of common occurrence.

No coal, either float or in place, was found in this part of the basin. It is, however, quite possible that it may exist, for rock exposures are not very abundant, and the drift is so widespread that the outcrop of a coal seam may easily be covered. It is reported that a thin seam of coal, and some narrow lenses, have been found in this belt farther to the south. Very thin seams of coal undoubtedly have been found in the Roche River district to the south, in rocks which are of the same age and presumably in the same basin as this.

BEAVERDELL DISTRICT, WEST FORK OF KETTLE RIVER, BRITISH COLUMBIA.

(*L. Reinecke*).

The season was spent in finishing the topographic map of the Beaverdell district, which was begun last year. The work was primarily topographic, but attention was given to the geology whenever time could be spared from the topographic work. An area of 162 square miles was mapped on a scale of 4,000 feet to one inch, $\frac{1}{48000}$. The primary and secondary control were obtained by transit triangulation and plane-table intersection, the detail by plane-table and stadia, and plane-table and tape traverse. Work was started on May 25, and the traversemen had all left the field by October 16. After attending to a few details necessary in finishing the topography, we left the field on October 27. Messrs. Chas. C. Galloway, W. G. Hughson, and Karl A. Clark assisted in topography throughout the season. Mr. Ernest Bartlett acted as traverseman up to the end of July, when his place was taken by Mr. F. H. McCullough. Mr. John Stansfield assisted in both topography and geology. My thanks are due these gentlemen for the unfailing interest they showed in their work.

LOCATION.

The area mapped lies in the valley of the West fork of Kettle river, in southern British Columbia. It is included between longitudes 118° 55′ and 119° 10′; and latitudes 49° 25′ and 49° 37·5′. Its southern boundary is 43 miles by wagon road from Midway, on the International Boundary, and almost 23 miles above where the West fork joins the Kettle river. Within the map sheet occur the silver-lead ores of Wallace mountain, the gold-silver ores at Carmi, and the gold and copper prospects of Triple lakes, Knob hill, and Arlington mountain.

HISTORY.

An account of the mining history of the district was given in the Summary Report for 1909.[1]

General Character of District.

TOPOGRAPHY.

A description of the topography was given in the Summary Report for 1909. This description is in the main correct, though the map does not take in as much of the drainage of the main Kettle as was proposed. The completion of triangulation also, has shown the elevation of the higher points within the map to lie between 5,600 and 5,760 feet above sea-level, making the maximum relief within the sheet between 3,200 and 3,300 feet.

A few other facts brought out more clearly by the topographic map may be mentioned here. A series of mature uplands is the most general and striking feature of this part of the Interior Plateau. The main drainage, on the other hand, occupies valleys in which the topography is in a more youthful stage. The present land aspect

[1] On the Beaverdell District, West Fork of Kettle River, B.C., by L. Reinecke. Summary Report of the Geological Survey Branch, Dept. of Mines, Canada, for 1909.

is, therefore, evidently the product of several epochs of erosion. A well marked upland, in which all evidences point to advanced maturity, occurs between the elevations of 4,000 and 4,600 feet. It is well represented in the northeastern part of the map. Above that is another, not quite so well developed, and carved out of what were once extensive volcanic flows. It is thought that at the time the volcanics were laid down on the lower plateau its topography very closely resembled that of to-day.

The valleys show a marked tendency to follow north-south and east-west directions. These are also the more common directions of fault planes in the underlying rocks, and were probably directions of structural weakness in overlying rocks long since eroded away. It may be inferred that the present valleys are the sites of the lines of drainage of the old uplands or plateaus.

The steep sides and flat bottoms of a few of the more important valleys are due to the effects of glacial erosion. Since glacial times the tributary streams, in getting down to the new level of these valleys, have cut gorges near their mouths. These gorges represent the youthful stage of a new epoch of erosion. A further change is recorded in the series of terraces representing old river bottoms left upon the valley sides. They probably represent uplifts since glacial times.

FLORA.

The following plants were collected by Mr. Karl A. Clark in two localities in the Beaverdell district. Both localities are in open valley bottoms, the higher at an elevation of 2,800 feet, and the lower at about 2,500 feet above sea-level. It is hoped that the list may be of interest to those studying the flora of British Columbia. The specimens were identified by Professor John Macoun of the Geological Survey. Popular names are put in parenthesis after the scientific.

1. *Pentstemon confertus,* Dougl. (Beard tongue).
2. *Antennaria parviflora,* T. and G., *var. rosea* (rose-coloured everlasting).
3. *Eriogonum heracleoides,* Nutt.
4. *Pyrola asarifolia,* Hook. (Liverleaf wintergreen).
5. *Erigeron speciosus,* DC. (Large flowered fleabane).
6. *Geum triflorum,* Pursh.
7. *Campanula rotundifolia,* L. (Scotch harebell or bluebell).
8. *Achillæa millefolium,* L. (Yarrow).
9. *Senecio balsamitæ,* T. and G., (Balsam groundsell).
10. *Lupinus laxiflorus,* Dougl. (Loose flowered lupine).
11. *Galium boreale,* L. (Northern bedstraw).
12. *Spiræa betulifolia = glauca,* Green.
13. *Astragalus campestris,* Gray. (Prairie milk vetch).
14. *Epilobium angustifolium,* L. (Willow herb).
15. *Zygadenus elegans,* Pursh.

General Geology.

TABLE OF FORMATIONS.

Quaternary	River deposits, glacial till.
Miocene	Basalt, andesite, and dacite lavas.
Oligocene (?)	Volcanic breccias and tuffs.
Jurassic (?)	Granodiorite batholiths.
Pre-Jurassic	Limestones, argillites, cherts, with interbedded volcanic matter and intruded dykes.

PRE-JURASSIC.

A series of limestones, jasperoids, and argillites occur in patches or narrow strips within granodiorite, in the southeastern part of the district. They are accompanied by interbedded volcanic matter, and intrusive aplite, augite-porphyrite, quartz porphyry, and younger feldspathic dykes. The sediments are all intensely metamorphosed, and almost all traces of bedding have disappeared. The interbedded volcanic matter appears to be of nearly the same age as the argillite or hornfels with which it is associated. The intruded dykes are of much later age. The mode of occurrence of the sediments, and the relations at the contacts with the granodiorite, indicate that they are older than the latter. It has been suggested that they are remnants of a sedimentary roof at one time covering the batholith. No fossils were found in them. They resemble strata found in the Boundary district, which have been provisionally classed as Palæozoic.

JURASSIC.

Most of the area examined up to an elevation of about 4,500 feet is underlain by granodiorite. Four types were recognized in the field. They vary in composition from a basic diorite to a rock closely resembling the Nelson granite, and represent several distinct intrusions.

TERTIARY.

Volcanic rocks of Tertiary age occupy the higher points. They consist of breccias and tuffs, overlain by dacites, andesites, and basalts. The breccias and tuffs are found in the region around Goat mountain, in the south. They have been assigned to the Oligocene through their resemblance to tuffs of that age in the Boundary district. No shales or sandstones were found with them.

Dacites, andesites, and basalts overlie the tuffs at Goat mountain, cap the high hills around the Nipple, and are found in patches in the northeastern half of the sheet. They are classed as Miocene.

RECENT.

Recent deposits consist of glacial till, talus, and river deposits. A thin mantle of glacial drift is found over most of the uplands. The river deposits, consisting partly of resorted glacial materials, are found in the form of terraces on the valley sides. There are series of them in some places ranging in elevation from 10 to over 100 feet above the present stream bed.

Economic Geology.

An account of the silver-lead ores on Wallace mountain, and the gold-silver ores at Carmi, is given in the Summary Report for 1909[1]. The Sally mines, on Wallace mountain, were shut down last winter, and very little mining has been done since. A railway is now, however, being built from Midway through Beaverdell. This will eliminate the long and expensive hauling of ore by wagon to Midway, which has been one of the chief hindrances to the opening up of the district. Renewed activity may be expected in the Wallace Mountain camp on its completion.

[1] On the Beaverdell District, West Fork of Kettle river, B.C., by L. Reinecke. Summary Report of the Geological Survey Branch, Dept. of Mines, Canada, for 1909.

SLOCAN DISTRICT, BRITISH COLUMBIA.

(O. E. LeRoy.)

The Slocan geological map sheet comprises an area of about 260 square miles, in the mining divisions of Ainsworth and Slocan, British Columbia. It includes all the mining centres from Fourmile on the south to Whitewater basin on the north; the east and west boundaries are Kootenay and Slocan lakes respectively. The field work, which is now completed, occupied the greater part of two seasons, during which period the writer was assisted most efficiently by Mr. C. W. Drysdale. Messrs. S. A. Hutchinson and R. Bartlett were appointed to the field staff of 1910, and both rendered material aid. The hearty co-operation of the mine owners and superintendents was of great assistance in facilitating the work connected with the examination of the mines.

During the midsummer of 1910 a portion of the district was visited by a most disastrous and fatal fire, in which six lives were lost and a large amount of valuable property wes destroyed. The Kaslo and Sandon railway was completely crippled as far east as Sproules. An irregular service has been kept up between Sproules and Kaslo, but this will be discontinued through the winter. It is to be hoped that the policy of the Great Northern Company will be to repair and rebuild the road at an early date. In the meantime a wagon road, built from Three Forks on the Canadian Pacific railway to Whitewater and to the Rambler Cariboo mine, is being utilized. The Canadian Pacific railway, only temporarily affected by the fire, operates a line from Sandon to Roseberry, where connexion is made with the lake service to Slocan city.

TOPOGRAPHY.

The Slocan district lies within the Selkirk system, which is here composed of a series of rugged ridges without any general trend. The crests are usually sharp, the general altitude varying from 6,000 to 8,000 feet above sea-level. The slopes are either bare, or covered by a mantle of wash or glacial drift of varying thickness.

A marked feature of the district is the transverse valley which extends from Kaslo to New Denver, with a low divide at Bear and Fish lakes, separating the drainage systems of Kaslo creek and Seaton-Carpenter creeks, which flow into Kootenay and Slocan lakes respectively. Schroeder creek, flowing into Kootenay lake, and Wilson and Fourmile flowing into Slocan lake are other important streams. The tributaries of all the main streams flow with steep gradients, with many local falls and cascades, and either enter the main valley at grade, or by a series of small falls through narrow gorges.

Water-power has been developed at several points to suit local requirements for mines and towns. Of the undeveloped powers the most important are the falls on Wilson creek.

GENERAL GEOLOGY.

The rock series underlying this district are the Shuswap, Selkirk, and Slocan, of which the former is Pre-Cambrian. The relative ages of the Selkirk and Slocan series have not yet been fixed with any degree of definiteness, owing to the apparently entire absence of fossils. The present contact relations between the three above series is to be accounted for by intense folding, accompanied by overthrust faulting during the later epochs of mountain building. The biotite schists of the Shuswap are in sharp contact with the softer green schists of the Selkirk, and those of the latter are similarly related to the black slates of the Slocan series.

Near the border of the Selkirk small infolds of the Slocan series are occasionally to be found, while along the Blue ridge summit there is a marked syncline, passing southwards into a monoclinal fold, the central portion of which is composed of rocks lithologically identical with those of the Slocan series.

In Jurassic, or post-Jurassic time the above series were intruded by enormous batholiths of granitic rocks, and mountain building processes continued long after this intrusion, as evidenced by the folded and faulted dykes and sills genetically connected with the batholith.

The Tertiary period is not represented in this district, and the Quaternary only by limited areas of glacial drift and alluvium.

Shuswap Series.—The Shuswap series is developed as a comparatively narrow band along the west shore of Kootenay lake, broadening somewhat in its northern extension beyond Schroeder creek. The series consists of interbedded acid and basic gneisses, hornblende, and biotite schists, quartzites and crystalline limestones, with intercalated sills of granite, quartz porphyry, diorite, etc. The general strike makes a slight angle with the trend of the shore line, and varies from N 15° W to N 25° W, with southwest dips ranging from 45° to 85°. The series also occurs along the east shore of Kootenay lake, and the west shore of Slocan lake in isolated exposures.

Selkirk Series.—The Selkirk series occupies a roughly triangular area in the north and northeast part of the sheet, and is composed, in the main, of rocks of igneous origin, with but a small development of sedimentaries. Hornblende, chlorite, and quartz schists predominate, with subordinate breccias, partially sheared eruptives both acid and basic, silicified ash rocks, cherts, quartzites, and limestones. Of the basic eruptives, dykes and masses of serpentine are of most frequent occurrence. The general strike of the series corresponds with that of the Shuswap, and in the northern extension of the series gradually swings to the west. With the exception of a portion of the Blue ridge syncline, the dips are prevailingly to the southwest and south.

Slocan Series.—This series occupies the main area of the sheet south and west of the Selkirk. It is composed of interbedded sandstones (passing into quartzites), argillites, slates, and limestones, with all grades of transition between the main types. The slates are usually highly carbonaceous, and in a crushed form become graphitic. The quartzites and sandstones are usually impure from clayey and calcareous material, and the limestones are both carbonaceous and argillaceous.

In the zone of contact metamorphism surrounding the granodiorite batholith, the above rock types have been altered to andalusite, biotite, and quartz schists, hornstone, crystalline limestone, and marble.

The series lies in an irregular basin, the rocks overlying the Selkirk on the east margin, and apparently the Shuswap on the west, although the Selkirk may also be present but concealed by the waters of Slocan lake. No basal beds are exposed, but sandstones and quartzites are predominant in the west, while limestone is a more prominent member of the eastern portion of the series. In the west the strike of the rocks is northerly, in the main, but gradually swings to the east and south of east, roughly corresponding to the trend of the contact between the Slocan and Selkirk series. The dips are usually high, and are rarely under 40°.

IGNEOUS ROCKS.

With the exception of those rocks peculiarly associated with the Shuswap and Selkirk series, the igneous rocks are later than the Slocan series. The oldest group occurs chiefly as sills in the slates and quartzites; they are completely altered and now consist of secondary quartz, carbonates, mica, and chlorite.

To Jurassic or post-Jurassic time is referred the enormous batholithic intrusions of granodiorite and other closely related plutonic rocks which occupy so large an area in the West Kootenay district. The northern part of the Nelson batholith occupies the greater portion of the southern border of the Slocan sheet. The rock varies from mica and hornblende granites to granodiorites, and even more basic types. They range from medium to coarsely porphyritic in texture, and in colour from light grey to almost white. Genetically connected with this batholith is the great series of sills, dykes, bosses, and stocks of finer grained porphyritic varieties of the above plutonics, which are widespread throughout the area, with the greatest development in the rocks of the Slocan series.

At a somewhat later period all the older rocks, both sedimentary and igneous, were cut by basic, mica lamprophyre dykes, and these represent the last evidences of igneous activity in the district.

Economic Geology.

Silver-lead and zinc deposits occur in the granitic rocks of the Nelson batholith, and in the Selkirk and Slocan series, the most important and numerous ore bodies being found in the Slocan slates.

In the Selkirk the ore bodies occur in the greenstones and schists, and have been found hitherto to be too small and of too pockety a character to render them important products. In the granitic rocks the ore bodies occupy fissures or zones of fissuring, which may correspond to the local master jointing in the rock. The fissure may be several hundred feet long, with a width varying from that of a knife blade to 5 or 6 feet. Both wet and dry ores occur in the granite; examples of the former are the Fisher-Maiden, Mountain Con, and Flint mines; and of the latter the Molly Hughes, McAllister, Sweetgrass, etc. In the rocks of the Slocan series the fissure system is best developed and contains the largest veins and ore bodies. The veins vary in length from a few hundred to about 4,000 feet, and in width from a few inches to 50 feet. They almost invariably cut across the strike or dip of the formation, bedded veins being quite rare. In such a wide area the strike varies greatly, and the dips range from 30° to 80°. The veins either end by swinging in on the bedding plane of the slates and quartzites, or feather out in the broad bands of softer slates. Faulting is difficult to detect on account of the similarity of the rocks; it is only where sills of porphyry occur that the small displacements may be seen.

Where the vein is wide the filling is largely crushed and broken country rock. Siderite, quartz, and calcite are the most common of the gangue minerals, and the deposits are characterized by having one of the above either as the predominant or as the almost exclusive gangue mineral.

The ore shoots are usually composite in character, and consist of irregular bands, lenses, and masses of clean galena or zinc blende, and intimate mixtures of the two.

The shoots vary from a few feet to 400 feet or more in length, and from a few inches to 40 feet in width. As a rule, the pay streaks of high grade ore favour the hanging wall, and vary from a fraction of an inch to over 5 feet in width.

The ore bodies favour the softer slates and sandstones which are more carbonaceous, rather than the quartzites and porphyries, but there are some exceptions in which the reverse is true.

The ores are classified under wet and dry; the former having calcite or siderite as gangue with the galena, while the latter have quartz. Galena, and blende, with tetrahedrite (freibergite, grey copper), are the chief metallic minerals. Ruby and native silver, and argentite are found in a few deposits. Chalcopyrite and pyrite are almost invariably present, the former in small amount, and the latter in increasing quantity as the lead content decreases.

At present the values of the ores mined range from about 7 per cent lead, and 20 ounces of silver, to the ton—which is low grade concentrating ore—to the high grade ore which ranges from 50 per cent to 75 per cent lead, and from 80 to 175 ounces of silver per ton. The dry ores run high in silver, with low lead content. Gold occurs in many of the ores, with assay values from $1 to $7 per ton.

MINING.

The following is a list of the producing properties of 1910:—

Whitewater, including the Deep, Rambler-Cariboo, Lucky Jim, Hope, Richmond, Eureka, Slocan Star, Van Roi, Standard, Hewitt, Bismark, Flint, Emerald, Utica, Ohio, Panama, McAllister, Payne, Evening, Bachelor, Idaho-Alamo, California, Molly Hughes, Noonday, Buffalo, and Fisher Maiden. The amounts produced by the above individual mines range from half a ton to about 4,000 tons. Steady development has been carried out on the Washington, Noble Five, Surprise, Twilight, and Sunset, with minor work on the Twilight, Jackson, Rio, Winona, Charleston, Sure Thing, Jo Jo, Milton, Monte Cristo, Sweet Grass, Elkhorn, Ya Ya, and several other properties.

Whitewater.—The Whitewater includes the Deep property, as both are on the same vein, and are operated under one management. The destruction of the mill and village by fire in July caused a temporary cessation of mining operations. During 1909 a cross-cut tunnel was driven to the vein from the valley of Kaslo creek, which gives a vertical depth of about 1,400 feet below the apex of the vein, and about 400 feet below the Deep or lowest drift tunnel. The upraise to connect with the present workings will be completed this winter, and at the same time intermediate levels and cross-cuts will be driven to prospect the vein between the main cross-cut and Deep tunnels. This is the most important development work recently undertaken in the Slocan district, and the results obtained will have a marked influence on further developments of similar character elsewhere in the district.

Lucky Jim.—This mine is the only one worked almost exclusively for zinc in the district. During the year of 1909 about 4,700 tons were shipped, with zinc content ranging from 39 per cent to 54 per cent. In 1910 No. 5 tunnel has been driven 200 feet vertically below the old workings, and has encountered two ore bodies, the size and character of which has not yet been definitely ascertained. No. 6 cross-cut is now being driven some 400 feet vertically below 5. The work this season was greatly hampered by the fire which destroyed all the buildings.

Rambler-Cariboo.—Mining was seriously interrupted by the fire which destroyed the buildings in July, and the mine was only put on a working basis again in the early part of November. The ore body discovered in 1909 has been partially developed on the eighth and ninth levels, with very encouraging results. The shoot pitches to the south, and all the lower levels will be driven in that direction during the winter and the ground thoroughly explored. The development work is sufficiently advanced to permit immediate and extensive stoping. The clean lead ore carries up to 64 per cent lead, and 175 ounces of silver per ton.

Hope.—The Hope mine, situated at Sandon, is still in the development stage, and the ore so far stoped has come mainly from drifts and raises. Four drift tunnels have been driven on the vein, and a fifth has been started. The most productive portion of the vein lies in the eastern half of the mine, between the second and fourth levels. There the ore body is made up of a series of lenses, the whole pitching rather flatly to the east or out of the hill. The ore is high grade throughout, from the large admixture of grey copper in the lead and zinc. With the completion of the lowest tunnel and the necessary raises to No. 4, the mine will be in a position to make steady and large shipments.

Richmond-Eureka.—This mine, owned and operated by the Consolidated Mining and Smelting Company of Canada, is situated at Sandon, on the opposite side of the gulch from the Slocan Star, the vein being the eastern extension of the Star vein. Up to June 30, 1910, the mine has produced and shipped 7,958 tons of ore, containing 443,938 ounces of silver, and 2,848,743 pounds of lead, the gross value being $334,648. The lowest, or No. 6, is a joint tunnel with the Slocan Star, as at this level the vein traverses the ground of both companies. The main work of the latter Company in recent months has been to develop the extension of the Richmond vein, both on No. 6 level and through the Slocan King tunnel.

Standard.—The Standard is situated on Fourmile, above Silverton. The large ore body developed on the lower levels has been the most important feature of mining development during 1910. The ore body is the continuation of that stoped on the level of No. 1 tunnel, and has steadily improved with depth, both in size and values. On No. 4 it is about 320 feet long, with clean ore varying in width from a few inches to 9 feet. On No. 5, when the drift was about 100 feet in the ore shoot, the vein had widened to 30 feet, with 23½ feet of ore, at one point over 12 feet being clean galena. The present shipments come only from development, the clean ore carrying from 70 per cent to 73 per cent lead, and from 80 to 90 ounces of silver to the ton.

No. 6 tunnel is now being driven, but is not in far enough to catch the ore body on its pitch. This level is 573 feet below No. 1.

Van-Roi.—The Van-Roi mine is situated on the south side of Fourmile, and just east of Granite creek. There are at least two veins on the property, and both are being developed at present. They are not quite parallel, but approach each other in their eastward extensions. They are known as the main or north, and the Beryl or south veins respectively, and have been partially developed by nine tunnels covering a vertical range of about 1,000 feet. In the past the ore was mainly won from the large ore bodies in the main vein, but recent developments are proving the existence of a large shoot in the south vein, which in future will probably produce the greater bulk of ore. Only development work is being done at present, and stoping will not be started until the new mill at the junction of Fourmile and Granite creeks is completed. An aerial tram-line now being installed connects No. 5 level with the mill.

Up to the end of 1910 the total production has been 78,203 tons. The ore is of the dry type, is low grade in the main, with lenses of high grade ore, and is characterized by having, as a rule, considerable ruby silver. The average of the metallic content of the ore for June, 1910, was 18 ounces of silver, 7·75 per cent lead, and 12 per cent zinc.

Hewitt.—The Hewitt joins the Van-Roi group to the west, and is on the same zone of fissuring. The mine buildings have been transferred to the east side of the ridge across which the vein outcrops, and the mine is connected with the Wakefield mill by an aerial tram. On the east side of the ridge the vein system is developed by seven drift tunnels. During the past two years development only has been carried on, and ore shipped has come from such work. The vein system on the second and third levels consists of the north, main, south, and main south veins. The two former join to the east, and the main is connected with the main south by the south vein. The largest ore bodies occur in the north and main veins, continuing down to and below the sixth level on the north vein. East of the main ore bodies, there are in the north vein smaller shoots of high grade, containing ruby and native silver, with considerable grey copper.

The Washington, Surprise, Noble Five, and Sunset have been engaged in development work only, and have made no shipments during the past year.

The Washington-Slocan Boy vein has been opened up by four main tunnels, with some intermediates. No. 1 is being driven through the hill in order to prospect the ground for bodies of clean lead, or high grade ore. Below No. 1 an important body of zinc blende, containing some lead, is being blocked out on and between the several levels.

The Surprise raise has been driven almost continuously since the autumn of 1909, and it is expected that connexions will be made with the old workings in Surprise basin some time early in 1911. With the raise completed active prospecting of the vein will be commenced.

On the Noble Five, the Deadman vein has been opened up by four drift tunnels and the ore body has been partially blocked out. Work on the Noble Five vein will be extended during the winter. A certain amount of ore has been taken out during the past year, but none has been shipped.

The Sunset is still driving No. 8, or the lowest tunnel, but with changed course, to bring the level directly under the projection of the ore body which extends downward from the seventh level.

Of the properties at present idle the more important are the Payne, Queen Bess (Queen Dominion), Reco, Alamo, and Bosun. All of them contain blocks of ground which should, in the light of past experience, prove favourable for ore bodies. With the exception of the Payne, which would require a lower adit level 600 or 700 feet below No. 5, the other properties have sufficient levels already driven, and the ground could be immediately prospected by upraises, with intermediate drifts and cross-cuts.

Such development as indicated would, of course, necessitate a varying amount of initial capital, and in the case of a lease, the owners ought to allow most liberal terms, and depend mainly on the benefits resulting from the proper development of their properties.

Deadwood Camp, Boundary District.

A small area in the Deadwood camp, consisting of about one-half of a square mile, was geologically mapped on the scale of 400 feet to 1 inch. It includes the Mother Lode, Crown Silver, Sunset, and Marguerite mines, and the map will be similar in character to those previously made of the Rossland and Phœnix camps. The areal geology was in charge of Mr. C. W. Drysdale, while the writer devoted his time to a study of the ore bodies and associated rocks. The area will be the subject of a special report which is now in course of preparation.

Franklyn Camp.

A week was spent in the Franklyn camp, on the north fork of the Kettle river, and a general examination of the geology and ore deposits was made, sufficient data being collected to outline detailed work for another season.

TOPOGRAPHICAL WORK IN THE SLOCAN AND DEADWOOD DISTRICTS.

(*W. H. Boyd.*)

The mapping of the Slocan district, begun last year (1909), was continued during the past season (1910). The methods employed were the same as those used the previous year, namely: camera, plane-table and stadia, compass and telemeter.

It was intended to complete the Slocan work this year, but, unfortunately, the dense mantle of smoke that hung over the country generally, and particularly over the Slocan district—due to the prevalence of forest fires—almost entirely prohibited camera station work from the middle of July to about the end of September; hence, it was impossible to obtain the information necessary for the complete mapping of the area.

One very disastrous fire swept over part of the area embraced by the map sheet, resulting in the loss of human life; the destruction of mining and railway property; the burning of much valuable timber, and the complete wiping out of the small town of Whitewater.

During the latter part of July and all of August, the time was occupied in obtaining as much information as possible by running traverses. Some camera stations were occupied during this period.

On August 29, the party moved to the Deadwood district, where a detail map of the vicinity of the Mother Lode and Sunset mines was made on a scale of 400 feet to 1 inch, with contour lines at 20 foot intervals. This map was completed by the end of September, as the smoke did not interfere with instrument work on this particular scale. The area embraced by the map is about one-half a square mile, and includes the Mother Lode, Sunset, and Marguerite mines. The method employed was: transit and stadia control traverses, cutting the area into small blocks; the detail being put in from the control hubs by plane-table and stadia.

On September 19, accompanied by Mr. Sheppard and one assistant, I went back to the Slocan district, in order to determine if it were possible to secure enough camera stations to complete the mapping. The remainder of the party was left, under Mr. Lawson's superintendence, to complete the Deadwood work. After arrival in the Slocan, rain fell almost continuously, consequently, while some results were obtained, it was found impossible to finish the work; the rain continuing nearly every day, with an ever increasing amount of snow on the higher levels, rendered station work prohibitory.

On October 3, the field season closed. Leaving the Slocan, I joined the Director at Nelson, and accompanied him to Frank, Alta., where a day was spent on Turtle mountain, after which I left for the east.

Messrs. W. E. Lawson and A. C. T. Sheppard were attached to the party as topograhical assistants, and both rendered efficient service. Messrs. E. E. Freeland, J. R. Cox, D. B. Cole, and H. F. Collier, were appointed as field assistants and did their work in a satisfactory manner.

On the way west, early in the summer, a few days were spent with Mr. W. A. Johnston, in connexion with the mapping of the area in the vicinity of Barrie, Ont. During the last week of July a visit was made to Mr. Reinecke's camp on the West fork of Kettle river; for the purpose of looking over the area included in the map sheet on which he was engaged, to see the progress of the work, and to inspect the methods used. A similar visit was made during the latter half of August to the parties working on Vancouver island, under the supervision of Mr. R. H. Chapman.

RECONNAISSANCE IN EAST KOOTENAY, CRANBROOK SHEET.

(Stuart J. Schofield.)

The season of 1909 was spent in completing the geological and topographical mapping of the Cranbrook sheet, an area in southeastern British Columbia enclosed by 115° 45′ and 116° 30′ west longitude, and 49° 30′ and 49° 45′ north latitude, embracing an area of about 575 square miles. A base line $1\frac{3}{4}$ miles long was measured on the St. Mary prairie and expanded into the main triangulation of the sheet. A trip was made to the International Boundary line for the purposes of correlation with geographical formations recognized in the Boundary survey. The writer was ably assisted in the field work by Messrs. L. E. Wright and R. Bartlett. The field season lasted from June 5 to November 17. The rocks and some of the prospects occurring in the area were described in the Summary Report of 1909.

SUMMARY AND CONCLUSIONS.

The region is underlain by a very thick, conformable sedimentary series, which is Cambrian or Pre-Cambrian in age. It is intruded by numerous sills of variable composition and small cross-cutting bodies of granite and granite porphyry. The principal ore-deposits of the area occur in the Kitchener formation, and are probably associated with the Purcell sills and the granite intrusives. The proper exploitation of the numerous copper deposits, which are low grade in character, will require economical management, and the bonding together of a large number of claims, in addition to good transportation facilities. The silver lead ores are now mined at the Sullivan mine, and successfully treated at the Consolidated Mining and Smelting Co.'s smelter at Trail.

The structure of the region is anticlinal, caused by mountain-building forces acting in post-Jurassic times.

General Geology.

The division of the sedimentary series into the three subdivisions, Creston, Kitchener, and Moyie, is based solely on lithological characters and structural relations; fossils were diligently sought for at all horizons, but without success.

TABLE OF FORMATIONS.

Pleistocene and Recent	Unconsolidated gravels and sands.
Jurassic ?.......................	Dyke intrusions; aplite, quartz porphyry, and pegmatite. Granite ; hornblende granite, granite porphyry.
Cambrian ?.	Moyie formation ; argillites, argillaceous quartzites, limestones, quartzites. Dyke intrusions ; lamprophyrs. Purcell sill intrusions ; sills probably of three types :— (1) basic : abnormal gabbro. (2) acid : abnormal granite. (3) differentiated : abnormal gabbro phase at bottom gradually passing into granite at the top. Kitchener formation ; argillaceous quartzites, quartzites, argillites, limestone. Creston formation ; argillaceous quartzites, quartzites, argillites, limestone.

Creston Formation.—In the western part of the area this formation consists of well-bedded quartzites and argillaceous quartzites, the beds having average thicknesses of 1 foot. separated by very thin beds of argillite. These sediments are a light grey colour on fresh fracture. and weather in grey tones. Ripple marks are present at various horizons. In the eastern part of the area, the formation becomes thinner bedded and more argillaceous; occasionally small bands of limestone occur. The estimated thickness of the formation is about 7,500 feet.

Kitchener Formation.—This formation consists of an alternating series of heavy bedded and thin bedded argillaceous quartzites and purer quartzites, the average thicknesses of which are 1 foot and 3 inches respectively. On fresh fracture, the sediments are generally a very dark grey to black. The heavier beds weather in grey tones, while the thinner beds weather a reddish brown, and, being in greater amount, give the prevailing red colour to the formation as a whole. One bed of grey limestone was found near Marysville. The estimated thickness of this formation is over 6,000 feet.

Purcell Sills.—The greater number of the Purcell sills were injected into the Kitchener formation. They were intruded probably near the close of the Kitchener epoch and before the Moyie, as no sills were found in the Moyie formation. Differentiation is well shown in some of these sills. At the bottom of each differentiated body is a gabbro phase, passing gradually into a granite at the top. The contact effect of these intrusives on the sediments is very slight.

Dyke intrusion; small, fine-grained, lamprophyric dykes are associated with the above-mentioned sills.

Moyie Formation.—This formation lies conformably upon the Kitchener formation. It is composed largely of very thin-bedded argillites, with a subordinate amount of pure quartzites and argillaceous quartzites. Near the middle of the formation limestone having a thickness of 150 feet is exposed on Whitefish creek. It is white in colour and weathers buff. Worm trails and borings were found near the base of the formation. The estimated thickness of this formation is over 10,000 feet.

Granite Intrusion.—Numerous small cross-cutting bodies of hornblende granite and granite porphyry, from 200 feet to 2 miles in diameter, cut all the sedimentary formations. They are relatively small in size, and seem to be associated with the major faulting in the region. No relation exists between this granite and the granite of the Purcell sills.

Dyke Intrusions.—Dykes of aplite. quartz porphyry, and pegmatite cut the younger granite and occur as apophyses in the sediments.

Pleistocene Deposits.—At the head of Palmer Bar creek, typical morainal material occurs, while over the whole region numerous sub-angular boulders of granite and diorite were found. Glacio-fluviatile gravels and sands are present in all the valley bottoms, and form benches on both sides of the valley.

Economic Geology.

The economic deposits of the region may be classified as follows:—

Metalliferous:—
- Silver-lead deposits,
- Copper deposits,
- Gold-quartz veins,
- Placer deposits.

Non-metallic:—
- Shale,
- Limestone,
- Marble,
- Clay.

SILVER-LEAD DEPOSITS.

The Sullivan Mining Group.—The Sullivan mine, situated about 2 miles north of Kimberley, resumed operations in January, 1910, under the management of the Consolidated Mining and Smelting Company of Canada which has a lease of the property until January 1, 1911. Prospecting of the ore body is being pursued on an extensive scale. The deposit occurs near the top of the Kitchener formation, and is a replacement of argillaceous quartzites by a fine-grained mixture of galena, zinc blende, and pyrite. The gangue, which is small in amount, consists of garnet and pyroxene intimately associated with the ore. During the first half of 1910, 6,704 tons were shipped to Trail, which yielded 46,196 ounces of silver, and 2,451,758 pounds of lead.

Mascot and Eclipse.—These claims are situated on the east branch of Hells Roaring creek, at an elevation of 5,800 feet. The vein occurs in the argillaceous quartzites of the Creston formation; it is well defined and conforms in dip and strike with the sediments, which near the vein dip N 5° E. angle 69°. The ore, consisting of galena, with a small amount of chalcopyrite in a quartz gangue, favours the hanging wall, and is associated with a band of gouge about 1 foot wide. At the bottom of a shaft 56 feet deep, which opens up the deposit, the vein is somewhat broken, but is still in evidence. About 200 feet down the hill from the outcrop of the vein, the sediments are intruded by a granite porphyry which contains large idiomorphic crystals of orthoclase in an isometric ground-mass of plagioclase, quartz, and hornblende. The following assays were supplied by the owners, Messrs. Tarrant and Angus:—

Sample.	Gold.	Silver.	Lead.	Copper.
	Ozs.	Ozs.	%	%
1	0·04	2·2	10·3	
2	0·16	0·6		
3	0·10	6·1	57·8	
4	0·24	3·4	....	1·2
5	0·11	6·8	49·4	
6	2·00	4·17	39·50	
7 (Dump)	4·80	2·34	....	4·12
8	2·20	4·69	32·11	

COPPER DEPOSITS.

The copper deposits occur as veins cutting the Purcell sills and also as impregnations or differentiations in the sills. The veins usually occupy zones of shear, their strike varies greatly in direction, and the dip is high in most cases approachng the vertical. In one or two cases, veins containing copper, with a little galena, were found at the contact of the sills with the quartzites. In one case, a vein which was very strongly defined, and about 8 feet wide in the sill, quickly pinched out in the neighbouring quartzites. The sills in which these veins occur vary from 6 feet to 2,000 feet in thickness.

McKay's Claims.—These are situated on the northern slope of Whitefish creek, and about 7 miles from where it joins St. Mary river. The vein, which is 8 feet wide, occupies a shear-zone in a Purcell sill of basic type. The ore consists of chalcopyrite and cupriferous pyrite in a quartz gangue. Sheared fragments of the wall rock occur in the vein, and along the wall of the vein the feldspars show an alignment parallel with the vein.

Sylvia.—This claim is situated about 2 miles east of Marysville, and contains a vein 7 feet wide in a coarse-grained abnormal gabbro which probably forms one of the Purcell sills. The vein contains cupriferous pyrite in a gangue of quartz and calcite.

Blue Dragon.—The Blue Dragon claim is situated about 1 mile east of the Sylvia. The vein, consisting of a number of vertical shear-zones, contains 4½ feet of workable ore, which consists of chalcopyrite and pyrite in a quartz-calcite gangue. An open-cut 20 feet long and 7 feet deep exposes the deposit.

Black Hills.—This claim, adjoining the Dragon, contains three main veins, probably in a Purcell sill of basic type. An open-cut exposed two intersecting veins which are 6 to 8 feet in width, and are filled with quartz impregnated with pyrite and cupriferous pyrite.

Yankee Girl.—This property contains a quartz vein 6 feet wide which carries pyrite and chalcopyrite as ore minerals. Cobalt bloom occurs as one of the products of oxidation. A shaft 25 feet deep, and an open-cut expose the vein. The following assays were supplied by Messrs. Angus and Tarrant:—

Sample.	Gold.	Silver.	Copper.
	Ozs.	Ozs.	%
1 (open-cut)	0·80	1·44	6·90
2 " "	0·44	4·20	2·05
3 (shaft)	trace	2·80	32·50

Cole's Claim in the Bootleg Basin.—The vein, which is 4 to 5 feet in width, occurs in a Purcell sill of basic type. It is a shear-zone filled with quartz containing some cupriferous pyrite. A tunnel 350 feet in length, at an elevation of about 7,200 feet, has been driven along the strike of the vein.

Evans Group.—Work is being pursued on these claims to determine the size of the low grade ore body.[1]

Omineca.—This claim is situated about 1 mile west of Marysville, at an elevation of 3,100 feet. The vein occurs probably in a Purcell sill. It is 7 to 8 feet wide, and contains chalcopyrite and pyrite in a quartz-calcite gangue. An inclined shaft has been sunk on the vein to the depth of 60 feet.

GOLD-QUARTZ VEINS.

A number of quartz veins occur in the argillaceous quartzites of the Creston formation on Perry creek, but only one group of claims is at present being worked.

Running Wolf.—This claim is owned by the Perry Creek Mining Company, and is situated on French creek, at an elevation of 5,000 feet. It contains two parallel veins, 100 feet apart, and each 20 feet wide, vertical and striking S 50° W; and a single vein about 30 feet wide, vertical and striking S 50° E. The veins, occurring in the Creston formation, are composed mainly of quartz with very little, if any, sulphides. The country rock is an argillaceous quartzite, well-bedded and massive.

[1] Summary Report, 1909, Geol. Survey, p. 138.

PLACER DEPOSITS.

Renewed activity in placer mining was seen on Perry creek. In addition to the hydraulicing plant of the Perry Creek Hydraulic Mining Co., Ltd.[1], a steam shovel, situated on Perry creek about 6 miles above Old Town (now called Perry Creek), after some years of idleness was put in operation during the season of 1910.

SHALE.

At Wycliffe, shale of the Creston formation, suitable for the manufacture of fire-bricks, is exposed in a railway cut. It is reported that bricks made from this shale have been successfully used in the burner of the saw-mill at Wycliffe, and in the smelter furnaces at Marysville.

MARBLE.

Situated about 1½ miles north of Wycliffe is a small area of white marble, produced by the contact effects on limestone of a granite porphyry which is here intruded into the Creston sediments. The marble is white to grey in colour, and is practically free from secondary minerals, although garnet and epidote, associated with a little pyrite and chalcopyrite, are developed immediately along the contact.

LIMESTONE.

About 16 miles up Whitefish creek a band of limestone of the Moyie formation outcrops in the creek. It is a white siliceous crystalline limestone weathering a buff colour. The band is about 100 feet wide, and would be of value for a flux, or the manufacture of lime.

CLAY.

Large quantities of clay, occurring in the Pleistocene river deposits on Perry creek and St. Mary river, could be used for the manufacture of bricks and stoneware.

---

[1] Geological Survey Summary Report, 1909, p. 138.

ICE RIVER DISTRICT, BRITISH COLUMBIA.

(John A. Allan.)

According to instructions, a survey was begun on a sheet which will include the Ice River district and the area about Field, B.C. The field season was comparatively short, extending from the middle of June until the middle of September. In order to become familiar with the various sedimentary series across that part of the Rocky Mountain belt, a rapid survey was made during the first two weeks along the Canadian Pacific railway, between Golden and Banff, the section worked up in 1886 by R. G. McConnell. July and August were spent in the Ice River area proper, which is important because it contains one of the very few igneous intrusive masses which are at present known in the whole of the Rocky Mountain belt. The igneous mass is of the alkaline type, and contains sodalite deposits; this mineral has a limited occurrence in Canada. During the remainder of the season a reconnaissance was made up Ottertail river, McArthur creek, over McArthur, Duchesnay and Dennis passes to Mt. Stephen, for the purpose of connecting up the sedimentary series in Ice river with those already determined on Mt. Stephen by C. D. Walcott.

The topographical map used was that issued by the Department of the Interior, in April, 1909, on a natural scale of $\frac{1}{150000}$, or approximately 2 miles to 1 inch, contour interval of 250 feet. This map was enlarged to 1 mile to 1 inch for field use. As the field examination of the area is not yet complete, final conclusions cannot be given on many points.

The writer was efficiently assisted by Mr. Fred. J. Barlow.

LOCATION AND HISTORY.

The area examined in the field season of 1910 is situated on the west slope of the Rocky Mountain belt, and is separated from the Rocky Mountain trench[1] by the Beaverfoot range. It includes about 100 square miles, and lies almost entirely within a 15 foot rectangle between 51° and 51° 15′ north latitude, and between 116° 15′ and 116° 30′ west longitude. It is within the Yoho park, which is reserved by the Dominion Government, and is located within East Kootenay district and Golden mining division. Ice river is readily reached by a good pack trail from Field, or from Leanchoil, which is 17 miles west of Field, on the railway, where the trail leaves the railway and follows up the northeast side of the Beaverfoot valley for a distance of 12 miles, where it crosses Ice river. This trail has been in use for over half a century, and was originally used by the Stoney and Kootenay Indians, and is known as the Kootenay trail. It continues southward down the Kootenay valley to Fort Steele.

The district has never been examined in detail. G. M. Dawson, in 1885, made a hasty visit to the mouth of Ice river, and his observations are included in his preliminary report which appeared in the Annual Report for that year.[2] He notes the intrusive mass, with the occurrence of sodalite, and gives the probable extent of the igneous body. R. G. McConnell worked out the well-known geological structure section across the Rocky Mountain belt in the vicinity of the 51st parallel.[3] During the last three years C. D. Walcott has studied the Cambrian sedimentary series about Field

[1] R. A. Daly. Nomenclature of the North Amer. Cordillera between the 47th and 53rd Parallels of Latitude. Geog. Jour. 1906, p. 576.

[2] Annual Report, Part B; 1885, p. 122.

[3] Annual Report, Part D; 1886.

and east on the Canadian Pacific railway, and his accurately measured sections have since been printed by the Smithsonian Institution.[1] The district has been thoroughly prospected during the last twenty years. Many small pockets of ore have been opened up, some of which will be described under economic geology. Prospecting has, however, been abandoned in the last two years, as the ore was not found in paying quantities. The district is especially known because of the somewhat rare occurrence of sodalite, which is found in the intrusive mass. This beautiful blue mineral has attracted many tourists into the valley, who wished to obtain specimens of this decorative stone. Ice River valley, and its parallel to the south—Moose Creek valley—are known locally as good hunting grounds.

General Character of the District.

The area under consideration lies to the south of the Canadian Pacific railway, to the west of Field, in a range of mountains, a part of which has been called the Ottertail mountains.[2] This range is continued to the northwest in the Van Horne range which is parallel to the Rocky Mountain trench.[3]

The topography of this area is very rugged, and characteristic of the Rocky mountains. Relief is very distinct. The whole district is maturely dissected, and the interstream areas have been worn down to very narrow knife-like ridges, which in many places are not a foot in width.

The intervening ridges rise from 8,000 to 11,500 feet above sea-level. The interstream divides have a fairly uniform elevation of 8,000 feet. The highest peak in the area is Mt. Goodsir—11,676 feet. Other peaks in the area over 10,000 feet high are Chancellor peak, Mt. Vaux, Hansbury peak, Mt. Sharp, and Helmet mountain. The highest average elevation is in the northern portion of the rectangle, in the range which, since it is parallel to the Ottertail valley, has been called the Ottertail mountains. In general, the average elevation decreases towards the south, and that part of the area along the Beaverfoot valley rises about 8,000 feet above sea-level. The drainage system is important, and characteristic of the region. It is largely dependent upon the geological structures.

The principal stream valleys follow the trends of folding. Beaverfoot and Ottertail rivers have a northwest and southeast trend, which corresponds to the major axis of folding in the Rocky Mountain belt. Ice river, Moose, Goodsir, and McArthur creeks, have a north and south trend, which corresponds to the axis of a later period of folding. Other smaller valleys have a northeast-southwest trend.

The valley of the Beaverfoot averages 2 to 3 miles in width; it is faintly terraced on both sides. This valley is continuous with the Kootenay valley to the southeast. The divide between the Kootenay and Beaverfoot rivers can scarcely be located, and the head branches of these streams interlock with each other. The summit has an elevation of 4,000 feet, or 250 feet above the mouth of the Beaverfoot. The Beaverfoot follows a narrow but tortuous channel over the bottom of the valley. It is joined by Ice river 12 miles from its mouth, and by Moose creek 6 miles farther up the valley.

Within 2 miles of their points of junction with the Beaverfoot the courses of these two streams turn sharply to the southwest. These facts seem to strongly suggest that the drainage has formerly been to the southeast, and a slight uplift has caused the Beaverfoot to capture some of the streams at the headwaters of the southeastward drainage system.

Ice river, which has been very appropriately so named on account of the extreme coldness of the water at all times of the year, and Moose creek, head in small hanging

[1] Cambrian Geol. and Palæontology, Smithsonian Inst., Vol. 53, No. 1812, 1908.
[2] G. M. Dawson, Annual Report, Part B, 1885, p. 122.
[3] R. A. Daly, Geog. Jour., 1906, p. 596.

glaciers, which are the last remnants of the continental ice sheet. The valley of the former is about 8 miles long; both are U shaped and have been carved out by the ice. The former existence of a valley glacier is suggested by the number of hanging valleys on the sides of both valleys. Many of the side tributaries head in glacial cirques or rock basins, some of which are readily recognized on the map; but many of the finest are too small to show on a map of this scale. Small blocks of ice may still be found in some of these cirques. Remnants of the British Columbia ice sheet are seen in the Washmawapta snowfields and the glacier at the head of Ice River valley The former lies on the east side of Moose creek and towards the head of the Ottertail; it covers an area of about 8 square miles, including smaller masses to the northwest. The glacier at the head of Ice river covers about 5 square miles, is deeply crevassed, and has a visible thickness of at least 1,500 feet. The water coming from under the ice is loaded with silt, which it deposits on the floor of the valley below. The glaciers are decreasing in size. Glacial striations and groovings are not found, on account of the rapid rate at which erosion is proceeding in this part of the mountains.

The side tributaries are fast eating back into the intervening ridge, forming in some cases large fan-shaped talus slopes, some of which are 1½ miles long, with slopes from 30° to 50°. The intervening divides are narrow, and in many places less than 2 feet wide.

Timber line is between 6,500 and 7,000 feet. The lower levels are heavily wooded with a second growth of spruce, balsam, fir, and aspen; underbrush of many kinds abounds in the valleys.

The summer season is very short, as snow begins to fall early in August, and the upper parts of the ridges are pretty well covered until the first of July, while many slopes and cañons retain snow in patches throughout the year.

Big game is becoming abundant, as it is protected within the park limits. It consists of goats, deer, grizzly, black and cinnamon bears, moose and caribou. Of these goats are especially abundant, and may be seen in large flocks on rocky slopes above timber level. Small game includes the beaver, lynx, coyote, wolverine, martin, mink, marmot, and porcupine. The last three named are abundant. Beaver are becoming abundant in the Beaverfoot and Kootenay valleys.

General Geology.

TABLE OF FORMATIONS.

As the correlation is not yet complete, only a general classification can be given, which is as follows:—

Pleistocene, and Recent	Stream deposits.	
	Glacial drift.	
Post-Cambrian	Dyke intrusions.	
	Alkaline intrusion.	
Cambrian (Upper?)	(4) Alternating hard and soft bands of argillaceous, calcareous, and siliceous shale, weathering light yellow, grey, and buff	2,975 feet
	(3) Thin-bedded siliceous dolomites and dolomitic limestones dense and hard; especially developed in Mt. Goodsir.	6,040 "
	(2) Massive blue limestone with shaly bands	1,550 "
	(1) Thin-bedded grey argillaceous slates weathering yellowish buff, underlain by dark grey argillaceous shales and slates	1,160 "
	Total thickness	11,725 feet

CAMBRIAN (UPPER?)

The oldest rocks in the area are sediments of Cambrian age, with a total thickness throughout the area of about 11,700 feet. They represent a distinctly conformable series, which can be easily subdivided into four separate formations, as shown in the table. As the examination is not yet completed they have not been given names. The beds are for the most part calcareous or dolomitic, and argillaceous. An almost complete section of the series is exposed on the west slope of Mt. Goodsir, with the exception of the first division, which forms the uppermost beds on the east side of Moose creek.

The lowermost beds consist of dark grey to light grey shales at the base, with a silken lustre. Above these are grey slates, which weather reddish, brownish to yellowish, and buff. Many of these slates contain concretions of pyrite; sometimes the pyrite appears in leaf-like impressions along the bedding, and sometimes the concretions are encased in tremolite. This slate cleaves parallel to the bedding, frequently weathering out into large thin flags. Some of these are 4 feet long, 2 or 3 feet broad, and ⅛ to 1 inch thick. The commercial importance of these slates is doubtful, as they become highly discoloured on exposure to the atmosphere. They are especially well exposed in Zinc valley, and in the east base of Chancellor peak, where they form long, even talus slopes.

These slates are overlain conformably by a band of limestone, composed of thick bedded massive blue limestone and alternating thin-bedded dolomites and limestone, which, on weathering, have a furrowed surface. This limestone band is a good horizon-marker, being traceable about the sides of Ice River and Moose Creek valleys. This band thickens towards the southeast. It has a total thickness of 625 feet at the head of Zinc valley, and increases to a measured thickness of 1,550 feet in the creek to the north of Mt. Mollison.

In Mt. Goodsir, and about Ice River valley, the limestone is overlain by thick and thin-bedded siliceous slates, dolomites, and limestones.

Much of this formation is highly fractured, and, the rock being dense, weathers readily into angular fragments. In Mt. Goodsir there is an estimated thickness of 6,040 feet.

To the south of the area these beds are replaced by soft argillaceous and dolomitic slates, which are especially well developed in the more southerly part of the ridge to the east side of Moose creek. For an elevation of 4,000 feet above the valley on the side of this ridge, there are exposed alternating bands of soft argillacous shale which weather readily into gentle slopes, and more resistant dolomitic argillaceous shales which form steeper slopes. These beds give the face of the mountain a distinctly striped appearance. Thirty-two hard bands, and the same number of soft bands, are exposed. Those accessible were measured. The whole formation has an estimated thickness of 3,000 feet. It lies conformable upon the limestone, and is intensely metamorphosed and cleaved. The cleavage planes dip almost vertically and strike S 50° E, while the beds have a general strike of east and west with a dip of 30° S. These beds were originally fossiliferous, but metamorphism has been so extensive that only small fragments can now be found. Metamorphism throughout the sediments seems to have been regional.

The age of the sedimentary rocks in the area cannot yet be definitely fixed, but from their lithologic appearances they must closely resemble those beds of the upper Cambrian as determined by Walcott in his section in Mt. Bosworth on the Continental Divide.[1] Only one fossil horizon has been found; that is in the uppermost part of the blue limestone band. The specimens found are very poor, and, although they have not yet been specifically determined, they appear to belong to the Cambrian. The fossils include trilobites, and at least one species of a brachiopod and one of a pelecypod. The genus Bathyriscus was determined by Walcott. Furthermore, in a reconnaissance up Ottertail river and over McArthur pass to Mt. Stephen, it was found that the series as exposed in the Ice River area has a higher position than those exposed on Mt. Stephen, which are placed in the middle Cambrian. It seems

[1]C. D. Walcott—Cambrian Geology and Palæontology. Smithsonian Misc. Coll. Pt. III, No. 1812, 1908, p. 204.

probable that the series in question belongs to the upper part of the Cambrian, but, until the correlation is more extensively worked out to the north, they cannot be definitely named. There is no general strike and dip to the sediments in question as the structure is anticlinal. Ore bodies of small size are found in the lower weathering slates, and in the limestone band above these slates.

POST-CAMBRIAN.

Alkaline Intrusive.—As the main object of the survey of this area was to make a study of the intrusive alkaline mass, much of the time was spent on this problem. The igneous mass covers between 12 and 15 square miles; it is very irregular in outline, and is shaped somewhat like a retort. It is an injected body and is laccolithic in character. Its southerly limit is in the north face of Mt. Mollison, where it dips steeply and conformably under the blue limestone band. The contact follows under this horizon-marker of blue limestone to Chancellor peak. Here it pinches out in the form of a sill, in which the lower contact is traceable down to the bottom of the valley of Ice river. This sill projecting from the main mass is 3 miles long, and has a maximum width of 1¼ miles. From the bottom of the valley the contact runs irregularly up the west slope of Zinc mountain, around the head of Zinc valley, and ends abruptly in the side of Mt. Goodsir. The igneous mass covers the whole dividing ridge between the valleys of Ice river and Moose creek, between Mt. Goodsir and Mt. Mollison. The lower contact may be found about 500 feet down the Moose Creek slope, where it conformably overlies the blue limestone, as is the case in Garnet mountain in Ice River valley. There is another small mass of similar syenitic rock exposed at the head of Moose creek between Mt. Sharp and Helmet mountain. This appears to be the lateral extension of the northern end of the main mass.

This alkaline intrusive varies greatly in composition and mineral constituents. The principal type is a normal light grey nephelite syenite; it is especially abundant in Zinc mountain and Sodalite creek. This rock varies through intermediate types into one very basic in appearance, made up almost entirely of basic constituents among which hornblende and pyroxene predominate. This dark type is especially well developed in the sill-like extensions on the west side of Ice river and also along the eastern side of the intrusive. In many places these two extreme types are transitional into one another. The light grey syenite is sometimes found brecciating the darker types, enclosing fragments, and sending dyke-like apophyses into the surrounding rock. These facts suggest that there were disturbing forces at work while the mass was still in a semi-plastic condition. Very few apophyses are found cutting the surrounding sediments. Pegmatitic phases are found in several places throughout the intrusive. Some consist of crystals of nephelite, and a variety of amphibole; others contain very large hornblende crystals. The largest crystals of hornblende observed were 10 to 12 inches long, and biotite 4 inches in diameter. Other minerals noticed in the darker rock types are: sphene, in excellent crystals, magnetite, ilmenite, tremolite, scapolite, zeolites, pectolite, thomsonite, serpentine, schorlomite, and sodalite. A large variety of minerals is expected from a microscopic study of the various types in this alkaline intrusive. Sodalite is an important mineral found in the igneous material; it has a deep blue colour and takes an excellent polish. It is found in places associated with the nephelite syenite, and usually occurs on or near the contact of the normal rock with the sediments. It occurs both as a mineral constituent of the rock and also as veins of almost pure sodalite. Very thin stringers may be found extending several yards from the contact. A few very small veins were found in some of the surrounding sediments. A 6 inch boulder of almost pure nephelite and cancranite was picked up near the head of the valley of the Ice river. Its position suggested that the fragment was derived from a rock-body lying to the north of the mass already mapped.

On the contact between the igneous rock and the limestone there is sometimes a band of dark reddish, dense, hard hornfels, which varies in width from a few feet to a maximum of 300 feet. It has always been found conformable with the limestone above, but the igneous body has both conformable and cross-cutting relations with the hornfels band. Microscopically, the hornfels is seen to contain muscovite, sericite, diopside, calcite, epidote, chlorite, and quartz. This band is provisionally regarded as representing the contact phase in originally calcareous sediments. Fragments of the hornfels were found enclosed in the igneous rock near the contact. Near the upper surface the igneous rock has also enclosed fragments of the limestone, which have become crystallized with a development of calcite, hornblende, and siderite.

The cross-cutting relations can be seen at the head of Zinc valley. A few apophyses also cut the siliceous and dolomitic slates on the side of Mt. Goodsir. It seems evident that the dark type of igneous rock, which represents the femic pole of the magma, was the first to solidify. It appears, however, that all varieties of types belong to one period of intrusion, as suggested by the transitions between types. These transitions may be gradual or sudden; they possibly represent immiscible portions of the magma. There is sometimes fluxional structure in the femic phase.

DYKES.

There are very few dykes in this area. Those noted are generally under 2 feet in width. They all represent very basic types, and seem to be complementary to the intrusive mass. Some have the form of sills, as they are almost conformable with the bedding of the sediments.

PLEISTOCENE AND RECENT.

The large valleys are floored with glacial detritus. This detritus in Ice River valley is known to extend at least 200 feet above the present stream, which has since cut down its broad course. The silt of the main streams coming directly from under the glaciers has formed local broad flood-plains in their valleys. Some of these plains are over a mile wide, and along the surface the stream quietly meanders. The main streams carry a large amount of sediment in suspension.

The glacial detritus has become partially re-cemented; this is seen in the banks of some of the side streams. The boulders are well smoothed, grooved, and faceted by the action of the ice. Most of the material is of local origin, but there are a few quartzitic boulders, which are similar in appearance to rocks exposed within a few miles. Small terminal and lateral moraines occur around some parts of the glaciers. There appears to be little or no plucking or berg-schrund erosion by the existing glaciers. The cirques are numerous, and are as a rule floored with glacial debris and talus.

Structural Geology.

The whole of the area considered during this season lies within one of the Rocky Mountain folds, which has a general trend of northwest and southeast. The large streams, the Beaverfoot and the Ottertail, follow this trend of folding. A later system of minor folds have their major axes striking almost north and south; it is along these folds that the valleys of Ice river and Moose creek have been developed. Ice river flows in an anticlinal valley. The anticline pitches towards the south. In Moose Creek valley the strata are synclinal towards the head, and anticlinal towards the outlet of the valley. The inter-stream ridges, and many of the higher mountains, are synclinal or monoclinal.

The cleavage in the sediments, especially about the intrusive mass, is approximately parallel to the axes of these folds. This period of folding appears to have come after the igneous intrusion, for a fragment of the syenitic rock was found enclosed along a plane of cleavage in the limestone on the top of the ridge to the south of Chancellor peak.

A shifting in the direction from which the pressure came seems to have formed other folds, and to have cleaved the argillaceous shales and slates in the direction S 50° E. Many of the sediments, especially the thin-bedded limestones, are crumpled and contorted, which on the weathered surface show miniature folds and faults.

From the present observations it appears that the intrusion came after the main period of mountain building, and was followed by a later period of folding, which was probably caused by the intrusion.

Larger faults are few in number and have small displacement. Those observed were either normal or reversed. Small breaks and slips are numerous, especially in the dense slates in Mt. Goodsir.

Economic Geology.

METALLIFEROUS DEPOSITS.

The small prospects which have been opened up in Ice River area show that the mineralization is not extensive. It is confined to the blue limestone and the underlying slates. A note will be sufficient on each of these. The workings on Mts. Stephen, Field, and Dennis were also visited: of these the Monarch mine of Mt. Stephen is alone of importance, and is the only property which has been worked during this season.

PROSPECTS IN THE ICE RIVER AREA.

Waterloo Mining Claim.—This property is located near the head of Moose creek, on the west side of the valley, at an elevation of 7,100 feet. The workings consist of two tunnels 250 feet and 50 feet long respectively. The ore-body, so far as the limited exposures showed, forms a continuous bed, conformable with the bedding of thin bedded hard, dense, quartzitic limestone, with strike of N 15° E and dip 42° N. Where seen, the ore-body was about 6 feet thick. The ore minerals are sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, and pyrite, and are usually found in separate zones of almost pure material. The pyrite is well crystallized. The gangue minerals are calcite, with some quartz sparsely disseminated through the ore. The values which have been obtained are reported to have been in copper and zinc, with low values in gold.

ZINC VALLEY MINING CLAIM.

This is only a small prospect driven 15 feet into the yellowish buff weathering slates on the south side of Zinc valley, but seems worth mentioning on account of the position of the minerals in the ore body. A band of siliceous limestone about 15 feet thick is interbedded in the slates, which strike N 75° W and dip 30° S. This less resistant band has been squeezed into lenticular masses. The mineralizing solutions have replaced the lower portion of one of these lenses. The opened up portion of the ore body is 8 feet in maximum thickness. It appears to pinch out about 15 feet down the dip. The surface outcrop of lenticular form is about 60 feet long. The ore minerals are sphalerite, galena, pyrite, chalcopyrite, arsenopyrite, and native arsenic; the gangue is calcite and quartz in small amounts. The pyrite forms a layer on the foot-wall about 1 foot thick, and a thinner one on the roof. Within the pyrite zone is one of arsenopyrite and native arsenic, which in the upper part is almost free from minerals of the other zones. The central zone contains sphalerite, with some galena and chalcopyrite. It is very irregular, sending short branches into the surrounding zones. Other pockets of ore have been found in this band of siliceous limestone in the slate.

SHINING BEAUTY MINE.

This property has been abandoned for two years. It was owned and worked by the Labourers Co-operative Gold, Silver, Lead, Zinc, and Copper Mining Company of Golden. The mine is located about 3 miles north of the bridge over Ice river, at the head of the first large creek entering from the west. A wagon road was built from Leanchoil to Ice river, with the intention of extending it up to the mine, but it was never completed, and it is now used only as a pack trail. The workings are between elevations 6,500 and 7,500 feet, and consist of three almost parallel tunnels, one above the other and about 200 feet apart. The upper one is 375 feet long, the middle one is 450 feet, and the lower one about the same length. They follow closely along the strike of the limestone, which is N 35° W and dip 72° W. A vertical vein, about 2 feet wide, of calcite, containing zeolitic material, fills a fissure in the limestone almost parallel to the strike. Pyrite and galena were the only minerals visible. Reported values are $20 in silver, zinc, and lead. Pockets of almost pure pyrite, arsenopyrite, and some bornite are found in the limestone.

MONARCH MINE.

The Monarch mine is situated on the precipitous face of Mt. Stephen, about 3 miles east of Field and 1,000 feet almost vertically above the Canadian Pacific railway. It is reached by a trail which leaves the railway about half a mile farther east on the base of Cathedral mountain. The trail passes around the cliff, clinging to the slightly projecting harder bands of blue siliceous and dolomitic limestone, and supported in places by brackets. It finally reaches this apparently inaccessible point at which the ore body outcrops, and from which a tunnel has been driven into the mountain.

The property is owned and operated by the Mt. Stephen Mining Syndicate, with Mr. James Crudders in charge. This mine is one of the earliest opened in British Columbia, and was first worked in 1885. During the past three years development has been carried on part of each year. More extensive developments have been carried on during the past year, and the first shipment of ore was made to the Trail smelter in the spring of 1910.

The ore body occurs in a broad band of bluish limestone which on the weathered surface is slightly pinkish in colour. This band is in the Cathedral formation, which is middle Cambrian.[1] Development consists of about 500 feet of tunnelling. The rock is fissured nearly vertically, and in one of these fissures the ore body occurs. The limestone is brecciated on both sides of this fissure and the fragments are cemented with calcite and ore minerals, which are argentiferous galena, with some sphalerite. The ore body is almost vertical. Its thickness is irregular—in one place as much as 15 feet. Pockets several feet in diameter of almost pure galena have been found.

The following assay from a representative sample was given by the Provincial Mineralogist in his report for 1909.[2] Gold, 0·04 ounce; silver, 6·0 ounces; lead, 50 per cent; zinc, 15-18 per cent; iron, 1-2 per cent; sulphur, 12-14 per cent; silica, 1-2 per cent; lime, 4-6 per cent. The syndicate has an air compressor at the side of the railway, which is operated by two gasoline engines. The ore is taken around the cliff on a narrow tramway and dumped down a chute with a slope between 35° and 40°, which is partly built under the talus and through solid rock to an ore bin at the side of the railway. The syndicate expects to build a concentrator at the base of the mountain in the near future. The zinc blende is intimately associated with the galena.

Other Prospects.—On Mt. Field several prospects have been opened. In the Black Prince claim a short tunnel has been driven along a vein, which cuts almost perpen-

[1] C. D. Walcott—Cambrian Geology and Palæontology. Smithsonian Misc. Coll. Pt. III, No. 1804, p. 4.

[2] Annual Report—B. C. Bureau of Mines, 1909, p. 98.

dicular to thin bedded black limestone, producing conditions somewhat similar to those on Mt. Stephen. The vein, 2 to 3 feet wide, is of almost pure argentiferous galena. Further development of this property is expected in the near future. Other prospects on Mts. Field, Stephen, Dennis, and Ottertail river contain chalcopyrite, bornite, azurite, malachite, pyrite, pyrrhotite, and arsenopyrite, with quartz and calcite gangues.

BUILDING AND ORNAMENTAL STONES.

Slate.—The grey slates in the lower part of the sedimentary series as exposed in Zinc valley and the slopes of Chancellor peak may prove of economic value as roofing material, if experiment proves them to be non-fading.

Syenite.—The normal syenite, which is comparatively free from fractures, would make a good stone, either for building or ornamental work. The amount of this material is unlimited.

Sodalite.—This mineral has a beautiful blue colour, it takes an excellent polish, and the purer material has a handsome appearance in jewelry. This mineral, as has been previously stated, is found in different localities in the border of the syenitic mass. In every case it is apparently associated with the igneous contact. Where it occurs as a mineral constituent of the nephelite syenite, this rock becomes important as a decorative stone. The sodalite also forms veins of pure mineral, varying from a fraction of an inch to an inch and a half in width. In some veins of almost pure material an undetermined brownish mineral may be seen. A small boulder of pure sodalite and cancranite was found near the head of Ice River valley, an occurrence which suggests that the sodalite of some localities is not directly in contact with the igneous rock. Minute veinlets of sodalite are found in some of the sediments a few yards from the contact. It appears that the mineral has been brought in by pneumatolytic action at the close of the intrusion of nephelite syenite. An analysis was made of this mineral from Ice river by Dr. Harrington. It is similar to sodalite found in the nephelite syenite of Mount Royal. The formula of the sodalite as derived from analyses is $3Na_2O, Al_2O_3, 2SiO_2 + NaCl$.

The following analyses of the sodalite from these two localities,[1] and also that from Dungannon, Ontario,[2] have been made by Harrington.

	Ice River.	Montreal.	Dungannon.
SiO_2	37·52	37·50	36·58
Al_2O_3	31·38	31·82	31·05
Fe_2O_3	....	0·01	....
FeO	....	....	0·20
CaO	0·35	....	....
MgO	....	....	....
Na_2O	19·12	19·34	....
Na_2O_3	....	....	24·81
Na	4·48	4·61	....
K_2O	0·78	0·27	0·79
Cl	6·91	7·12	6·88
SO_3	....	....	0·12
H_2O	....	....	0·27
Insoluble	....	....	0·80
	100·54	100·67	101·50
Specific gravity	2·220	2·293	2·295

[1] B. J. Harrington, Trans. Roy. Soc. Can. Vol. 4, Sec. iii, 1886, p. 81.
[2] B. J. Harrington, Am. Jour. Sc. Vol. 48, 1894, p. 17.

Before the material can be considered of economic importance, it will be necessary to find out its extent, which can only be ascertained by development of the property. This occurrence is worthy of consideration, as the material can be inexpensively worked, and the transportation problem is not a difficult one. Part of this sodalite property has been located by Mr. M. Dainard, of Golden.

LAKE MINNEWANKA SECTION.

(Hervey W. Shimer.)

LOCATION OF AREA.

Lake Minnewanka, or Devils lake, is about 9 miles northeast of Banff, in the Rocky mountains, western Alberta. It lies in a long, narrow valley, which in a generally east and west direction forms a pass through the ranges from the foothills westward to the Bow River valley. The lake itself occupies the western half of the valley, with a length of 11 miles, and a nearly uniform width of half a mile. Here the valley of the eastward flowing Bow river is continued in the valley of Lake Minnewanka, and this long southwest-northeast trough is crossed by the northwest-southeast valley of the Cascade river, and the southward bending Bow. Bankhead, with its coal mines, is in the valley, 2 miles west of the western end of the lake. The higher mountain tops of the region vary from 8,000 to 9,000 feet in altitude, with Mt. Aylmer exceeding 10,000.

The section here studied embraced the southern termination of the Palliser range where it rises from the northwestern shore of Lake Minnewanka, and the eastward continued valley of this lake.

PREVIOUS WORK.

In 1886 G. M. Dawson[1] published a 'Preliminary Report on the Physical and Geological Features of that Portion of the Rocky mountains between latitudes 49° and 51° 30'.'

In that report the general physiography of the region here under discussion was outlined in the chapters on the Bow valley, and on Devils lake and vicinity, and the general geology is indicated on the map in two stratigraphic groups: (1) the Kootanie, the Cretaceous coal-bearing rocks, and (2) the Limestone series, Carboniferous, and Devonian.

These larger groups were somewhat subdivided by McConnell[2] in the diagram of a section measured across the mountains eastward from the Columbia valley to the gap of the Devils Lake valley. The formation here given of the section along the valley of Lake Minnewanka are: (1) Cretaceous of the Cascade trough, (2) Banff limestone (Devono-Carboniferous), (3) Intermediate (Devonian), and (4) Castle Mountain group (Cambrian).

In the geologic map of the Cascade coal basin included in his report on this basin, D. B. Dowling[3] gives as the geological section below the Kootanie the following:—

Fernie shale—Jurassic.
Upper Banff shale—Permian?
Rocky Mountain quartzite }
Upper Banff limestone } Carboniferous.
Lower Banff shale }
Lower Banff limestone }
Intermediate limestone—Devonian.
Castle Mountain group—Cambrian.

The work of the summer of 1910 was undertaken for the purpose of determining with greater definiteness and detail the age of the various formations from the Upper

[1] Geol. and Nat. Hist. Surv. of Canada, Ann. Rept. for 1885, part B, 169 pp.
[2] R. G. McConnell, Ibid, Ann. Rept. for 1886, part D, 41 pp.
[3] 1907. Geol. Surv. of Canada, sess. paper 26b.

Banff shale to the Intermediate limestone, inclusive, to distinguish the boundaries between them, and to correlate their faunas with those of corresponding formations in other parts of America and elsewhere. To this end the formations were measured and examined in detail, and a representative set of fossils was collected from each bed in which they were found.

Geological History of the Region.

The history of this region, so far as the rocks of the eastern Rockies are concerned, began with the submergence of the entire area beneath the sea, for the Cambrian dolomites of the Castle Mountain group contain marine fossils. If the upper Ordovician and Silurian were periods of deposition for this region, all of these sediments must have been eroded before the area was again covered by the sea during the deposition of the Intermediate and Lower Banff limestones, partly at least of Devonian age. The region remained beneath the sea during the Mississippian, Pennsylvanian, and Permian, that is, during the deposition of the Lower Banff shale to the Upper Banff shale inclusive.

The sea was apparently never very deep, since minor cross-bedding occurs at intervals throughout every formation, mostly in the coarser grained beds, the calcarenites; the presence of coral reefs furnishes a similar argument. During the time of th Lower and Upper Banff shales one or more large rivers entered this sea, carrying quantities of mud. The mixture of this mud and the lime from the organisms then living should give in some of these areas a perfect natural cement. Taken as a whole, this sea became gradually shallower from the time of the deposition of the Lower Banff limestone to that of the Upper Banff shale. The coral reefs are most conspicuous in the upper portion of the Upper Banff limestone, while above this the proximity of the shore is indicated by the appearance of quartzite beds, showing the presence of sandy shores; these quartzite beds become thicker, and with progressively thinner limestone beds separating them the higher the Rocky Mountain quartzite formation is examined. About 50 feet below the top of this formation a few pebbles make their appearance with the sand; these grow into almost conglomerate beds at the top.

The succeeding condition for a part of this area at least was bog-like for a time, as about 5 feet of unevenly bedded quartzites, very full of iron nodules, separate the quartzites from the shales above. During the deposition of the Upper Banff shales the region remained more or less continuously beneath the sea, as marine fossils occur through it. The presence of Lingulæ apparently indicate a near shore deposit; these Lingula beds are likewise usually cross-bedded and ripple marked. Mud cracks are rather abundant, but were never found associated with fossils; these may indicate that this was a land surface for a time.

During probably a part of the Permian, the Triassic, and lower Jurassic, this area was land. In the upper Jurassic sediment was again deposited in the sea, forming the Fernie shale. During the Comanchean period the warping of the land surface caused the deposition of the continental formation, the Kootanie, with its coal measures indicating swamp conditions during a portion of the time, while during the Cretaceous (upper Cretaceous) the sea again invaded the region, leaving remains of the life then inhabiting it in the Upper Ribboned Sandstone deposited at that time. At the close of this period, this region, together with the entire Rockies, was elevated, folded, and faulted. The fault blocks here trend approximately north-northwest to south-southeast, with the strata tilted to the west at an angle of about 45°. Since this time of elevation the weathering agencies have worn away the softer rocks—the Fernie, Kootanie, and Cretaceous—more rapidly than the limestones, so that remnants of the former are now confined largely to the valleys, while the limestones and quartzites occupy the tops of the mountains.

LOCATION OF SECTIONS.

Since all the formations could not be studied in their entirety by making a cross section across any single fault block, sections were made across four blocks, with two minor sections for correlation.

Section I was made along the road and Cascade river from northeast of Bankhead to the junction of the river with Devils creek, the outlet of Lake Minnewanka. This gave an excellent section of the Upper Banff shale and the upper portion of the Rocky Mountain quartzite; the remainder of this latter formation and the upper part of the Upper Banff limestone were studied upon the western side of the river about 1½ miles north of its junction with Devils creek. The two parts of this section were connected by a common datum plane so that the measurements could be made exactly.

Section II began at the Cascade river just south of its junction with Stewart cañon, and was continued east-northeast along the north shore of Lake Minnewanka, that is, along the southwestern edge of the Palliser range, including the southern edges of Mount Astley,[1] the Castle,[2] and Mount Standly.[3] This section gave excellent exposures of the Upper Banff limestone (except the uppermost portion), Lower Banff shale, Lower Banff limestone, and much of the Intermediate limestone.

Section III was made rather hurriedly up the southern slope of Mount Aylmer, at the western edge of the head of Aylmer cañon. Its purpose was to get the contact between the Upper Banff shale and the Rocky Mountain quartzite, and to note if any variation had occurred in this distance in the thickness of the beds and in the detailed succession of the fauna in the Rocky Mountain quartzite and the Upper Banff limestone.

Section IV was made along the northern edge of the valley forming the eastward continuation of the Lake Minnewanka valley. The section extended from the gully at the western end of Middle lake,[4] westward along the foot of the mountains. The purpose of this section was mainly to get the lower part of the Intermediate limestone and its relation to the Castle Mountain group below.

TABLE OF FORMATIONS.

The rocks of this region are entirely of sedimentary origin; the seven formations studied consist almost entirely of limestones and calcareous shales. The following correlation of the formations is provisional; a thorough study of the fossils collected will be necessary before the correlation can be made accurate.

Permian		Upper Banff shale.
Pennsylvanian	Carboniferous	Rocky Mountain quartzite.
		Upper Banff limestone.
		Lower Banff shale.
Mississippian		Lower Banff limestone.
Devonian		Intermediate limestone.
Cambrian		Castle Mountain group.

[1] The name applied locally to the peak between Stewart cañon and the western end of Lake Minnewanka. It was given in honour of Mr. C. D. Astley, who lived at its southern foot for twenty years.

[2] Locally applied to a castle-like cliff, as seen from the lake, east of Mount Astley, formed of almost horizontal strata and separated from the rocks east and west by ravines.

[3] A name applied to the prominent projection just west of Aylmer pass, between the pass and the lake. The name is given in honour of Mr. John Standly, who was the first to operate profitably on this lake a boat for the accommodation of tourists, and thus assured the continuation of this accommodation.

[4] There are three lakes in this valley between Lake Minnewanka and the Devil's Gap, which are named West, Middle, and East lakes respectively.

DISCUSSIONS OF FORMATIONS.

Upper Banff Shale.

An alternation of heavy bedded, light grey, calcareous sandstones and thin bedded, dark grey, calcareous-arenaceous shales. The latter are especially conspicuous for their numerous black laminae. The shales often weather reddish. At frequent intervals throughout the entire thickness occur many ripple marks, mud flows, minor cross bedding, and mud cracks.

The contact with the Fernie shale above is apparently very abrupt, though the exact contact was not seen. The topmost hundred feet of the Upper Banff shale is a light grey, heavy bedded, calcareous sandstone, while the lower Fernie is an alternation of black, very fissile shale, and almost black limestone.

The contact with the Rocky Mountain quartzite below is plainly seen in the Mount Aylmer region; here the two formations are apparently conformable, but the change from quartzite to arenaceous shale is rather abrupt, with a very conspicuous development of iron concretions for 5 or 6 feet at the contact.

Marine fossils occur throughout most of the formation, though locally restricted; they are often found in beds varying from 2 to 6 inches in thickness, while above and below they are apparently entirely absent. They are very poorly preserved, and the species are confined to lingulae and pelecypods. The age, as indicated by a brief laboratory examination of the fossils, is Permian, with an apparently Pennsylvanian affinity. Thickness about 1,200 feet.

Rocky Mountain Quartzite.

An alternation of light grey quartzite and light grey limestone, the former predominating in the upper portion, the latter in the lower, where it merges imperceptibly with the Upper Banff limestone. The uppermost 50 feet contain considerable conglomerate, with rounded quartzite and calcareous pebbles up to 2 inches in diameter.

The formation is fossiliferous at intervals throughout its entire thickness, but mostly in its upper and lower portions. All the fossils indicate marine origin. About 10 feet below the top is a very light grey chert bed 2 feet thick, which is one mass of silicified fossils; about half of these are specimens of *Euphemus carbonarius* and would thus strongly argue a Pennsylvanian age, but a further study of the specimens is necessary since some apparently Permian elements are present. Exactly the same association of species here noted in this chert bed is seen in the Pennsylvanian ? of the Toroweap valley in northwestern Arizona. Thickness about 600 feet.

Upper Banff Limestone.

Thin bedded, light to dark grey limestones, fine-grained beds alternating with coarse-grained, and frequently respectively chert-bearing and chert-free. The formation below this becomes more and more shaly until it merges with the Lower Banff shale.

The fine to medium grained limestones are usually fossiliferous, often strongly so. The coarse-grained beds are as a rule free from any indetifiable fossils except crinoid joints. Thickness about 2,200 feet.

Lower Banff Shale.

Predominantly a dark grey to black calcareous shale, weathering brownish. It is typically shale below, while above it becomes more and more calcareous, until with many repetitions of shale and limestone it merges with the Upper Banff limestone.

Fossils are abundant throughout the formation, except the lower 500 feet, where none were noted. Thickness about 1,300 feet.

Lower Banff Limestone.

Heavy bedded, light grey limestone. The upper 150 feet are alternately more thinly bedded and of a darker colour, being thus transitional to the Lower Banff shale.

The formation is fossiliferous, though not conspicuously so, except in the upper portion. Fossils were found at intervals throughout the entire thickness. At about the middle of the formation the rock is very conspicuous for its dolomitic segregations: these look much like poorly preserved forms of pencil-like, branching bryozoans, or corals. Some such segregations occur in most of the beds, as likewise in those of the Intermediate limestone and the Castle Mountain group beneath. Thickness about 1,000 feet.

Intermediate Limestone.

Alternating fine to coarse-grained limestone. The rocks when struck emit a strong odour of hydrogen sulphide.

Comparatively few fossils were noted, about 600 feet below the top they were rather abundant though poorly preserved. These indicate a Devonian age. Thickness about 1,600 feet.

COAL FIELDS OF JASPER PARK, ALBERTA.

(D. B. Dowling.)

Introduction.

Great activity in exploration and prospecting work on the coal areas of western Alberta, in the vicinity of the Grand Trunk Pacific railway, was noticeable during 1910. Although the end of the completed portion of the railway was distant from the mountains about 80 miles, a force of about 20 men was employed on the construction of temporary mining works near Roche Miette, and a force of perhaps 30 men on properties between that point and the Brazeau. In the coal area on the Embarras river little was attempted, on account of litigation between rival companies; but a branch line from the Grand Trunk Pacific railway has been located, and is now being built towards it; so that shortly, it may be expected, prospecting will be resumed.

A great part of the time spent by the Survey party in the field was devoted to inaugurating a triangulation and photographic survey of the outer ranges south of the railway line, hence geological details will be confined mainly to the field thus partially mapped.

This portion, important from an economic standpoint on account of its coal areas, is also of interest to the travelling public as one of the future pleasure and health resorts in Jasper park. Hot sulphur springs, situated within 10 miles of the railway, will probably be utilized for medicinal baths. A suitable location for a town is at the mouth of Fiddle creek; and it is probable that within a few years a resort similar to Banff will be established there.

The data for the topographic mapping was obtained mostly by my assistants, Messrs. W. S. Barrows and L. H. Gass, who proved very energetic in the performance of their duties.

SUMMARY AND CONCLUSIONS.

The Nikanassin basin to the southeast, described in last year's summary, does not continue as a coal field northward past the watershed of the branches of the McLeod river, though the lower beds of the Kootanie formation, occasionally having very thin coal seams, apparently continue through to the next coal basin northward, which crosses the Athabaska river west of Fiddle and Moose creeks.

In the foothills, the upper part of the Kootanie formation which there forms the productive coal measures is brought to the surface in several places, the first of note reported being on the west branch of McLeod river, where seams have been prospected on several small branches. This productive area is interrupted by the anticlinal ridge known as Folding mountain. North of this, in the vicinity of Brulé lake, the rocks in contact with the upthrusted limestones of the first range are found to be lower Cretaceous, and contain the coal measures which are exposed south of Folding mountain. This indicates either a rapid dip northward of the axis of the anticlinal fold, or a transverse break across the direction of the outer ranges. The latter supposition is the more probable, since the formation of the Athabaska valley indicates a line of weakness, and the ledges exposed on opposite sides of the valley do not seem to be exactly in line.

The coal fields in the immediate vicinity of the railway consist, therefore, of two areas, the first, an eastward dipping series of rocks that are the eastern limb of an anticline, the crest of which is almost on the line of the fault in front of the first range.

(The western limb is probably short, and overridden by the Devono-Carboniferous beds.) These rocks slope towards the northeast, and coal exposures have been found north of Brulé lake. Should the seams be found to the south of the lake, their proximity to the railway would be of great advantage in mining.

The second coal field is inside the first range, and, as will be seen from the series of sections in the stereogram (Fig. 5), is divided along its length by a broken anticline.

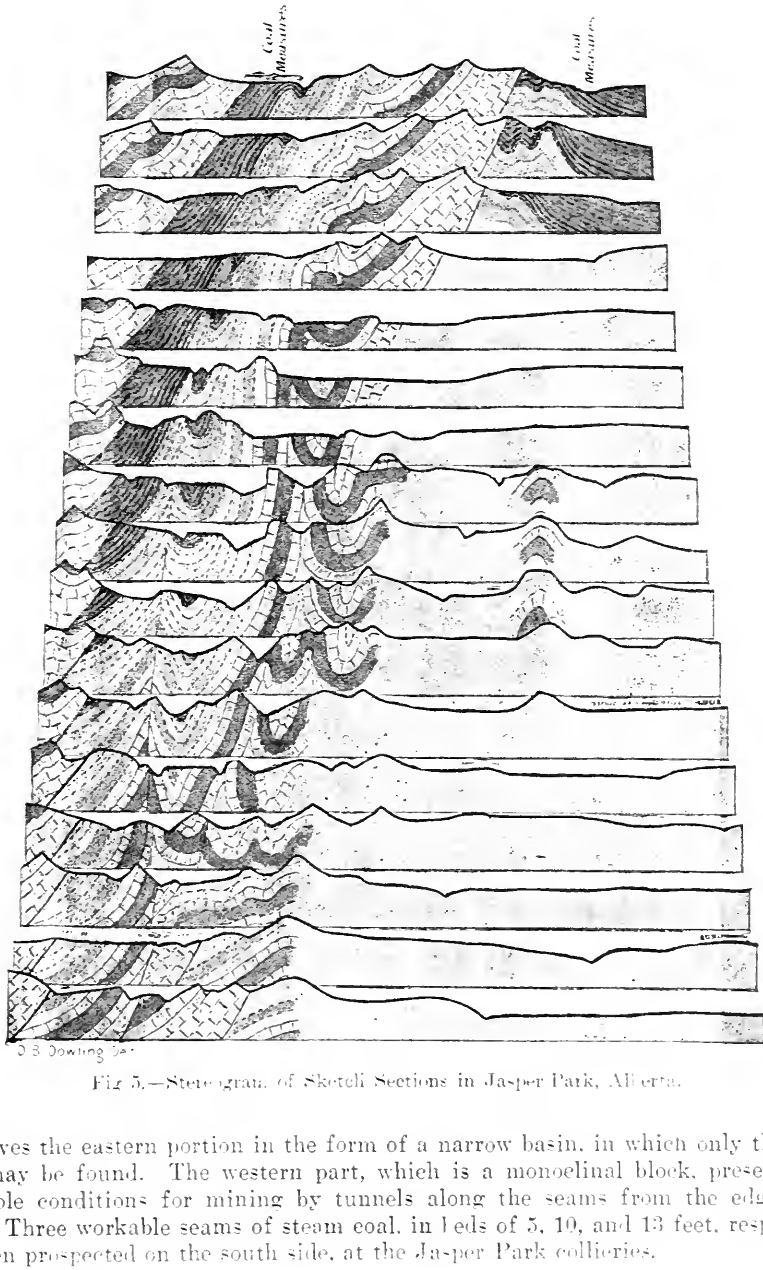


Fig 5.—Stereogram of Sketch Sections in Jasper Park, Alberta.

This leaves the eastern portion in the form of a narrow basin, in which only the lowest seams may be found. The western part, which is a monoclinal block, presents more favourable conditions for mining by tunnels along the seams from the edge of the valley. Three workable seams of steam coal, in beds of 5, 10, and 13 feet, respectively, have been prospected on the south side, at the Jasper Park collieries.

TOPOGRAPHY.

The area visited this summer forms part of the outer ranges of the Rocky mountains. The deeply eroded valley of the Athabaska river crosses the northern part, and into it drain several streams flowing between the tilted and folded blocks of strata that form the ranges. The tributary from the south—Fiddle creek, which occupies the principal place in the small accompanying map—flows in a very crooked channel, which crosses a pronounced ridge of limestone three times, through narrow cañons. One mountain range lying along the southwestern margin of the district seems to be quite persistent, although its direction changes somewhat at the Athabaska. A flat-topped, cliff-sided point on this ridge, south of the Athabaska, has long borne the name Roche Miette, and forms one of the most striking features in the landscape. Between this range and the foothills the mountains are more irregular, due largely to the geological structure. At the north end of the portion mapped, the outer ridges are the upturned edges of the harder beds of a wide fault block. At the Athabaska river this block shows signs of deformation by longitudinal folds and breaks, which farther south have disturbed the continuity of the ranges. One short ridge, occupying a position in advance of the mountains, is plainly caused by a simple fold of the outer crust, and the arch so formed—a short ridge of limestone exposed by the erosion of the softer rocks of the original surface—bears the descriptive name, Folding mountain.

The general structure of the Rocky mountains from the International Boundary north to about the Saskatchewan river is that of a series of fault blocks, consisting of the same series of rocks, resting against each other. A repetition of form and colour, and a continuity in the ranges therefore obtains; but in going northward, more diversity in the form of the blocks is noticeable. The regularity of dip and repetition of beds, to a great extent, is replaced by folded strata and a greater variety in the outline of ridges.

The foothills near the Athabaska valley are not prominent, and to the south are somewhat irregular, especially near the mountains; to the north the ridges have steep faces towards the ranges and long easy slopes northeastward.

The drainage channels through both mountains and foothills, in many instances suggest breaks in the upthrusted blocks. Thus in the Athabaska valley there is evidence that, through the outer ranges at least, and for some distance through the foothills, there were cross fractures in the fault blocks, now shown principally in an unexact alignment of beds on opposite sides of the valley. The devious course followed by Fiddle creek, crossing, as it does, three times through a ridge of vertical limestone, the first occurring at a distance of less than 3 miles from its mouth, also suggests cross fractures.

The present stream, occupying the Athabaska valley for some distance above Brulé lake, is depositing material along its course, and seems to have partially filled a former lake. Its meandering course through a swampy flat by many channels, with evidences also of discarded ones, suggests that Jasper and Brulé lakes will also at no very distant date become silted up.

Gravel terraces similar to those on the Bow river are found at elevations up to 300 feet above the present river. These, no doubt, belong to the same period as the transported deposits known as the Saskatchewan gravels. The tributary streams entering on each side are moving a large amount of gravel into the Athabaska valley, and in almost every case show a steady growth of the fan deposit near the mouth. Thus, at the mouth of Fiddle creek, the steeper grade of the tributary stream has enabled it to move material towards the Athabaska river that could not be removed by the current of that stream. Consequently the river has been forced over against the rocky walls of the ridges on the north side. At the mouth of Moose creek, a smaller collection of river-borne material forms a flat fan, which occupies a part of the river flat. This appears to be due to the activity of the current of Moose creek. The large tributaries from both north and south, which enter the Athabaska near Roche Miette, may have been the agents causing the formation of Jasper lake, by moving material into the valley and thus forming an obstruction partially damming back the water. Brulé lake, although it seems to be silting up, has no doubt also been lowered, by the erosion of the barrier at the outlet. This barrier consists of the tilted beds of Cretaceous sandstone, separated by shale, so that it forms a succession of hard ribs. The channel being cut through them from Brulé lake to the mouth of Prairie creek, although having a fairly uniform, heavy gradient, is still in process of erosion where each of the ribs crosses it. The gradient in the channel which has been cut through this barrier steepens perceptibly after leaving the lake, and there are several rapids, but none at the outlet, so that the erosion which is still going on does not immediately threaten the existence of the lake.

NATURAL ADVANTAGES FOR A PARK.

The great importance of the reservation of the timber and game of the country on the eastern slope of the Rocky mountains is generally recognized and need not be enlarged upon here. The ease with which the mountains can be reached by railway offers great inducement to those seeking change for health or recreation, and the adaptability of this area for health and pleasure resorts may be noticed. The scenery of Jasper park, although not of the bold and rugged type of the higher altitudes, is nevertheless pleasing; since the valley of the Athabaska, which is wide and well furnished with lake-like stretches of water, forms a pleasing foreground to a background of mountain peaks with ranges on either side. The approach by railway along the Athabaska river offers ever changing scenic views of river stretches, and wooded hills, above which can be seen the rugged ridges of the outer range.

Along the line of railway townsites will doubtless be selected. The gravel built sloping plane near the mouth of Fiddle creek seems to afford a suitable location for such a town, being not only well adapted for a town site, but also the nearest point to a series of hot sulphur springs on one of the western branches of Fiddle creek. When proper roads have been constructed, these springs may be reached by a drive of about 8 miles, over a picturesque route, affording probably glimpses of the cañon of Fiddle creek and of the wall-sided ridge through which it has been cut. Mountain climbers will find no great elevations to attract them in this part of the park, though a peak just south of the springs has an elevation of nearly 9,000 feet, and affords from its summit an extensive view of the surrounding hills and valleys. Among other attractions for the general tourist there is boating on the lake and river, at present somewhat impaired, however, by the shallowness of the lake, and the strength of the current in the river.

FOREST.

The largest area of green forest, containing timber of marketable size, occupies a triangular stretch of country lying to the east of Brulé lake. The wagon road to Prairie creek runs along its southeastern margin. Along the Athabaska, burnt country extends from the east to a point nearly half way between the lake and Prairie creek. Other fairly large areas of unburnt timber are found within the mountains, on the flat lands through which wind the many channels of the Athabaska river. Another area of green forest, but consisting of patches only, extends from the head of Drystone and Prairie creeks to the western sources of McLeod river. Although throughout the district there are, here and there, small patches of living trees, the greater part of the original forest has been burnt.

TRANSPORTATION.

By the date of the issue of this report, the rails will probably be laid for the Grand Trunk Pacific railway from the east to the crossing of the Athabaska, which point lies west of the limits of the accompanying map. The low water during the winter will be taken advantage of to place the caissons for the pier excavations. During the construction of the piers and superstructure a temporary terminal will be made in the vicinity of, or near the west end of Jasper lake. The necessary construction roads along the line of railway are being made of a more permanent nature in the park, than through the foothills, and, later, they will be maintained by the park administration as wagon roads. The original trails through this district were merely pack trails or paths, along the banks of the river, crossing the streams by fords, which are passable only at low water. The fords were situated, one at Swifts, above the railway crossing, another below Jasper lake, a third at the outlet of Brulé lake, and a fourth at Cache Pecotte, east of the mouth of Prairie creek. Crossings were made, towards the close of the past season, by cable ferry at Jasper House, and by gasoline launch on Brulé lake. Trails follow the valleys of Snaring and Stony rivers on the north, and the Athabaska, Jack creek, and Rocky river on the south, and there are a few in the foothills, including one from Prairie creek to and up McLeod river. An old Indian trail, practically blocked by fallen timber, leads over the hills to Fiddle creek above the cañon, and another follows the east side of the steep, straight ridge through which Fiddle Creek cañon is cut. New trails have been made from the end of the wagon road constructed by the Jasper Park Collieries, to Sulphur creek. These trails were intended to replace the trail up the bed of Fiddle creek, which was very rough for horses, but though they avoid the rough creek bed they cross some very steep hills. A route with easier grades might be found along or near the bank of Fiddle creek, though some rock blasting would be necessary at the cañon. When this road is completed as far as the Hot Springs, and repairs are made to the road from Prairie creek, tourists will be able to reach many of the points of interest.

COMMERCIAL POSSIBILITIES.

Since the area under discussion has been reserved as part of a national park, its commercial development will be effected more directly under Government supervision than other areas; and the coal deposits, which are of importance, will be mined under lease.

The localities of the coal outcrops are very advantageously situated both for mining and shipment, and the demand for coal, after the completion of the railway, will be sufficient to ensure the opening of collieries, so that small mining towns are sure to grow up within the park.

GENERAL GEOLOGY.

The rocks exposed in the eastern ranges of the Rocky mountains are very similar, over long distances, in general character and age, and it may be remarked that the formations there exposed have been traced almost continuously from the Bow River valley to the Athabaska. Slight changes in the character of the deposits are noticed, but the section, as a whole, is practically uniform. Of the consolidated rocks, all of which were deposited previous to the mountain uplift, the section here includes a sequence of beds from middle Cretaceous measures to and including Devonian limestones. The upper part—that including Cretaceous and Triassic rocks, being of easily eroded strata, does not form any material part of the ridges known as the Rocky mountains. The crests of the ridges are generally of limestone, in thick beds, belonging to deposits probably of Carboniferous age. The lower limestones in the area shown on the sketch map are probably of Devonian age, and are exposed along the lower scarped eastern faces of the ranges next to the fault by which they are brought up into contact with higher beds, the maximum displacement being where the Devonian is in contact with the upper part of the lower Cretaceous. The complete list of formations which, judging by analogy, will be found to occur in the district, but of which fossil evidence, establishing their age, has not yet been obtained, includes the following:—

Recent	River deposits. Sands and silts, lake deposit
Pleistocene	Boulder clays. Cemented gravel (similar to Saskatchewan gravels).
Cretaceous	In the foothills, probably the whole section of the Cretaceous will be found. In the mountains, beds of Kootanie or lower Cretaceous age are exposed.
Jurassic	Shales and sandstones.
Triassic and Permian	Siliceous shales and dolomites.
Carboniferous	Limestones.
Devonian	Dolomitic limestones.

CRETACEOUS.

Kootanie Formation.—The beds of this formation contain the coal seams that are found in the Rocky Mountain areas. The formation as a whole is of fresh water origin, although salt water deposits are not entirely absent. Plant remains are to be found throughout nearly the whole thickness of the measures.

A measured section of the lower part of the formation was made on Villeneuve creek.

The nearest section for comparison is one measured by Mr. Malloch on Chungo (Trail) creek, which occupies a gap near the north end of Bighorn range. The sections in the northern field differ from those in the Cascade coal field to the south, mainly in the presence of a heavy conglomerate band in the central part of the measures, and an increased thickness of sandstone beds in the lower part. Although small seams of coal are found below the conglomerate, none appear to be workable deposits, but above it there are at least three seams that are thick enough to mine.

Comparing the section on Chungo creek with that in Jasper park, there is a similarity in the general nature of the deposits in those portions below the conglomerate band, but there is an increase in thickness in the northern section, assuming that the conglomerate band occupies the same horizon in each. The conglomerate band in the northern field is very persistent, and forms a strong rib, which is often detected in the topographical forms, and is useful in tracing the probable position of coal seams.

The upper portion on Chungo creek is complete to the overlying beds of later Cretaceous deposits, but in the section under examination this season, the thrusting and faulting of mountain building has cut away the upper portion. A complete section may yet be found in the foothills, but the surface covering there is generally thick, and rock exposures are confined to the river valleys.

Section on Villeneuve creek.	—	Bighorn Coal Basin. — Malloch's Section on Chungo creek.[1]	—
Coal seam	16 feet (not dug out.	Shales and sandstones, containing seven seams of coal	2,072 feet.
Sandstone	300 feet.		
Coal	12 "	Conglomerate	12 "
Sandstone	350 "		
Coal	(?) not dug out.	Sandstones, etc	367 "
Sandstone	120 feet.		
Coal	5 "		
Sandstone	350 "	Shales, sandstones, and streaks of coal.	328 "
Conglomerate ridge	50 " about.	Sandstones	672 "
Sandstone and shale	500 feet.		
Streaks of coal—	(?)		
Sandstones and shales	300 "		
Streaks of coal	(?)		
Sandstones and shales	900 "		
Streaks of coal	(?)		
Sandstones	600 "		
	3,497 feet.		3,451 feet.

Jurassic.—Below the lowest, heavy sandstone bed of the section given above, black shales, in which sandstone beds are distributed, are found to hold marine shells—a passage downward from land conditions to salt and brackish water deposits. A sandstone rib, probably 100 feet below the sandstone of the above section, is found to contain marine shells, recognized by Mr. Raymond as being probably *Arctica* (Cyprina) *occidentalis, and Nemodon* cf. *Sulcatinus.*

The first of these is recorded by Mr. Whiteaves from the lower shales of Queen Charlotte islands, regarded now as Jurassic, and the second is probably one of the varieties determined by Mr. Whiteaves under the name *Arca (Nemodon)* from the same beds.

Separated from these sandstones by 100 feet, approximately, of dark shales, lies a second sandstone and shale rib. In this, specimens of *Gryphæa planoconvexa, Ostrea strigicula,* and a species of Terebratulina were found. Of these Mr. Raymond says: 'The fossils and their mode of occurrence strongly suggest the Ellis formation of Montana and the Yellowstone National Park.' The Ellis formation has been considered Jurassic, and this, therefore, furnishes the first correlation between the Fernie shale horizon and the Jurassic of Montana, although previous to this the Jurassic age of the Fernie shale, and of the lower shales of Queen Charlotte islands, has been admitted.

Triassic and Permian.—The sandstones and shales comprising the beds of Jurassic age rest on a series of dolomitic and siliceous shales. Generally reddish in colour, these shales are in this district often bright yellow, shading to brown in the lower beds, the upper light coloured part having occasional thin, bright red streaks or beds. This colouring is probably due to iron oxide, and the variations from red to yellow are merely local expressions of chemical changes, due to differing conditions in the beds during the mountain building. No fossils were detected, and the formation seems almost barren of animal remains.

Carboniferous.—Limestones in two heavy beds, separated by thinner bedded limestones and shales, occupy positions in the section similar to the Upper and Lower Banff limestones. The Lower Banff shale, which in the south separates the limestones, is here of a somewhat less definite character, and it is a question whether it might not

[1] Summary Report, Geol. Surv., 1908, p. 75.

be better, in the northern area, to recast these divisions. The general character of the limestones, in appearance at least, all through these ranges from the Banff locality, is very persistent, so that there is very little doubt about the correlation of the group as a whole.

Devonian.—The beds exposed just below the grey limestone are somewhat similar, particularly in the occurrence of yellow streaks and thick bedding, to the Intermediate beds at Banff, which are of Devonian age; but as no fossils have been found in them the limits of the formation are not yet defined.

Historical and Structural Geology.

The character of the deposits found in the district suggests that in later Devonian and Carboniferous times there was a period of continued submergence by the sea, during which very little detrital matter was distributed. The bands of shale in the limestone formations seem to indicate that during this period there were slight disturbances in the crust, causing the emergence of areas of land elsewhere, from which the waters of the sea received a burden of silt. In the upper part of the Carboniferous formation shallow water deposits are found, indicating a slight rise at that period, concurrent with, probably, a greater elevation of parts of the continent both east and west. The narrowing of this sea, or a near approach to a shore line, is shown by the occurrence of more siliceous material in the beds immediately above the Carboniferous limestone. During the Jurassic period, which elsewhere was a time of great disturbance, no considerable amount of earth movement appears to have taken place in this area, except that the sea was probably still further narrowed, and the water of this narrow sea, or inlet from the northwest, was very much burdened by fine silt, indicating active erosion in some other, possibly the western portion of the continent. The deposits of the early Cretaceous, generally coarse sand and silt, filled this arm of the sea, and the continued continental elevation assisted the rapid shifting of surface material to this broad trough, which, to the south, appears to have been mostly above sea-level, though during early Cretaceous times the flat country near sea-level may, by slight oscillations, have been inundated by the sea; but generally the deposits appear to have been brought to it by fresh water, while its general elevation was near sea-level. A temperate climate is indicated by the abundant plant remains which are preserved in the coal seams.

Elsewhere, the rocks of the Cretaceous indicate that after the period marked by these coal seams there was a widespread subsidence, and, in the central part of the continent, marine beds form a considerable portion of the Cretaceous deposits. A final recovery of elevation marks the close of Cretaceous times, and land conditions then prevailed, and coal deposits were formed, while the surface was at a low elevation. Greater elevation during Tertiary times is suggested by the remains of plants of types resembling the present flora. The deposits in which they are buried are of fresh water deposition, in lake basins and from river flooding.

The Laramide revolution, or the disturbance of the crust during which the Rocky mountains were forced up, succeeds the time of the deposition of the Tertiary rocks of Alberta. A compression of the crust, increasing in intensity, was relieved by folds and breaks that run northwest and southeast, with a general upthrust of the western side. A period of general erosion of the surface, which is still going on, forms the concluding chapter in the geological history of the region.

The outer or eastern edge of the disturbed belt in front of the mountains is nearer the ranges at the Athabaska than it is farther south, on the Brazeau. The faults between this line and the outer range of the mountains form, roughly, a radiating series narrowing to the north. This narrowing may have resulted from changes in the direction of the pressure, or from a greater lateral movement in the southern part. In the outer ranges many of the fault lines, which are the lateral boundaries of fault blocks, show a diminishing throw northward, until they become folds instead of faults, and merely deform succeeding fault blocks. Thus, at the Athabaska, the fault blocks show on their lateral section several minor folds, the axes of which run parallel to the fault lines. These facts seem to indicate a diminution in the lateral movement of the crust. The appearance of the mountains, too, seems to point to the same conclusion, since their greater folding can thus be interpreted as resulting, not from greater pressure, but from less lateral movement, and, possibly, less pressure.

Economic Geology.

Cement and Lime.—The wide use of cement in the building industry in Alberta has led to the construction of cement works on both branches of the Canadian Pacific railway near the mountains, since the necessary calcareous material is found in very small amounts in the rocks of the plains. The market may at some future time warrant the construction of a similar plant near the line of the Grand Trunk Pacific, since both limestones and shales suitable for cement making are here found, and coal is to be had in the immediate vicinity.

Iron Ore.—Some of the shale bands which separate the heavy bedded limestone formation contain a certain amount of iron oxide. In some cases these beds have a distinctly brownish colour, and samples, showing enrichment of the lower beds by infiltration from higher levels, are found, which could be called ores. These, if found in sufficiently large bodies, may be mined, but exploration sufficient to establish their presence in such quantity has not been undertaken. Claims for iron have been staked on the face of Fiddle mountain, (between Fiddle and Drystone creeks) on a band of iron-bearing black shale which lies between the heavy limestone formations. The greatest impregnation of iron oxide is to be found in a series of siliceous shales between the limestone and the coal-bearing rocks above. As red bands, these rocks have been traced northward from the Kananaskis river, and their greater thickness, compared with the lower shales, should increase the possibility of finding in them mineable portions, though, as a rule, they would be of low grade. The smelting of these ores might be made possible by the reduction of the siliceous material by concentration.

COAL.

Foothills.—The rocks of the Kootanie, which is in general a sandstone and shale formation containing coal seams, are exposed in the foothills near the mountains. The uplift necessary to bring these beds to the present surface was accompanied by the formation, to the east, of a wide syncline in the rocks of the plains. This basin, at the latitude of Edmonton, is wide, but farther south narrows down, and the dip of the beds on either limb of the syncline steepens perceptibly. North of Brulé lake the limestone formation has been pushed up on an anticline of the coal-bearing beds, crumpling and folding the western limb. The eastern limb dips, with lessening slope, beneath higher beds of the Cretaceous. Several coal seams in the upturned edges of the measures in the hill west of Brulé lake have been prospected near and in the valley of Scovil creek. The seams there found have been opened since our visit, with the result that, it is reported, seams having a thickness of 10, 12, and 5 feet respectively, have been discovered. The exposure on Scovil creek was visited, and the seam measured and sampled; the thickness is 9 feet 6 inches and the dip northeast 25°.

The sample was taken by channelling across the whole seam. Some of the dirty layers could be mined out and the ash reduced in the commercial output. Analysis by F. G. Wait, Mines Branch:—.

Moisture	1·09
Volatile hydrocarbons	17·88
Fixed carbon	56·95
Ash	24·08
	100·00
Coke, firm coherent	81·03

It is reported that, in other exposures south of Folding mountain, on one of the west branches of McLeod river, these beds dip towards the mountains and contain beds of coal, including one very thick seam with about 30 feet of coal. The tracing of the measures between these two exposures has occupied the energy of prospectors, and Mr. McEvoy reports the discovery of coal on the south side of Brulé lake, near the railway. No details of any of these seams are yet to hand, except the one seen on Scovil creek.

The Mountain Coal Basins.—Within the first series of mountain ridges a depression or valley, drained by Moose creek, on the north side of the Athabaska, and by branches of Fiddle creek, on the south, is found to be due to the erosion of the softer beds that form the upper members of a wide fault block. In the area illustrated by the accompanying topographic sketch (Fig. 6), the coal-bearing beds of the Kootanie form an upper member of this partly eroded series, and portions are found to remain both in the centre of the valley and in contact with the next succeeding fault block to the west. The fault line, which is the western boundary of the coal area, is generally concealed by detritus from the higher slopes, but its approximate position is indicated by changes in the dip of the beds, and by local folding.

Owing to a differential uplift of the western edge of the fault block containing the coal measures, and to a deformation of the block by an anticlinal fold, the southern end of the block is raised, and the beds containing the workable seams have been eroded. This elevation results also in the cutting away almost entirely of the rocks of the lower part or non-productive portion of the Kootanie formation, so that only a very narrow band, if any, remains to form a connexion with the Nikanassin basin to the south. The measures containing mineable coal seams can be followed near the fault line to a point a short distance south of the crossing of Sulphur creek.

As will be seen in the sketch section, the coal basin is divided by an anticlinal fold along its length. Faulting, with an overthrust of the western part on the eastern, has complicated the form in which the two parts, so divided, are now found. The eastern part is mainly in trough form, but the break along its western edge has probably occurred in the upturned beds of the western limb of the anticline.

The western portion of the field remains generally in the form of a monocline, although remnants of the anticline along its eastern border still remain. It is a wedge-shaped block, narrow to the south but broadening northward, the rocks dipping towards the southwest at fairly constant angles varying from 50° to 70° in different parts of the field. This part occupies the western edge of the fault block, and is overridden by rocks of the next range.

The measures near the western fault are sometimes upturned, and probably folded back, especially in beds exposed on the higher spurs. Those near the fault at lower elevation are probably overridden by the limestone, and show less disturbance. The strong ribs of sandstone, and the rib of conglomerate near the base of the productive coal measures, form prominent ridges and show a continuity that argues well for the condition of the coal in their proximity; the lower seams, therefore, at least for this block, should be mineable south from the Athabaska to Villeneuve creek. Northward the block appears to widen, and should be, from that fact, of greater value as a coal field, since higher beds may be exposed and a greater number of seams found. Up to the present, the greatest amount of prospecting has been done south of the Athabaska river.

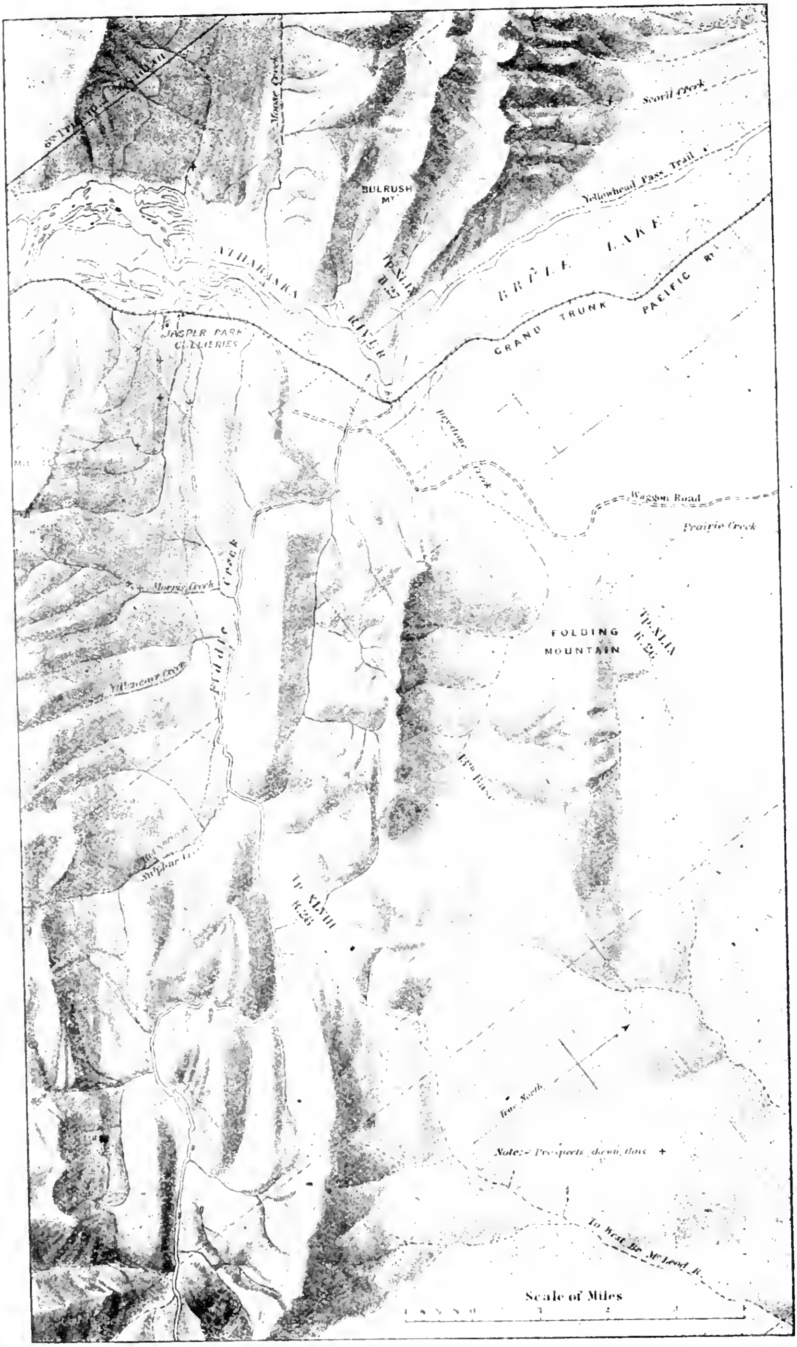


Fig. 6—Topographical Sketch of a Portion of Jasper Park, Alberta.

The eastern part of the coal field is in the form of a trough, the southern end of which is elevated, and, south of Villeneuve creek, eroded away. On that creek the trough is too shallow to warrant the expectation of finding in it mineable coal seams, but on Morris creek it is much wider, and the beds of the eastern limb of the syncline are not so much disturbed as those of the western limb. The inference, from the exposed part of the section, is that the upturn on the west was accompanied by faulting, and that this fault line, which separated the two coal areas, reached nearly to the Athabaska valley, and probably terminated there. The section on Villeneuve creek shows an upturn of the beds on the western limb of the syncline, but after a short interval of concealed beds, lower sandstones are found dipping to the west in conformity with those of the block next the mountains. This indicates a displacement other than by folding.

On Morris creek there is an apparent trough, but at the point of reversal of dip, which should be the centre of the trough, the beds on the east belong to a place at least 1,200 feet higher in the section than those on the west. There is here probably a break in the western limb and a push up of the block on the west; the amount of displacement, though depending on the unascertained dip of the fault plane, was evidently greater than 1,200 feet.

The surface drainage north of Morris creek runs to the Athabaska, and the exposures are below those of Morris creek. The only exposure there, along the eastern edge of the western block, occurs on Mountain creek, quite near the probable line of break, and shows sandstones, containing a 9 foot coal seam, lying almost horizontal, and evidently, from the attitude of neighbouring beds, forming the centre of a syncline. Near the Athabaska the eastern block is traced only by the sandstone ridges of its eastern margin, and the structure is concealed. Gravel terraces along the sides of the Athabaska valley mask all the outcrops on the lower slopes, and prospecting is limited to points 280 feet above the river.

North of the Athabaska the break that separates these two blocks is shifted to the east, and the eastern trough is very much compressed, and probably disappears as a coal field. Mineable areas on this eastern trough are probably confined to the block between Morris creek and the Athabaska. The western block appears to present no serious folding or faulting in the lower part of the coal measures. As the beds in the two blocks are of the same series, there is a repetition in them of the same beds, and the location of a coal seam in one should prove a help towards the discovery of the corresponding seam in the other.

COAL SEAMS FOUND IN WESTERN BLOCK.

Villeneuve Creek.—The lower shales and sandstones of the Kootanie appear by the sections on this creek to contain very little coal, thin streaks only being observed from the bottom sandstone up to near the conglomerate bed. Some coal dust, occurring below this conglomerate, may indicate a small seam, but its thickness can not be very great. Above the conglomerate the beds show the following section:—

Sandstones.	Feet.	—
Coal, over	10	
Sandstones.	250	
Coal.	12	Sample and analysis.
Sandstones	350	
Streaks of coal	....	
Sandstones	100	
Coal	5	
Sandstones	250	
Conglomerate	30	
Coal dust	.....	

Morris Creek.—On Morris creek, the first western branch of Fiddle creek, the following section is given, but it is only approximate, the distance being estimated by pacing.

Sandstones	heavy bed.	
Coal	3 feet 10 inches.	Coal, 10 feet 11 inches. Sample and analysis.
Shale	6 "	
Coal	7 " 1 "	
Sandstone	150 " 0 "	
Sandstone and shale	100 " 0 "	
Coal	9 " 7 "	
Sandstones	350 " 0 "	
Coal	5 " 6 "	Coal, 8 feet 6 inches.
Sandstone	2 " 0 "	
Coal	3 " 0 "	
Sandstones and shales	300 " 0 "	
Conglomerate		

NORTH OF MORRIS CREEK.

Below where several streams, coming from the east face of Roche Miette, unite to form a brook, locally called Mountain creek, an exposure of a seam in a shallow syncline shows 9 feet of coal. This may be in the bent-over eastern edge of the western block, since, farther north, a seam of the same thickness outcrops along the face of the sandstone ridge to the west. In the gorge, west of this, in more regular beds dipping 42° southwest, a 5 foot 7 inch seam has been uncovered. Neither of these seams has been traced by the prospectors towards the Athabaska, but the sandstone ridge between them is prominent, and runs to the edge of the valley, where it sinks beneath the gravel terrace. On its eastern flank, a 9 foot seam was followed by trenching about a mile, to a point about 1,500 feet from the edge of the terrace, and farther, by pits in the gravel; then by an open-cut and a covered roadway 500 feet long from the edge of the terrace at the level of the seam, an entry was made on the coal seam.

The surface slope along the ridge is to the north, and from Mountain creek to near the tunnel entry it is gradual, but steepens near the Athabaska. From the point at which it meets the sloping surface of the terrace, the outcrop dips very gently, so that the tunnel will have light cover for perhaps 1,000 feet from the entry. Beyond that point the cover will be sufficient to ensure the coal being below the zone of surface weathering, and the coal will be high enough above the entry for economical mining.

The seam dips 56° to the southwest, and is here about 500 feet, horizontally, west of the conglomerate outcrop. This is a distance through the beds of about 414 feet. The section of the seam at the tunnel is:—

Coal	9 feet 6 inches.
Sandstone	2 " 0 "
Coal	3 " 0 "

From this entry it is proposed to cross-cut the measures to the west, to reach another seam, whose outcrop has been located, 1,050 feet from the tunnel. The latter seam is a good coal, and has a thickness there of 13 feet. It is an upper seam, and, measured by the dip of the beds, is about 870 feet above the tunnel seam.

It is probable that other seams that are indicated in the sections on Morris and Villeneuve creeks may also occur here; if this is found to be so it will add materially to the value of the mine.

NORTH BANK OF THE ATHABASKA.

The exposures along the sides of the valley are largely masked by the old river gravels, in the same manner as to the south, although the terrace is not so well marked. It is partly on account of this drift cover that so few seams have been found near the river.

An opening has been made into a seam, at about the horizon of the tunnel seam, having a thickness of 10 feet 5 inches. The seam is on the slope of a small gully, and the prospect trench in which it was found is high up on the side of the gully, near the surface, and not deep enough to reach the unweathered coal. A small seam has been found about 1,000 feet west of this, which may be near the horizon of the 13 foot seam on the south side of the river, and another is reported, about 3 miles north, occurring below the conglomerate. Prospecting in this area is difficult, owing to the surface covering, so that the resources of the lessees have been withdrawn largely from prospecting, and have been directed towards installing a temporary mining plant on the two seams already found near the railway, on the south side.

EASTERN TROUGH.

The southern limit of the eastern trough, considered from the point of view of its value as a coal mining area, will be found to be between Morris and Villeneuve creeks, since, on the latter, only the lower part of the coal bearing beds remains, the bottom of the trough passing probably less than 800 feet below the trench cut by the creek. On Morris creek the trough is much deeper, and the measures, consequently, thicker, so that the coal seams near the conglomerate, although probably folded at the bottom of the trough or near the fault line, may prove of value. On this latter creek in the same trough, on the eastern side, a seam was observed, standing at a high angle, with the following section:—

Sandstone roof—	
Shale..	1 foot 5 inches.
Coal	1 " 2 "
Shale	1 " 7 "
Coal	1 " 0 "
Stone	0 " 2 "
Coal	3 feet 6 "
Yellow clay	1 foot 2 "
Coal	0 " 8 "
Yellow clay	0 " 7 "
Coal	1 " 7 "
	13 feet 6 inches.

On the western side a small seam dipping east was noted, but it did not appear important. Northwest to the Athabaska there are exposures of the sandstones, and of the conglomerate ridge of the eastern edge of this trough only, so that no estimate of its depth could be formed. One coal seam has been found having 5 feet 2 inches of coal. This is on a small eastern branch of the stream, that cuts through the terrace at the collieries.

Character of the Coal.—The coals of this district show the effects of surface weathering probably more than in the fields to the south. Some analyses from outcrops on hillsides, where erosion by stream action is absent, give results that would indicate very soft coals, that is, with high volatile hydrocarbon percentages, and a potash reaction similar to that of lignites. That this is due to weathering is shown by the following analyses:—

The first sample is from the bottom of a shaft 30 feet below the surface and at the top of the hard coal. The second is from the same seam farther up the hillside, where the seam is reduced to black powder and noticeably filled with surface dirt.

Tunnell Seam, Jasper Park Collieries.—Lump Coal from Upper Part.

—		Recalculated for	
		Clean Coal.	Dry and clean.
Moisture	0·99	1·03	....
Volatile	20·46	21·32	21·34
Fixed carbon	74·52	77·65	78·46
Ash	4·03	....	....
	100·00	100·00	100·00

Tunnel Seam at Prospect Hole near Surface.

—		Recalculated for	
		Clean Coal.	Clean and dry Coal.
Moisture	5·83	7·89	....
Volatile	21·33	28·87	31·34
Fixed carbon	46·73	63·25	68·66
Ash	26·11	....	....
	100·00	100·00	100·00

The recalculation is made to facilitate a comparison of the coals in the two examples. The weathered coal in many of these exposures, while showing very little fracturing due to lateral movement, is so fissured that it contains a large amount of water, and crumbles readily in the hand. Its finely fractured appearance seems to be largely due to the action of frost, and this agency may have also aided in the oxidation of the coal.

The exposures in Morris and Villeneuve creeks are of somewhat fresher coal, since the scouring action of the stream removes a small portion of the surface of the seam each season.

The sample taken from a similar seam on Villeneuve creek, generally supposed to be the Tunnel seam, gives the following analysis, according to Mr. Wait:—

Sample across Seam.

—		Recalculated for	
		Clean.	Clean and dry.
Moisture	2·37	2·54	....
Volatile	22·38	23·98	24·60
Fixed carbon	68·58	73·48	75·40
Ash	6·67	....	....
	100·00	100·00	100·00

Sample from opening on 10 foot 5 inch seam, north bank of Athabaska, supposed to be the same as Tunnel seam.

Analysis by Mr. Wait:—

—	Recalculated for		
		Clean.	Clean and dry.
Moisture	3·52	3·77	....
Volatile	21·42	22·99	23·89
Fixed carbon	68·22	73·23	76·10
Ash	6·84	....	....
	100·00	100·00	100·00

Upper Seams.—The correlation of the seams at the collieries with those on the creeks is difficult, so that the following analyses, although they appear to be very similar in character, may be from different seams.

Analysis by F. G. Wait of coal from 13 foot seam west of Tunnel seam at collieries. Sample from lump coal on dump, hole full of water:—

—	Recalculated for		
		Clean Coal.	Clean and dry Coal.
Moisture	1·05	1·08	....
Volatile	24·68	25·51	25·79
Fixed carbon	71·02	73·41	74·21
Ash	3·25	....	....
	100·00	100·00	100·00

Sample across upper seam on Morris creek, coal 10 feet 11 inches. Analysis by F. G. Wait:—

—	Recalculated for		
		Clean Coal.	Clean and dry Coal.
Moisture	1·34	1·44	....
Volatile	22·91	24·70	25·06
Fixed carbon	68·51	73·86	74·94
Ash	7·24	....	....
	100·00	100·00	100·00

These both appear to be coking coals. Part of the seam at the tunnel cokes in the laboratory.

A sample was taken across the 5 foot 2 inch seam in the eastern basin, east of the collieries. It showed, on analyses, the same character as in the weathered sample from near the mine, that is, high volatile hydrocarbon and high ash. The comparison with the hard coal in the tunnel seam shows the futility of using these analyses of weathered material to show the character of the coal beneath.

Coking Qualities.—The samples which were taken from the parts of the seams which appear to be least affected by weathering show that all the seams are probably bituminous, but approaching the anthracitic, that is, comparing them with other known coals, they probably are somewhat harder than the Crowsnest coals and the coals of the Brazeau field, but softer than the Canmore steam coals.

It is not certain that the lower seams will prove to be coking coals. A seam below the conglomerate north of the Athabaska, from an analysis furnished by the Collieries Company, is, probably, similar to the Canmore coal, and, therefore, probably too high in fixed carbon to coke.

The seam in the tunnel at the collieries has possibly been mined far enough to give unweathered coal, but the sample taken in September, 1910, was from near the surface, and shows that part of the coal will coke. None of the other samples from natural outcrops of this seam near the surface give a hard coke. In the case of the upper seam, even when it is judged from samples, possibly weathered, there appears to be no doubt of its coking properties. Thus, in mining the coal from these two seams, there is a probability that the fine coal produced may be utilized to make coke of a high grade.

DEVELOPMENT WORK.

Before the completion of the railway much of the development work was necessarily of a temporary nature. Log houses for the men and officers, and other temporary buildings, were erected; and the mining consisted principally in sinking pits on the outcrop of the seam, and the commencement of a tunnel. The plan temporarily adopted for mining was by level entry along the strike of the coal; starting from the edge of the terrace an open-cut was made through gravel, followed by a covered way, partly in gravel and partly in rock or coal, carried to a point where the tunnel was altogether in coal.

The edge of the terrace is about 270 feet above the grade of the Grand Trunk Pacific railway at this point, so that the mine cars will be lowered down the slope to a temporary tipple.

The dip of the seam, which appears to be 56°, will be tested by slopes, and a permanent entry will then be constructed from the face of the gravel terrace, at an elevation of 30 or 40 feet above the railway. The temporary tunnel will then be used as a return air way.

HOT SPRINGS.

About 1¾ miles up Sulphur creek, at the centre of a broken anticline, in which the limestones are standing at a high angle, great boulders of travertine are seen in the bed of the creek, and on the hillside to the north. These show that the springs, which deposited the material of which they are made, issued from points above the present surface. On account of the denudation of the gorge the springs are now tapped at a lower level, and issue by several openings, apparently, in the case of the larger spring, through loose fragments. The fissuring through which these springs emerge is confined to a zone possibly 200 feet wide, and as many as six separate springs are to be found, mostly near the bed of the creek, and of differing temperatures from tepid to 120°. The water is charged with gases that give off a smell of sulphur.

A specimen of the water, obtained by officials of the Interior Department, was submitted by them to the chemist at the Experimental Farm. His report shows that sulphates of lime and magnesia form the larger part of the dissolved solids, and are the materials that are being deposited by the springs.

'*Report on Water from Hot Springs creek, Jasper park, Alberta.*'

'Clear and sparkling, distinctly alkaline reaction. No odour or marked taste.

—	Parts per Million.	Grains per Gallon.
Total solids at 212° F.	1,825	127·75
Loss on ignition	90	6·3
Solids after ignition	1,735	121·45

The solids as obtained by evaporation are white, and there is no charring on ignition. The ignited solids effervesce with dilute acid.

ANALYSIS OF SOLIDS.

—	Parts per Million.	Grains per Gallon.
Silica (SiO_2)	45	3·15
Sulphuric anhydride (SO_3)	902	63·14
Carbon dioxide (CO_2)	85	5·95
Phosphoric acid (P_2O_5)	traces.	traces.
Chlorine (CL)	7	0·49
Oxide of iron (Fe_2O_3) Alumina (Al_2O_3)	none.	none.
Lime (CaO)	558	39·06
Magnesia (MgO)	108	7·56
Potash (K_2O)	21	1·47
Soda (Na_2O)	17	1·19
	1,743	122·01

'In the following table the foregoing are presented combined, and as they probably exist in the water.

—	Parts per Million.	Grains per Gallon.
Sodium chloride (NaCL)	11	0·77
" sulphate (Na_2So_4)	27	1·89
Potassium sulphate (K_2So_4)	39	2·73
Magnesium " ($MgSo_4$)	324	22·68
Calcium " ($CaSo_4$)	1,104	77·28
" carbonate ($CaCo_3$)	193	13·51
" phosphate (Ca_3 (PO_4) 2)	traces.	traces.
Oxide of iron, Alumina ($Fe_2O_3Al_2O_3$)	"	"
Silica (SiO_2)	45	3·15

'Owing to the small quantity of water furnished—about 750 cc.—it was not possible to obtain a sufficiency, in certain of the determinations, for a thoroughly satisfactory conduct of the work. Among such instances, lithium might be mentioned; no trace of this metal could be detected, but the value of this finding is very considerably affected by the small volume of water available for the test.

'Judged generally, the water appears to be moderately hard, the hardness being "permanent" rather than "temporary": the chief constituent is sulphate of lime and next in order is sulphate of magnesia, which latter would probably render the water slightly laxative in its effect on the system. Notable amounts of the sulphates of potash and soda are also present.'

(Signed) FRANK T. SHUTT,
Chemist, Dominion Experimental Farm.

Following the same line of faulting southeast there are found several large springs, but none, so far as noted, that could be called hot springs. They are all depositing large quantities of lime and magnesia, and may be found to be of medicinal value.

SASKATCHEWAN RIVER DISTRICT.

(*W. McInnes.*)

The region explored lies just north of the Saskatchewan river. in the eastern part of the Province of Saskatchewan. It includes, in its southern part, a drift-covered area which forms part of the Saskatchewan valley, and in its northern part, the higher land of the Pre-Cambrian plateau, while between lies a comparatively flat or gently tilted upland underlain by Palæozoic sediments.

OBJECT OF EXPLORATION.

The exploration was undertaken for the purpose of fixing the positions of the northern edges of the various sedimentary systems which overlap the Pre-Cambrian; and to gain a better knowledge of a tract of country hitherto unexplored, and lying away from regular routes of travel.

METHODS OF WORK.

Travel through the country was altogether by canoes; a continuous survey was made, with compass and micrometer telescope, from Cumberland House, on Cumberland lake, northward to the eastern end of Wapawekka lake, connecting there with the surveys of 1908, and giving a tie line between Stanley, on Churchill river, and Cumberland, on the Saskatchewan; an offset was also run to Pelican narrows. Surveys in detail were made of all the lakes along the route, including Ballantyne lake, an open body of water upwards of 150 square miles in area, connected by a narrows with Deschambault lake. Track surveys were made of Torch and Oskikibuk rivers, and of a part of Amisk lake.

Mr. W. B. Wiegand acted as assistant in the micrometer work.

GENERAL DESCRIPTION.

The southern portion of the area forms part of the easterly-trending, broad valley of the Saskatchewan river, and is about 900 feet above sea-level. It is very imperfectly drained by the river, which, in periods of flood, overflows its banks and spreads over nearly all of this low lying land.

From the northern edge of the valley, the land underlain by the Palæozoic sediments gradually rises northerly, and reaches, at the northern rim of the sediments, a height of about 1,100 feet above the sea, while beyond, to the northwest, the Pre-Cambrian plateau, in places, is 1,200 feet or more above the sea.

The low, flat country forms a broad belt along this part of the Saskatchewan river, extending northerly from the river for 15 miles, and southerly for 25 miles to the base of the Paskwia hills. Through it the river flows easterly, with everywhere a strong current, and along certain stretches a very rapid one, which, in places, where trains of boulders from the till cross the channel, forms heavy rapids. Many islands divide the current into various channels.

About forty years ago, at a point 33 miles above Cumberland House, the river broke through the 2 mile wide barrier of low land separating it on the north from the channel of Torch river, a large stream draining Candle lake, and flowing, in a course roughly parallel with the Saskatchewan, into Cumberland lake. The break occurred during the period of the spring flood, the water following the course of an old canoe portage leading from one of the sharp northerly bends of the Saskatchewan to a southerly elbow of Torch river.

At first a small stream, the overflow has yearly increased in volume by wearing away its banks, until now, at low water, the old Saskatchewan channel carries but little water, and vessels of all kinds, even flat bottomed scows, follow the new channel. The great increase in the volume of water now flowing in what was Torch river has caused the stream to break through its banks in many places, and to carve out new channels through the low land, so that now the water follows many meandering courses, which reach Cumberland lake through mouths situated at various points along 12 miles of its southern shore. Even after reaching the lake the water keeps to a river-like channel, skirting the northern shore and separated from the lake by long, narrow, wooded islands that form an almost continuous barrier, the gaps between them being few and narrow. The water rejoins the old channel of the Saskatchewan by the Bigstone and Tearing rivers, the two old outlets of Cumberland lake, now, however, augmented by the increased volume of water into rivers with broader and deeper channels than formerly. The water of the Saskatchewan always carries a large amount of suspended, silty matter, and, from the greater abrasion along the new channels, pours into Cumberland lake a still more murky flood. The sedimentation due to this, together with the wearing down of the outlet channels by the increased flow of water through them, has already made the lake so shallow as to be navigable, in low water, only through tortuous channels leading to the two outlets.

The drainage of the whole of the area travelled is into the Saskatchewan river; the eastern and western parts directly, by streams flowing southerly and easterly to Cumberland lake, and the northwestern section by streams that run first northeasterly to Deschambault lake, and then, by a horseshoe curve at Mirond lake, southerly into Cumberland lake.

All the rivers have swift currents, and their courses are broken by many rapids and occasional falls.

CLIMATE.

The climate is much like that of the cultivated portion of northern Manitoba, though the higher latitude makes the hours of sunlight longer in summer and shorter in winter.

The winters, though long and cold, are not so severe as might be expected. It was rather surprising to find among the Indians on Deschambault lake, young cattle in excellent condition, that had wintered out protected only by a string of dog bells to frighten the timber wolves. The summers are warm enough to ensure the ripening, in an average season, of all common grain crops.

No systematic farming is carried on anywhere in the district, though around the Hudson's Bay Company's posts at Cumberland and Pelican Narrows, the Company officers cultivate successfully all the common garden vegetables, including tomatoes and Indian corn, and the Indians grow potatoes at many places throughout the district.

FAUNA AND FLORA.

Moose are found everywhere in the area, and, if not actually increasing in numbers, are at least holding their own. They are particularly plentiful in the low lands north of the Saskatchewan, where, in the slightly higher western region, wapiti and jumping deer are also found, though less plentifully.

The ordinary fur-bearing animals of this latitude are still fairly numerous, except beaver and otter, both of which have been nearly trapped out.

There are areas still standing of good white spruce, both in the region of the Saskatchewan valley, and in the higher land to the north, though forest fires have denuded much of the region of what valuable timber it once supported. Several tracts of considerable size were burnt over last summer. Could the fires be prevented or checked, large areas would within a measurable period become reforested, since the rate of growth in favourable situations is fairly rapid. Two white spruces growing in Cumberland lake were cut into for the purpose of ascertaining their rates of annual growth. It was found that the added growths for the past three years, deduced from the rings of growth, were three-fourths of an inch and half an inch respectively, rates that compare favourably with those of many a much more southerly locality.

MEANS OF ACCESS.

Access to the country is had by the Saskatchewan river, which has been the highway of travel since the region was first visited by Europeans more than a century ago. For years the fur trading companies carried their supplies in north canoes and York boats, by this route. Subsequently river steamboats of high power and low draught were used on the river, but after railways gave access to the upper reaches of the river. the boat service was largely discontinued, until now no general passenger or freight service is maintained.

A branch of the Canadian Northern railway is open to the Pas mission on the right bank of the river, and a bridge is now being built for its extension northward to Hudson bay. It is under contemplation also to improve the channel of the river, and surveys were being made by the Public Works Department during the summer, with the object of ascertaining what could best be done in this direction and at what cost. With the completion of the railways now under way, the contemplated improvement of the channel will make all parts of this great valley easily accessible.

The northern part of the area, beyond the Saskatchewan valley, must still be reached by canoes or York boats, owing to the small volume and steep grades of the streams.

General Geology.

The northern part of the region explored is underlain by part of the great complex of Pre-Cambrian rocks that forms the Canadian shield. These Pre-Cambrian rocks are overlapped by Palæozoic sediments coming in from the south, the northern edge of the overlap presenting a most irregular line due to unequal erosion, but running in a general east and west direction. It is thought that the heavy cover of drift conceals in the southwestern parts of the area, undenuded remnants of lower Cretaceous beds, probably including sediments of both Benton and Dakota age.

Evidence of a general glaciation of the region is everywhere present. Erratics are common, and striated surfaces plentiful. The general course of the striæ is a little east of south, indicating that the ice sheet which left these records had its source in the Keewatin rather than the Labradorean centre of dispersion.

TABLE OF FORMATIONS.

Quaternary	Recent, fluviatile, and lacustrine deposits.
	Post glacial lacustrine clays.
	Glacial boulder clays.
Cretaceous	Benton shales.
	Dakota sandstones (not exposed).
Devonian	Magnesian limestones (not exposed).
Silurian	Niagara magnesian limestones.
Ordovician	Galena-Trenton sandstone and magnesian limestones.
Pre-Cambrian	Laurentian and Keewatin biotite gneisses, hornblende gneisse and schists, diorites, etc.
Igneous	Granites and pegmatites.

QUATERNARY.

The Saskatchewan river and, to a smaller degree, its tributary streams, have, since the close of glacial time, deposited large amounts of transported material, largely taken from one part of the area and redeposited in another, but partly brought from outside the area. The process is still going on actively, and the effects are very plainly seen in the region of Cumberland lake and its vicinity, where the river is now depositing material very much as over a delta plain.

Areas of clay about the central part of the region, from their character seem to be the result of sedimentation in lakes bordering the retreating ice sheet of glacial time.

Glacial boulder clay occurs as erosion remnants here and there throughout the area; these probably represent parts of a once extensive sheet that spread widely over the low land now forming the Saskatchewan valley.

Erratics, ice borne from the northwest, are scattered everywhere over the district; many dropped by the ice in their present positions, and many washed by later erosion from the boulder clay.

CRETACEOUS.

No Cretaceous rocks were seen during the exploration. Mr. J. B. Tyrrell, however, informs me, in a personal letter, that at a low stage of water in the Saskatchewan, he found in the river bed along the stretch between the Tobin rapids and Birch islands, shales that he was able to recognize as of Benton age.

On Carrot river, to the south, and on the shores of Wapawekka lake, to the northwest, Dakota sandstones are exposed, and it may be inferred that, in the intervening area also, they form the lowest beds of the Cretaceous, underlying the drift cover.

DEVONIAN.

It is probable that Devonian rocks which protrude from beneath the Cretaceous cover, both east and west of this area, also occur in the same position within the area, though no exposures that were recognized as of that age were seen, owing probably to the great thickness of the drift in the part of the region where they might be looked for.

SILURIAN.

Silurian beds, consisting of white-weathering, brown-buff, magnesian limestone, are the highest Palæozoic rocks exposed. They overlie, conformably so far as can be seen, the Ordovician, and are made up of white-weathering, brown-buff, hard, somewhat crystalline, magnesian limestone, which forms a gently undulating sheet extending over the southern part of the area. Exposures were seen at a few points only, on Cumberland lake, near the northern edge of the Saskatchwan valley. A few very badly preserved fossils, collected from these beds, were examined by Mr. Percy E. Raymond, who was able to identify *Isochilina grandis latimarginata*, Jones, and *Favosites*, with *spiriform septæ*. These, taken in conjunction with the earlier collections of Tyrrell, Dowling, and others, fix the age of the beds quite satisfactorily.

ORDOVICIAN.

The most widely exposed sediments of the region are of Ordovician age, and of about the horizon of the Winnipeg limestone. They occupy a broad belt, directly overlying the Pre-Cambrian complex, and apparently conformably overlain to the south by the succeeding similar beds of the Silurian.

At the base occurs a thickness of 10 feet or more of a very siliceous, friable, white sandstone, made up almost entirely of well rounded, grains of white quartz, overlain by 6 inches of very soft shaly sandstone; a band a few inches thick of iron carbonate rock; 12 inches of red-purple, mottled, hard calcareous sandstone, and, over all, a cover of brown-buff, hard magnesian limestone, which spreads widely, in gentle undulations, over the central part of the area.

Owing, as in the case of the Silurian, to the crystalline character of the limestone, the fossils collected were few; but they serve, as in the other case, when taken with earlier collections, to fix the age of the containing beds.

Mr. Raymond identified among them: from Deschambault lake, *Platystrophia lynx* (Eichwald), and *Receptaculites Oweni,* Hall; from Bigstone lake, *Receptaculites Oweni,* and a fragment of a large coral; and from Pelican lake, *Clionychia,* sp.

PRE-CAMBRIAN.

The northern part of the area is entirely underlain by Pre-Cambrian rocks. They consist mainly of biotite gneisses, hornblende gneisses, and granodorites, but include two belts of more basic rocks, which, from their lithological characters, may be referred to the Keewatin. One of these belts, where it emerges from beneath the Ordovician limestone at Amisk lake, has a width of about 12 miles. The other, which is exposed near the northwest corner of the area, emerges also from the limestone cover; it is narrower than the first and is lost in the gneisses within a few miles.

INTRUSIVES.

One large area of intrusive red granite, or, more exactly quartz-mica diorite, since most of the feldspars are plagioclase, was recognized as being a continuation of that found, in 1908, along Wapawekka lake. Exposures were seen along Wapawekka river and its tributary lakes and streams. Minor intrusions of granite and pegmatite are common. They cut everything up to the sedimentaries, which are quite undisturbed.

Economic Geology.

Economic interest has been confined to the Keewatin belts, since these seem, from the experience gained in other areas, to afford a more promising field for the work of the prospector than any of the other areas. No part of the area can be said to have been prospected yet, although a few prospectors have made hurried trips through parts of it. Though both the Keewatin belts may be described as not unpromising, the eastern one, from its greater width and extent, is the more attractive. So far as known, no deposits of sufficient value to be worked have yet been found.

Limestones which, though magnesian, are well suited for burning commercially for lime are plentiful over all the area, except the extreme northern part. Many of the beds of limestone are also well situated for quarrying, and adapted for building stones.

CLAY AND SHALE DEPOSITS OF WESTERN CANADA.

(*Heinrich Ries.*)

During the summer of 1910 the writer was in the field for a period of somewhat over three months, engaged in a study of the more important clay and shale deposits of the western provinces. He was aided throughout in the work by Mr. Joseph Keele, of the Geological Survey, but previous to my taking the field, Mr. Keele spent several weeks alone in Manitoba, and the results of his work in that Province are reported on separately.

The field work was begun at Winnipeg, Man., and extended westword as far as Victoria, B.C., but the present summary covers the territory between Regina and the coast.

Samples were collected from many localities, for the purpose of testing, but as the laboratory investigation of these is not yet complete, only the mode of occurrence of the clays and shales, and the industry based thereon, is referred to.

With reference to the geographic distribution of the clays and shales, it may be pointed out that the most extensive and important deposits lie east of the Cordilleran area, in other words, in the region of the Great Plains; while second in extent are the deposits of the Pacific coast belt.

Few or none are found in the region lying between the eastern boundary of the Rocky mountains and the Coast ranges.

Geologically, the clays and shales show a somewhat restricted distribution, ranging from Jurassic to Pleistocene.

For convenience of description the occurrences may be divided into three areas, viz., the Great Plains, the Cordilleran, and the Pacific coast.

GREAT PLAINS REGION.

In that portion of the Great Plains area lying west of the longitude of Regina and Prince Albert, surface clays and silts are abundantly distributed, and often used locally for the manufacture of common brick. The product thus made is usually of red colour, and often highly porous, but since in many districts no other material is locally available, it has to be used. Those clays which are strongly calcareous yield a buff brick.

The Pleistocene clays and silts referred to above are in most cases glacial deposits, some of them containing small pebbles, at times of calcareous character. They are worked around Regina, Saskatoon, Prince Albert, Moosejaw, Medicine Hat, Red Deer, Cochrane, and otther places of minor importance.

At some points, as Edmonton, flood plain deposits are extensively employed for making common and pressed brick. In most cases, however, the surface clays are not adapted to pressed brick manufacture.

There are certain areas, some of them rather extensive, that are underlain by clays and shales of Tertiary or Cretaceous age, which hold out strong promise for the future, and whose prospective value has been, in part at least, realized, even at the present time. I refer to the areas around Dirt hills, Souris valley, Medicine Hat, Edmonton, and Calgary.

Dirt Hills Area.—This name is applied to a group of hills rising from the plains about 30 miles south of Moosejaw, and extending south and southeastward for some distance. The beds are of Laramie age; and about 23 miles south of Drinkwater, on the Portal branch of the Canadian Pacific railway, there are exposed a series of white and brown clays in the outer slopes of the Dirt hills. The beds appear to dip westward, and the hills in which the clays occur have a steep eastern face, and a western slope conformable to the dip.

The predominant beds are white and greyish white sandy clays, and brownish red siliceous clay shales, as well as some gypsiferous beds and bluish clays. The white sandy beds, which form the larger part of three hills, are quite prominent, and contain occasional lenses of a finer grained white clay.

The succession of beds, from the bottom up, where the white clays are best exposed, appears to be as follows:—

Brownish clay-shales.
Soft sandstone.
Grey clay.
White sandy clay.
Thin beds of purplish and bluish shale.
Brownish clay-shales.
White and grey clays.

The white clays are fireclays, fusing at cones 30 to 32.

Some of the white sandy clay has been hauled to Moosejaw and made into boiler setting brick, with good results.

The practical development of these clays hinges upon a satisfactory solution of the transportation problem, and this may occur at no distant date, as there is said to be a projected branch of the Canadian Northern, which will pass within 3 miles of these clay deposits.

Souris Valley.—The lignite seams of the Souris coal field have been described by Dowling[1], and in his paper mention is made of the sandstones and shales which are interbedded with the lignites. There seems little doubt that many of these shales could be utilized for the manufacture of clay products, but up to the present time not much has been done to develop them.

The only locality at which they are worked, is at Estevan, Sask., where the shales belonging to the upper member of the coal series in that field are mined by the Estevan Coal and Brick Company.

The section shown in their workings is as follows:—

Top glacial clay	10	to 20 feet
Lignite		8 "
Parting clay shale	2	to 2½ "
Lignite	8 in.	to 2 "
Blue clay shale, upper 15 feet smooth	30	to 40 "

The top clay, which is highly calcareous and cream burning, is used for making common brick.

The shale, which is won by drift mining, is used for making dry-pressed brick. It is red burning.

Shales are found at a number of other points in the Souris River coal field, but some of them crack in air drying. One very smooth plastic deposit was found overlying the clay at Pinto.

Medicine Hat.—This town lies in the Belly River shale area, the beds of this formation being exposed at a number of points along the Saskatchewan river, as well as in the slopes of some of the surrounding hills, where the shales have not been removed by pre-glacial erosion, or are not covered by glacial clays or silts.

It may be said of the shales of this area in general, that they consist of more or less lenticular bodies of clay shales, and shales which are sometimes separated by lenses of sandstone.

[1] Can. Geol. Survey, Annual Report, Vol. XV, Pt. F.

The lenticular character of the beds is proven by the fact that their structural relations can sometimes be well seen in one excavation, and also because sections on opposite sides of the river may be totally unlike so far as regards the beds over and underlying the same coal seams.

The shales show a variety of colours, and range from highly silicious to those of very fine grain. Some of the beds evidently contain a large amount of colloidal material, and have to be dried very slowly to prevent cracking, but this cannot always be avoided. Some of them may be cured of cracking by pre-heating, and experiments are now under way to determine this.

Most of the shales of the Medicine Hat region are not refractory, and only one of the beds thus far opened up is claimed to be a good fireclay.

The Belly River shales are now worked near Coleridge and Red Cliff. At the former locality the shales outcrop on the slope of a steep ridge, and are said to have been tested by 80 foot borings. The beds show the usual lenticular arrangement, and since the lenses vary in character, and are interbedded in places with sandstone, some selective mining and sorting is necessary. Among the types of clay thus far identified here by the owners are, sewer-pipe, pressed-brick, and fireclay.

The shales are loaded on cars, which are run down a spur to the Canadian Pacific railway, and thence to Medicine Hat, where they are to be used at the new and extensive plant of the Alberta Clay Products Company.

At Red Cliff, 6 miles up the Saskatchewan river from Medicine Hat, a somewhat deep section is exposed in a coulée running from the top of the cliff down to the river level. The shale bank has been opened up about half way down the coulée, and the section is somewhat as follows:—

Shales with sandstones	50 feet
Dark, chocolate clay, checks in drying	3
Alternating shales, silts, and some lignite seams	30
Lignite	5
Sandy shales	15
Lignite	4–5
Carbonaceous shale	2
To river level (concealed) about	50

The run of the bank is used for making a red, wire-cut brick, while one bed in the upper part of the bank is employed for dry press. All of the shales are red-burning, and it is not likely that any of them are refractory.

The raw material is worked up in the recently established plant of the Red Cliff Brick Company.

Directly across the river is another coulée, showing an equally deep section, but the beds are entirely different, and are mostly very sandy in character.

Edmonton.—There are four possible sources of clay or shale in this area as follows:—

(1.) Flood plain clays, of very silty or even sandy character, underlying the low terrace bordering the Saskatchewan river. This material is used for common and pressed brick.

(2.) Glacial (?) clays of highly plastic character, underlying the upper level terrace on which Strathcona and Edmonton stand.

(3.) Shales underlying many of the coal seams, and usually too thin to be utilized.

(4.) Shales higher up in the section than the coal seams at Edmonton and Strathcona.

The last named appear to represent the best type of material found in the immediate vicinity of Edmonton. The best observed exposures lie just northeast of Strathcona, in the valley of Mill creek, and along the Edmonton, Yukon, and Pacific railway. They are exceedingly plastic, and are said to burn to a vitrified body. No claim is made for a high refractoriness, and some of them have a rather high air shrinkage. This horizon should be carefully prospected to determine the occurrence of clays at other localities.

The development of the clays around Edmonton is a matter of the highest commercial importance, as the demand there for all grades of structural clay products is large.

South of Edmonton, between that point and Calgary, Tertiary shales are found outcropping along the Red Deer river, near the town of Red Deer. Some of these weather to a very plastic clay, but they are not utilized.

Calgary.—The Cretaceous shales are the most important clay resources of this district. They evidently underlie a considerable area, but at most points the outcrops have been obscured by glacial drift. The shales have, however, been opened up for working at two localities. One of these is at Sandstone, and the other about 5 miles west of Calgary. At both points the bank shows massive layers of grey and buff shale, interbedded with beds of sandstone up to 2 and 3 feet in thickness. The latter have to be rejected in quarrying.

Although the shales contain sufficient lime carbonate to effervesce briskly with acid, there is not sufficient to destroy the red burning character of the material. It is used at both localities for making dry pressed brick.

At Cochrane, west of Calgary, there are somewhat extensive exposures of shale, some of which are free from the sandstone beds, so abundant at the two localities mentioned above.

Other Localities.—The Belly River shales are well exposed along the Belly river at Lethbridge, and also in the workings of the coal mines there. Those associated with the coal are often highly carbonaceous, and often gritty, but some, such as those exposed along the wagon road near the bridge across the river, work up to a very plastic mass, even though they appear rather unpromising in the outcrop.

There are also abundant shale beds from 2 to 6 or 8 feet in thickness, interstratified with Cretaceous sandstones, in the low foothills west of Lundbreck. They are best seen in the railway cuts between that town and Hillcrest. Their value and character cannot be definitely stated until the tests on them are completed.

A somewhat important shale bed overlies the coal along the south fork of the Oldman river, 6 miles northwest of Pincher creek, and other Cretaceous clays outcrop in the creek bank on the western edge of the town, as well as several miles to the southwest along Mill creek.

Cretaceous shales, of gritty character, have also been quarried at Seebe siding, east of Kananaskis. Eastward from there along the Bow river, Cretaceous outcrops are frequent, and the entire section should be carefully searched.

CORDILLERAN REGION.

The occurrence of extensive clay deposits was not expected in this region, but nevertheless all reasonable precautions were taken to search for them.

In the Crowsnest Pass district, the Fernie shales have been utilized at Blairmore for making a red, dry-pressed brick, of good quality. Similar shales occur at Coleman.

Shales are associated with the coal seams at Canmore and Bankhead, but are not adapted to brick manufacture.

Flood plain and glacial clay deposits of small extent occur in many of the valleys, and are worked at several localities, including Nelson, Castlegar Junction, Kamloops, and Enderby.

A deposit of colluvial clay, derived from the phyllites on the slopes of Mount Stephen, is found at Field, and a fine-grained plastic clay, suitable for earthenware, occurs in the Yoho valley.

From the few preceding paragraphs it will be seen that no fireclays appear to be known in the Cordilleran region. This is unfortunate, since there are several smelters, and numerous coke ovens in operation, which now have to obtain their supplies of firebrick from the United States and England.

It is hoped that this demand will be supplied in the future by bricks made from the fireclays at Clayburn, or possibly those of the Dirt hills, or even the fireclay (if it proves to be such) at Medicine Hat.

PACIFIC COAST BELT.

The Tertiary beds of Sumas mountain, near Clayburn, contain one of the most interesting series of shales to be found in the western provinces.

The section involves a series of shales, sandstones, and at least one conglomerate. Some quartz porphyry is present, but not in contact with the worked shale deposits.

The entire series appears to dip southwest at an angle of about 15° to 20°, and the shales range from those of a highly refractory character to others of much lower refractoriness. On this account some of the shales burn buff, and others red.

At the base of the section, there appear to be at least two beds of fireclay, the lowest one divisible in some places into three parts. Of these, the lowest bench is called a china-clay, and is said to burn white, but our tests show that it does not. The middle and upper bench are separated by a seam of coal, of variable thickness, and containing flint clay partings. Some of the best fireclay in the mine has a fusing point of cone 32.

These shales are said to be adapted to the manufacture of pressed, paving, and firebrick, and sewer-pipe.

Pleistocene clays are found on the lower slopes of the mountain, and can be used for common brick.

There is now one factory in operation at Clayburn, that of the Clayburn Brick Company. A narrow gauge road has been laid for a distance of 3 miles up a gulch in Sumas mountain, and the total rise in this distance is 450 feet. The mines belonging to the Company are located along the line of this railway.

Other deposits, not yet developed, are found on the opposite side of the mountain, but these will probably be opened up before long.

Around Vancouver, along the Fraser river, at least as far east as New Westminster, and at Sumas mountain, as well as other points, there are deposits of a bluish grey stratified Pleistocene clay, which usually forms lenticular deposits surrounded by coarse sand. The clay is of value for common bricks and is worked at New Westminster, Clayburn, Port Haney, etc.

A glacial clay is employed for common and pressed brick manufacture on Anvil island, in Howe sound. Similar material is also worked on Sidney island, and around Victoria.

Sewer-pipe and fireproofing are made at Victoria from shales obtained near Comox, Vancouver island, and residual fireclay from the northwest end of the same island.

Clay Working Industry.

The main clay working industry at the present time is the manufacture of common brick, but the product in many localities, as around Victoria and Vancouver, does not supply the entire demand, and common brick are imported in large quantities from Seattle, Washington.

Dry-pressed brick are made in small quantities at a number of points, but the only plants of large capacity are those at Medicine Hat and Clayburn.

Most of the pressed brick now used in the western provinces are imported, and command a high market price. The same is true of fireproofing, terra-cotta, fire-bricks, pottery, and sewer-pipe.

It will be seen, therefore, that there is room for abundant development and expansion in the home clayworking industries. The relation of this to tariff questions, which are an influencing factor, will be discussed in more detail in the final report.

Other Mineral Developments.

It may not be out of place to make brief reference to some of the other mineral developments in the region covered in this summer's work.

In the Crowsnest Pass district, active development is going on in the coal area between Frank and Hillcrest, some of the new mines having reached the shipping stage. The lime rock of the Frank slide is being used for the manufacture of lime.

The Medicine Hat gas field continues to yield steadily, and wells are located as far from Medicine Hat as Red Cliff in one direction, and Dunmore Junction (now Coleridge) in the other, but the limits of the field are not definitely known.

According to Mr. A. K. Grimmer, city engineer of Medicine Hat, about eighteen wells have been drilled at this locality, of which about eight were sunk by the city. Of the latter group three had a depth of 1,000 feet, while the others varied from 300 to 650 feet. The deeper ones show a pressure of about 650 pounds per square inch.

There are three important wells from which the city is drawing its supply, located as follows:—

(1.) Corner Main street and West Allowance: 1,000 feet deep, 4⅝ inch casing, 550 pounds capped pressure; volume 1,000,000 cubic feet per twenty-four hours.

(2.) Corner North River street and Third Avenue: 1,000 feet deep, 6 inch casing, 560 pounds capped pressure; volume, 1,250,000 cubic feet per twenty-four hours.

(3.) On Bridge street, known as Big Chief: 1,000 feet deep, 6 inch casing, 560 pounds capped pressure; volume, 3,000,000 cubic feet per twenty-four hours.

In addition to this the city has four wells to a depth of 700 feet, and the private wells in the city are as follows:—

(1.) Central Canada Packing Company: 750 feet deep, 2 inch casing. This is a wet well, was never in good condition, and is not in use.

(2.) C. Colter, Second avenue: 700 feet deep, 3 inch casing, and 270 pounds pressure when capped.

(3.) C. Colter, Main street: 400 feet deep, 3 inch casing, and 100 pounds pressure when capped. Not in use.

(4.) H. Yuill, South Railway street: 850 feet deep, 4⅝ inch casing, and 270 pounds pressure when capped.

(5.) Canadian Pacific railway: 1,000 feet deep, 6 inch casing, with 2 inch tube and packer. This has a pressure of 560 pounds when capped, and a volume of 1,250,000 cubic feet in twenty-four hours.

(6.) Hargraves well, at end of highway bridge in city; this well is 1,042 feet, has a pressure of 560 pounds when capped, and a discharge of 2,800,000 cubic feet in twenty-four hours.

On May 31, 1910, the city began drilling a well at a point 2 miles east of Medicine Hat, in the N.E. ¼ of N.E. ¼ of sec. 30, tp. 13, R. 5, W. 4th. This well has a diameter of 10 inch casing, and a depth of 937 feet. It was completed August 30, after striking a good flow of gas, with a pressure of 560 pounds at the end of twenty-four hours. A small flow of gas was struck at 550 feet, and continued down to 660 feet.

This well has been turned over to a manufacturing industry, and the gas will be used for blast furnace purposes.

During the summer of 1910 there was a reported discovery of oil at Matsqui, near Vancouver. The facts are these: In digging the foundation for a power-house of a new electric railway, near Clayburn station, a coarse sand containing asphaltic material was discovered, and led to the conclusion that it must represent the hardened seepage from oil-bearing sands. With this idea in view a number of drill holes were put down, none of them to a great depth, and while no flow of oil was struck it is said that some indications were found. Steps have been taken to organize a company and raise money for deeper drilling, and subsequent development if it is warranted.

CLAY RESOURCES OF THE WESTERN PROVINCES.

(*Joseph Keele*).

The investigation of the clay resources of the Dominion, begun last year in the Maritime Provinces, was continued this year in the western provinces. I was again associated with Professor Ries, and accompanied him throughout his stay in the field. Our work was chiefly prospecting for shale and clay deposits suitable for use in the various clay working industries, and also in visiting the localities where brickmaking is now carried on.

Having preceded Professor Ries to the field by about two weeks, this time was occupied in visiting various points in the Province of Manitoba. Owing to the wide scope of the work planned for the summer, only a limited number of localities in each province could be visited. Those in Manitoba were selected with a view to giving a good general idea of the material available in that region. About 20 samples of clays and shales were collected at various worked and unworked localities. The limitations and possibilities of these materials will be fully considered in a report to be issued after the series of tests that are now in progress are completed.

The material available for structural purposes is obtained from two sources—surface clays and shales.

The surface clays, which are usually lake or estuarine deposits, some of which may be of direct glacial origin, are the most widespread. Notwithstanding the fact that these surface deposits are, in many places, of great depth, only a limited portion of them unfortunately can in some localities be utilized by the clay worker. This is the case in the neighbourhood of Winnipeg, where only about 3 feet of the deposit can be used, and although there is often as much as 40 feet of clay of different quality beneath this, it is quite unsuitable for brickmaking purposes. At Brandon the surface deposits consist of stratified sands, silts, and clays, with the sandy and silty layers so much in excess that good hard bricks cannot be produced from them.

At Portage la Prairie, Virden, Hartney, and Gilbert Plains, there are good deposits of clay, which can be worked to as great a depth as the brickyard owners desire. There is only a light covering of soil to be removed, and in places the brick clay comes almost to the grass roots.

The surface clays in Manitoba are nearly all calcareous, the lime content being usually high. The underburned bricks made from them are of a light red colour, and soft and porous; the fully burned bricks are hard, light buff in colour and make a good durable building material.

Shales of Cretaceous age form the bed-rock of most of the western portion of the Province, but on account of the thick mantle of surface deposits, they are not generally seen outcropping. They outcrop plentifully at some localities, however, notably at the Riding, and Pembina mountains, and at two points are worked for brickmaking purposes. The shales, where exposed, are generally hard and non-plastic, so that when finely ground and mixed with water they cannot be moulded into shapes; but in some cases they are decomposed by weathering, and have become quite soft and plastic. The shale used for making dry press brick at Leary siding is in this condition. The shales burn to a red colour, and will stand much harder firing than the surface clays.

About twenty-six brickyards are in operation in Manitoba; of these about four produce dry press bricks, and the rest, with the exception of one stiff mud machine at Alsips yard in Winnipeg, turn out soft mud bricks.

The burning is mostly done in scove kilns, the fuel being generally dry poplar wood, but a few of the more progressive plants have down draft kilns, and burn coal. The season's output varies from 500,000 to 12,000,000 in the various yards, the average length of the season being about 150 days.

The principal difficulties met with by brickmakers using surface clays are: the liability of the green brick to air check while on the drying racks, and in judging the proper degree of burning. Calcareous clays have their points of incipient vitrification and fusion so close together that quantities of the brick near the arches are melted, while the upper layers, which receive the least amount of heat, are underburned and soft, consequently there is great waste. It seems impossible to avoid this in scove kilns, but there is far less waste, and a greater economy of fuel in down draft kilns.

If the clay is mined in the fall, and allowed to weather in a stockpile over winter, subsequent air checking in the drying racks will be considerably reduced, the clay will be easier to work, and it will be available for use earlier in the spring; but only in one instance that came under my notice was this method taken advantage of.

There was a great scarcity of brick in Manitoba during the early part of the building season of 1910. No brick were left over from the season of 1909, and on June 1 there was not a kiln of brick yet burned in the Province. On the night of June 2, about 2,000,000 bricks were frozen on the drying racks, and consequently destroyed.

Common brick usually sell in Winnipeg for $11 per thousand, but this summer they sold as high as $15, and as the local yards were unable to supply the demand large quantities were imported. Most of the pressed brick used for facing buildings is imported.

All the structural hollow ware, and sewer-pipe used in the Province is imported, but the use of paving brick is prohibited by the high freight rates on such a heavy commodity.

I am now carrying on experimental work under the direction of Professor Ries, with mixtures of shales and clays, to find out if it is adapted for a wider range of products than simply common brick.

Special experimental work is also being carried on with the object of devising some practical method of treatment for the underclay at Winnipeg, which may render it available for brickmaking purposes.

A general description of the deposits and works seen in the provinces farther west is given in the summary by Professor Ries, so that it will be unnecessary to repeat it here.

At the close of the season two plants in the United States were visited where deposits are worked similar to certain undeveloped or partially developed deposits in Canada, in order to find out the range of wares that could be manufactured here.

In the vicinity of Seattle, Washington, the clay-working industry is in a flourishing condition, and facing brick, hollow ware, paving brick, sewer-pipe, and glazed terra-cotta are manufactured from material similar to that which occurs so abundantly in Sumas mountain, a short distance east of Vancouver.

At Dickinson, North Dakota, there is a series of clays and shales that appear to be precisely similar to unworked deposits which occur about 25 miles south of Moosejaw, in the Province of Saskatchewan. At the former point a large business is done in firebrick, made by the dry press process, and also in dry press face brick for buildings, and mantels.

GUNFLINT DISTRICT, ONTARIO.

(J. D. Trueman.)

Introduction.

A large section of country west of Lake Superior has been examined by the Geological Survey, the results appearing in a uniform series of rectangular maps, on a scale of 4 miles to 1 inch. An area, however, southwest of Port Arthur and Fort William, and extending from Lake Superior west about 75 miles to Gunflint and Saganaga lakes, and from the International Boundary north to about latitude 48° 27', has not yet been included in that series. Intermittently since 1866 silver mining has been active within this district, the best known locality being that of Silver islet, on the shore of Lake Superior. A formation similar to that in which the iron ores of the Mesabi district, Minnesota, occur crosses the area diagonally. Though considerable prospecting has been done in the district, it has not been thorough, and the field still has possibilities for iron and silver discoveries.

Within the area outlined a sketch map[1] of the southeastern portion, as well as a detailed map[2] of a small area about Silver mountain, have been issued by the Geological Survey. During the past summer N. L. Bowen has been engaged in geological work in the eastern part of the district, for the Bureau of Mines, Ontario.

My instructions were to commence the survey of the unmapped area, working east from Gunflint lake. During the summer, examination was made of the country about Gunflint lake, and, to the northeast, about Northern Light, Mowee, and several unnamed lakes in that vicinity. The streams and lakes were surveyed by means of compass and micrometer where absence of local magnetic attraction permitted. Where magnetic attraction was encountered the plane-table and dial compass were used.

Efficient aid was rendered by my assistants, J. A. McKenzie Williams, and R. V. Saunders.

General Character of the District.

TOPOGRAPHY.

A line joining Port Arthur with Gunflint lake would roughly mark the boundary between two sections of country which are distinctly different in topographical character. To the north, as far as examined, in the regular sky-line, and in the rounded hills and numerous lakes, the usual characterictics of vast areas in Canada underlain by Archæan rocks can be recognized. Occasionally glacial drift conceals the underlying relief, but generally the rocks are bare, or covered by a thin mantle of soil supporting a rather heavy forest growth. To the south, erosion of the flat-lying or slightly dipping sedimentary rocks, intruded by diabase sills, has given rise to flat-topped hills, as near Port Arthur, or to sawtooth ridges as around Gunflint lake. The International Boundary is marked by water courses, the eastern section consisting of a chain of lakes flowing into Lake Superior by the Pigeon river. From North lake the water flows west into Gunflint and Saganaga lakes, and then, by numerous streams and lakes, into Rainy lake, and finally Hudson bay.

[1] No. 285. Thunder Bay Mining Region. Part II, Vol. III.
[2] No. 286. Silver Mountain Mining District, Part II, Vol. III.

TIMBER.

Owing to its rocky character, the value of much of the country near Gunflint lake as a national resource must lie entirely in its mineral and forest wealth. Over considerable areas valuable timber is still standing, the principal varieties of trees being red pine, jack-pine, spruce, balsam, and tamarack. White pine occurs, but is not common. Birch and poplar are quite abundant.

Forest fires during the summer season of 1910 proved unusually destructive over a large section of country west of Lake Superior. A long period of dry weather made conditions very favourable for the spread of fires, so that during the latter half of June, and the earlier part of July, a dense cloud of smoke remained almost continually in the air. While fires were burning in very many places, and immense tracts of forest were consumed, there can be no doubt but that over large areas, where fires existed, the total quantity destroyed was not large.

ACCESS.

The Port Arthur, Duluth, and Western railway, a branch of the Canadian Northern, furnishes the easiest means of access to the district. When lumbering operations were being carried on in the western part of the district by the Pigeon River Lumber Company, service on this line extended to the western end of Gunflint lake. At present trains are not taken beyond North lake, a small settlement maintained largely by the lumber mill of H. Bishop & Co. West and north of North lake there are few inhabitants, and canoes serve as the only means of transportation.

General Geology.

Examination has not yet progressed sufficiently to warrant a full statement concerning the geological history of the region. However, the detailed work conducted over a large area in the adjoining Vermilion district is of much value in interpreting the geological structures present in the Gunflint district, and the general relations of the rocks can be given briefly.

All the rocks of the district are of Pre-Cambrian age. The oldest series, called the Keewatin, consists largely of green schists formed from basic volcanic flows. At some time, possibly when mountain building forces were active, these rocks were intruded by batholithic magmas with the formation of granites and gneisses of Laurentian age. Much later, when the country was worn down to a low relief and the underlying granites were exposed, a sedimentary series called the middle-lower Huronian was laid down. After this the country was again subjected to orogenic movements, later eroded, and again a sedimentary series was deposited. This has been called the Animikie, or upper Huronian. In the immediate vicinity of Gunflint lake the middle-lower Huronian seems absent, so that there is a double unconformity between the Animikie and the older rocks. Since the Animikie sediments were laid down there has only been sufficient disturbance to raise them to their present position and give them the gentle inclination which they now possess. This disturbance probably took place towards the close of Keweenawan times. Except for a narrow band the Animikie sediments have been eroded off the area north of Gunflint and North lakes, and they now lie mostly to the south, with a slight dip away from the outcrops of the older formations.

TABLE OF FORMATIONS.

Pleistocene—

Glacial clay, sand, etc.

Unconformity.

Keweenawan—

Diabase sills and dykes, Duluth gabbro.
Igneous contact.

Upper Huronian (Animikie)—

Slate.
Gunflint iron formation.
Conglomerate.
Unconformity.

Laurentian—

Hornblende granite, hornblende syenite, and diorite.
Biotite granite, biotite granite gneiss.
Igneous contact.

Keewatin—

Greenstone, green schists.

Keewatin.—Though extensively developed in the Vermilion district, and on Hunter island, which lies to the east of the district examined, Keewatin rocks are not abundant in the Gunflint region. Schists of Keewatin age occur in small amount north of Gunflint lake, and greenstones and green schists occupy a larger area north of Saganaga lake. The development of hornblende and chlorite schist in the Keewatin is probably largely due to the presence of the Laurentian intrusives. An intensely folded body of banded magnetite-bearing rock was observed in the Keewatin, north of the northeast arm of Saganaga lake.

Laurentian.—North of the Animikie sediments the rocks are prevailingly granitic or gneissic in character.

Hornblende granite is extensively developed about Saganaga lake. It occupies a large area in Minnesota, and has been given the name of Saganaga granite by the geologists working in that region. On the east shore of Saganaga lake there are almost continuous exposures of this granite. There is a marked uniformity in the general appearance of the outcrops, and undoubtedly they form part of a single batholith. While the rock is typically a hornblende granite, it also contains biotite. Orthoclase and plagioclase both occur. The rock is especially marked by large phenocrysts of quartz and numerous small grains of sphene. Apatite can also be seen abundantly in microscopic sections of the rock. Eastward, between Saganaga and Northern Light lakes, the granite passes, with diminution of quartz, into a hornblende syenite. In addition to the minerals occurring in the granite, the hornblende syenite contains a varying amount of pyroxene, and the rock, at times, approaches a diorite in composition. Occurring as irregular areas in the hornblende syenite and other rocks are masses of hornblende-rich rock or amphibolite. This rock consists of the same minerals as the syenite, except that the ferro-magnesian minerals are more abundant. Part of the hornblende has formed secondarily from pyroxene. The amphibolite varies from a 'pepper and salt' schist to a rock of very coarse, massive character. It is, in places, clearly cut by apophyses or dykes of feldspar-rich hornblende syenite. The amphibolite may, in large part, be extremely altered Keewatin, but, at any rate, the hornblende syenite seems to grade into a rock at least approaching the amphibolite in composition. The hornblende syenite is frequently cut by calcite and quartz veins.

Around Northern Light lake are very extensive areas of biotite granite gneiss. The gneiss is almost invariably fine-grained, and generally white or grey in colour. The banding, though sometimes obscure, is frequently very pronounced. The gneiss cuts and includes masses of the amphibolite, and is clearly of igneous origin. Field and microscopic observations indicate that the gneissic structure was developed prior to the complete solidification of the rock. In part the banding is due to movements during the consolidation of the rock, but in part also to drawn out inclusions of hornblende schist. This gneiss is thought to be younger than the Saganaga granite, but is provisionally called Laurentian. Around Mowee lake is a rather coarse biotite granite similar in mineralogical character to the biotite gneiss. The rock has been subjected to shearing, as shown clearly by the fractured and drawn out quartz grains.

Animikie.—The Animikie is a sedimentary series dipping gently southeast, away from the exposed areas of Laurentian rocks. It is intruded by sheets of diabase known as the Logan sills. Except for a thin layer of conglomerate, the Gunflint iron formation is the lowest member of the Animikie series. The iron formation is generally siliceous, but varies greatly in character, and is made up largely of ferruginous chert and cherty carbonate. The formation is frequently banded, and shows minor folding. The slate is usually fine-grained, and its thickness is to be measured in thousands of feet. It forms far the greater part of the Animikie series.

Keweenawan.—In addition to sills in the Animikie sediments there are a few dykes of probably the same age cutting the hornblende syenite. The characteristic rock of these bodies is a black to green, medium grained diabase. Phenocrysts of feldspar are frequently present, sometimes of large size. Near the contact the texture is very fine.

Pleistocene.—Glacial drift does not occur in any quantity in the vicinity of North and Gunflint lakes, or northward until some distance beyond Northern Light lake. To the east of North lake there are considerable areas of drift, and agriculture is carried on in the valleys.

Malignite.—During the course of the summer the writer had occasion to visit Pooh-bah lake, the locality where malignite was found, which was originally described by A. C. Lawson. Although boulders of rock similar in appearance to malignite were frequently noticed in the Gunflint district, no outcrops were seen.

While in Port Arthur a block of porphyritic rock resembling malignite was noticed on exhibition. A thin section made from a specimen of this rock shows that it contains ægirine-augite, and a soda-rich amphibole, possibly katoforite, and so should probably be classed as a variety of malignite. The rock is handsome, when polished, and it is hoped that it can be used as an ornamental stone. The quarry, which is the property of the Egyptian Porphyry Co., of Port Arthur, is situated between Beck and McKenzie stations on the Canadian Pacific, about 12 miles east of Port Arthur.

Economic Geology.

Iron.—The possibility of finding iron ore in the district under examination seems limited to two geological horizons—the Keewatin, and Animikie.

Exposures of iron ore formation belonging to the Keewatin have been observed at many points in the Lake Superior region. Generally the rock consists of banded chert and magnetite, or hematite, and the formation is usually associated with Keewatin greenstones or schists. At a few places, as in the Vermilion district, at Michipicoten, and elsewhere, concentration of iron oxide has taken place on a sufficient scale to form an economic deposit. On Hunter island, which lies to the west of the Gunflint region, there has been considerable exploration of exposures of iron formation, but no important bodies of ore have yet been revealed. It was hoped that large areas of Keewatin would be found in the district examined, with the possibility of the occurrence of iron ore, but so far the bands found have been of limited extent. North of the northeast arm of Saganaga lake an intensely folded, banded, magnetite-bearing rock was observed. The deposit does not seem to be extensive, and in addition to a large percentage of quartz considerable amounts of garnet and epidote are associated with the magnetite.

The Animikie offers, perhaps, a more promising field for exploration for iron than the Keewatin, and is exposed over a large area. It is of much the same character as, and is indeed a continuation of, the formation which in the Mesabi district, Minnesota, has yielded enormous quantities of high grade ore. In the vicinity of Gunflint and North lakes it consists largely of cherty iron carbonate, banded occasionally with pure chert, and more massive ferruginous chert. The latter, as exposed on the north shore of North lake, was probably in large part originally greenalite, a silicate of iron commonly occurring in minute granules. It is here characterized by nodules of siderite, which weather out on the rock surfaces leaving cavities half filled with limonite. Exploration of the formation requires the use of diamond drills, and has so far not been carried out in a thorough manner. Perhaps the most extensive exploration has been made at what is called Paulson's mine, near the western end of Gunflint lake, on the Minnesota side. Here the iron formation has been greatly altered by the Duluth gabbro, with the formation of an amphibolitic magnetite rock. This is extremely resistant to weathering, the process by which bodies of iron ore are commonly formed. The gabbro does not, however, reach the shore of Gunflint lake, so that between the iron formation on the north shore of Gunflint lake, or to the east, and the gabbro, there is a considerable thickness of slate. There are, however, diabase sills in the Animikie, but the exact effect of these on the iron formation is not yet known. The iron-bearing rocks are not as metamorphosed as those to the southwest, and there seems a reasonable possibility of finding iron in economic quantities. East of Port Arthur, indeed, rather thin beds of ore have already been found at several places.

Silver.—Veins of calcite and quartz containing silver, either in the native form or as argentite, and cutting the rocks of the Animikie series, or the diabase sills, have attracted much attention west of Lake Superior, since 1866. The first veins discovered were on the shore of the lake, Silver islet being the most famous mine. Discoveries were later made farther inland, at Rabbit mountain, in 1882, and still later at Silver mountain. Some of the veins proved extremely rich, but many were unproductive. They were all associated with the Keweenawan trap, and in all probability owe their origin to heated waters liberated on the cooling of the diabase magma. Though considerable prospecting was done when the silver camps first opened, it cannot be said that the possibility of further discoveries has been exhausted.

While prospecting for silver-bearing veins was being carried on, claims were staked on some of the calcite veins occurring in the hornblende syenite of Northern Light lake. It is said that silver was found in one of these veins, but this could not be confirmed. Traces of galena and pyrite were the only metallic minerals observed by the writer. These veins have never been carefully tested, and if, as it seems, they are confined to the syenite, there appears to be no reason why a little careful prospecting in that rock would not be worth while. These veins occur most frequently where the syenite has been sheared, sometimes with the formation of a chlorite schist not unlike that in the Keewatin. Calcite is the usual gangue mineral, though quartz is sometimes present, especially on the sides of the veins.

SIMCOE DISTRICT, ONTARIO.

(W. A. Johnston.)

The field work of the past season was a continuation of the topographical and geological mapping of a portion of the Lake Simcoe district, Ontario. In carrying on the topographical work the plane-table method was used, and field maps were drawn on a fractional scale of 1:48,000, which, on the published map, will be reduced to 1:62,500, or nearly 1 mile to 1 inch. Topographical features are shown by contours at intervals of 20 feet, instead of 25 feet, which latter was the contour interval used previously in the field work in this district.

Field work lasted from June 2 until November 4, in which work the following assisted: Geo. H. Burbridge, L. B. Adams, R. L. Junkin, James I. MacKay, W. T. May, and C. B. P. Fitzgerald.

LOCATION AND AREA.

During the past season the sketching on the Orillia sheet, with contours at intervals of 20 feet, was completed. This sheet is bounded by latitudes 44° 30′ and 44° 45′, and longitudes 79° 30′ and 79° 45′, and includes an area of about 140 square miles, exclusive of the portions occupied by Lakes Simcoe and Couchiching. The topographical work on the Balsam Lake sheet was also completed, with the exception of the sketching, which was only partly done. The Balsam Lake sheet is bounded by latitudes 44° 30′ and 44° 45′ and longitudes 78° 45′ and 79° 00′, and has an area of about 170 square miles exclusive of the portions occupied by a number of small lakes

PREVIOUS WORK.

As stated in last year's Summary Report, the previous work of the Geological Survey in this district was done by Mr. Alexander Murray, in 1852 and 1853, the results of which are given in the Geology of Canada, 1863.

General Character of the District.

The maximum relief within the limits of the Orillia sheet is about 400 feet, the highest portion being in the vicinity of Rugby P. O., where morainic hills rise to 1,050 feet above sea-level, while the lowest portion is the valley of North river, in the northwest corner of the sheet. In the southern portions of both the Orillia and Balsam Lake sheets the solid rocks are deeply buried beneath a heavy mantle of drift, but in the northern parts the flat lying Ordovician limestones are well exposed, and near their contact with the Pre-Cambrian rocks generally form an escarpment which varies from a few feet to upwards of 100 feet in height. The limestones have a gentle dip towards the southwest, generally not exceeding 30 feet to the mile, and are rarely faulted or folded.

General Geology.

TABLE OF FORMATIONS.

Recent	Humus, sand dunes, marls, etc.
Pleistocene	Raised beaches, fluviatile and lacustrine sands, gravels and clays.
	Glacial clays, boulder clays and sands; fluvio-glacial sands and gravels.
	Sands, silts, gravels, and clay, generally stratified.
	Till, or boulder clay.
Ordovician—Lower Trenton	Kirkfield limestone (group) (new); the upper portion only included in the Trenton. The lower portion includes the Crinoid and Dalmanella sancti-pauli beds which are below the base of the typical Trenton in New York state.
	Hiatus.
	Coboconk limestone, correlated with the Leray limestone (Cherty Streptelasma beds) which the New York State geologists have included in the Lowville as the upper member.
	Lowville (Birdseye) limestone; dove-coloured limestone, with basal series of sandstone, shales, etc.
Pre-Cambrian	

DESCRIPTION OF FORMATIONS.

Ordovician.

Lower Trenton to Lowville (Birdseye).

In the southern portion of the area of Balsam Lake sheet the limestones of the lower Trenton are well exposed, and underlie the greater portion of the area south and west of Balsam lake. In a cutting made on the Trent Valley canal, between Balsam lake and Kirkfield, a section is exposed from which great numbers of crinoids, cystids, and star-fishes have been collected. In this section the cherty Streptelasma beds (Leray limestone which the New York State geologists have included in the Lowville under the name of the Leray limestone member[1]) are 'followed by a few feet of thin-bedded, shaly limestone, carrying *Dalmanella sancti-pauli, Orthis tricenaria,* and other fossils, indicating the upper part of the Decorah shale of Iowa and Minnesota, and suggesting overlap eastward from that area. A very thin corresponding bed, with similar fossils, has been locally found in New York just below the Trenton.

'The Dalmanella sancti-pauli bed is succeeded by thicker bedded sub-crystalline limestone, with black shaly partings containing great numbers of crinoids and cystids, of species found elsewhere in America only in the beds regarded as older than the base of the typical Trenton in central New York. At Ottawa, Canada, they are found at the base of the Trenton; in Minnesota they occur in the lower part of the "Fusispira bed," in or about the middle of what I propose to call the Prosser limestone; in central Kentucky they are found in the Curdsville limestone, which lies between the local equivalent of the cherty "lower Black River" (Leray limestone) and the Hermitage formation, which in Kentucky and Tennessee is the lowest division of the Trenton group.

'The stratigraphic interval between the Lowville and the Prasopera bed of the Trenton, as developed in New York and Ontario, indicates a very shallow, oscillating sea. The unequal distribution of the beds and their structural relations suggest, especially in view of the fact that the corresponding interval is represented in north-eastern Tennessee by as much as 500 feet of limestone, frequent and long continued sea-withdrawal.'[2]

In view of the fact, as above stated by Mr. Ulrich, that both the crinoid and the Dalmanella sancti-pauli beds of south-central Ontario are older than the base of the typical Trenton in New York state, and since for purposes of mapping in the Simcoe district the crinoid and Dalmanella sancti-pauli beds cannot be separated from the limestones of the lower Trenton, this series of limestones has been provisionally

[1]New York State Museum, Bulletin 138, p. 72.
[2]Communication from Mr. O. E. Ulrich to the Director of this Survey.

named the Kirkfield limestone group, from the village of Kirkfield, in the county of Victoria, near which they are best exposed. Since the Black River group as now fixed by the New York State geologists does not, apparently, include limestones of equivalent age to the Crinoid and Dalmanella sancti-pauli beds, it would also seem that an age term should be given to include the limestones as developed in western sections, between the base of the typical Trenton and the top of the Black River.

Underlying the Trenton limestones in New York State there is a series of limestones which the New York State geologists (returning to the old New York usage of Vanuxem, who named the Black River limestone from the limestone cliffs along that stream, for the beds beneath the Trenton) refer to the Black River group. This group comprises the Amsterdam limestone (new), the Watertown limestone (new) (formerly the Black River limestone), and the Lowville limestone with Leray limestone member (new).[1]

In New York state the limestones of the Black River group pass downward into the Pamelia limestone of Upper Stones River age, which in turn is underlain by the Theresa formation, the upper member of which is of early Beekmantown (Calciferous) age.[2]

Regarding the extension of these formations into Ontario Mr. E. O. Ulrich states:—[3]

'In New York north of Watertown, and in the vicinity of Kingston, Ontario, the Pamelia limestone, which is the northern equivalent of the Upper Stones River of the Appalachian valley, locally rests directly on Pre-Cambrian crystalline rocks. In New York, Ozarkian sandstone, and limestone, respectively the Potsdam and the lower part of the Theresa formation, and early Beekmantown limestone forming the top member of the Theresa, commonly intervene between the Pre-Cambrian and the base of the Pamelia. At Kingston, and to the north and northwest of that point, the Pamelia usually is in contact with the Pre-Cambrian, with only here and there small. intervening remnants of Potsdam sandstone in old down-warped embayments.

'The Pamelia wedges out at some undetermined point between Kingston and Lake Simcoe, being absent at the latter locality, and thence northward to Michigan.

'The supposed Chazy sandstone of south-central Ontario proves to be basal Lowville. the initial deposits of which consist of red and green shales and sandstones, with local intercalations of thin limestones containing Lowville fossils.'

In the Simcoe district of Ontario the following generalized section, in descending order, of limestones, sandstone, and shales, which immediately underlie the Kirkfield limestones and rest unconformably upon the Pre-Cambrian crystalline rocks, occurs:—

(1.) Dark blue to grey nodular and cherty limestones generally in massive beds from 1 to 3 feet thick. Fossils: *Girvanella* sp., *Columnaria Halli, Tetradium fibratum, Streptelasma profundum, Beatricea gracilis, Escharopera subrecta?, Nicholsonella* cf. *laminata* and *cumulata, Strophomena filitexta var., Refinesquina minnesotensis?, Orthis tricenaria. Camerella panderi*, var. nov. *Ctenodonta* cf. *Logani, C.* cf. *Scofieldi, Helicotoma planulata, Lophospire* sp. undet., *Hormotoma Salteri canadensis, Orthoceras*—small, pencil size, *O.* large species, externally resembling *Ormoceras tenuifilum, Actinoceras* sp. undet., *Cycloceras*, sp. undet., *C.*———*? arenoliratum.* Coboconk limestone correlated with the Leray limestone which the New York State geologists have included in the Lowville as the upper member. . . . . .10—20 feet.

(2.) Dove-coloured, fine-grained, even bedded limestone, in beds averaging 1 foot in thickness. In the upper portion the characteristic vertical calcite tubes are abundant, and the beds have a peculiar interlocking tooth-like arrangement at their contact. Towards the base the beds weather white and are separated

[1] New York State Museum, Bulletin 138, p. 72.
[2] New York State Museum, Bulletin 140, pp. 127-128.
[3] Communication cited above.

by thin layers of greenish sandy shale. Fossils: *Tetradium cellulosum,* Hall, *?Phytopsis tubulosum,* Hall, *Strophomena cf. filitexta, Gyronema* sp. undet., *Leperditia fabulites, var., Isochilina armata,* Walcott. *Bathyurus extans,* Hall, *Bathyurus spiniger,* Hall. *Ctenodonta cf. gibberula, Liospira* sp. undet., *Hermotoma angustata, Trochonema* sp. undet., *Orthoceras* near *O. recticameratum, Cycloceras* sp. nov. (near *O. perroti,* Clarke), *Isochilina armata*.. .. ..20 feet.

(3.) Greenish grey impure magnesian limestone, generally in compact beds which weather brownish to pink, and are characterized by numbers of drusy cavities. No fossils.. .. ..6—8 feet.

(4.) Fossiliferous, blue to dove-coloured limestone containing: *Rafinesquina minnesotensis, Cyrtodonta* n. sp.? closely allied to *C. Janesvillensis* and *C. huronensis C.—Sillimanensis? Vanuxemia rotundata, Pterotheca attenuata, P.*—sp. undet., *Helicotoma* n. sp., *Liospira progne, L.—vitruvia, Eotomaria vicinus, Clathrospira subconica, Lophospira concinnula var.. Holopea cf. concinnula, Subulites* n. sp. (near *S. regularis*), *Cameroceras* sp. undet., *Orthoceras cf. recticamerata, Isotelus, cf. obtusus, Strophomena filitexta var.* (Lowville var.), *Leperditia fabulites,* Conrad, *Isochilina armata,* Walcott.. .. ..6—10 feet.

(5.) Impure magnesian limestone in compact beds, on fresh fracture greenish grey in colour and weathering to yellowish brown.. .. ..8—10 feet.

(6.) Red and green shales and sandstones with local intercalations of thin dove-coloured limestones. and at the base locally a few feet of coarse grit or arkose resting unconformably upon the Pre-Cambrian crystalline rocks. .10—20 feet.

The fossils mentioned as occurring in the above described section were all identified by Mr. E. O. Ulrich, of the U. S. Geological Survey. Mr. Ulrich states that No. 1 of the above section is equivalent to the cherty lower bed of Cushing and Ruedemann's Black River limestone in New York State. and that the fossils of the balance of the section are all of Lowville species. Mr. Ulrich is of the opinion that the cherty beds should be included in the Lowville. for reasons which will be given in the sequel. and that they should be given a distinct name derived from some locality in the district. Accordingly these beds have been provisionally named the Coboconk limestone, from the village of Coboconk in the county of Victoria. Ontario. In a preliminary paper on the 'Lower Portion of the Palæozoic Section in Northwestern New York.'[1] Mr. H. P. Cushing unites the cherty beds with the '7 foot tier' to form the Black River limestone, but in a later report of the New York State Survey, as stated above, these beds are referred to the Lowville under the name of the Leray limestone member with the Lowville as a subdivision of the Black River group. If the cherty limestones are included in the Lowville under the name of the Leray limestone member, it would seem that the balance of the Lowville should receive a name derived from the district in which the typical Lowville is exposed.

The significance of the term Black River as a formational name has long been in question. According to the original definition of the Black River limestone. as given by Vanuxem in the Geology of New York, 1842. the Black River included all the beds between the Trenton and the Calciferous in the Mohawk and Black River valleys. This definition was later modified by Hall in 1847,[2] and the Black River was restricted to the "7 foot tier," and the underlying dove-coloured beds referred to the Birdseye, to which definition Clarke and Schuchert's Black River and Lowville apparently conformed.

In the section near Montreal, described in the Geology of Canada, 1863. pp. 136-137, the upper 10 feet are referred to the Black River. and the lower 28 feet to the Birdseye. It was recognized, however, that the line of demarcation between the two appears frequently to become very indistinct in Canada. and accordingly the two formations were grouped together. The upper 10 feet in this section apparently

[1]Bulletin of the Geological Society of America, Vol. 19, pp. 155, 176.
[2]Natural History of New York, Palæontology, Vol. I.

represented the '7 foot tier' of Hall, 1847, but as a distinct formation these beds have not been generally recognized in Canada.

In later writings some Canadian geologists have dropped the term Birdseye and made the Black River include the limestones which were supposed to belong to the Birdseye, but the lower limit of the formation does not appear to have been definitely fixed.

In the Simcoe district of Ontario the original Black River limestone of Hall (7 foot tier) is presumably absent, as its typical fossils have not been found. The fine-grained, dove-coloured limestones are relatively much thicker than the overlying cherty beds, and are characterized by fossils of Lowville age. The cherty beds, although only about 20 feet in thickness, are remarkably persistent and uniform in character, and constitute an easily recognizable horizon.

The uniting of the cherty beds with the Black River is objectionable on the grounds that, according to the original definition of the Black River limestone, it meant either all the beds between the Trenton and the Calciferous in the Mohawk and Black River valleys, or only the '7 foot tier,' and the inclusion of the cherty beds in the Black River would put a new interpretation on the term.

On the other hand, these beds are apparently more closely related faunally and lithologically to the original Black River of Hall than to the Lowville limestone, and on account of their persistent and uniform character it would appear that they should be separated from the Lowville. That the cherty beds, however, should be united with the Lowville is considered by Mr. Ulrich to be in the best interests of stratigraphical classifications, for the following reason.[1]

'Considering the composition and mapping qualities of the lower Mohawkian formations in Ontario, New York, Pennsylvania, Virginia, Tennessee, and Kentucky, the only place where the exigencies of areal mapping are as well or perhaps better served by associating the cherty bed with the typical (7 foot tier) Black River than with the Lowville, is in the vicinity of Watertown, N.Y. Elsewhere, for one reason or another, the separation of the cherty bed from the Black River is manifestly desirable. As a rule, the zone of the 7 foot tier cannot be recognized, and presumably is absent. In fact this zone, at least so far as its outcrop is concerned, is very limited even in New York. In this State it is confined to the north of the divide between the Black and Mohawk rivers. The cherty zone, on the contrary, is locally developed on both sides of this divide, and maintains its lithic and faunal characters as far from New York as Georgian bay to the northwest, and Tennessee to the southwest. In east middle Tennessee, and central Kentucky, the cherty zone is rarely present, and when it is, the zone is naturally associated with the underlying typical Lowville. On the flanks of these domes of the Cincinnati uplift the bed cannot very well be separately mapped, being only a few feet thick at its best, and further, being followed by another thin formation, the Hermitage, which is the first of the divisions of the Trenton group.

'Although the cherty bed represents a stage of geological history that is readily distinguished from the typical Lowville by differences in distribution of sediments and by faunal peculiarities, it is nevertheless a fact that the break between the Cherty bed and the later typical Black River limestone (7 foot tier) is much more important in every respect. That actual and widespread sea-withdrawal occurred at this time is unmistakably indicated by the irregularities of contact between the two beds at Watertown, N.Y., and by the rather general absence of the upper zone. The fauna of the latter is decidedly different from that of the underlying cherty zone; while the time importance of the break is suggested by the much greater thickness of limestone deposits in northeastern Tennessee, regarded as representing the corresponding parts of the stratigraphic column.'

---

* Communications cited above.

THE DEVONIAN OF SOUTHWESTERN ONTARIO.

(C. R. Stauffer.)

The work of the field season (1910) just past consisted in a stratigraphical and palæontological study of the Devonian of the southwestern part of Ontario. The object has been to re-determine the formational units into which this important system may be divided, and to collect any other data regarding it that might be available; the whole for use in the prospective geological mapping of the area. Only three months were spent in the field, and, therefore, the work must be classed as preliminary. However, a considerable amount of material has been collected and is being worked up for the final report, which it is planned to make as complete as possible.

Distribution of the Devonian.—The portion of the Province covered by Devonian formations may be roughly described as that part lying to the south and west of a line drawn from Fort Erie westward through Humberstone, Dunnville, and Hagersville, almost to Woodstock; then northward through St. Marys, Wingham, and Formosa, reaching the northernmost point near Cargill; then swinging around to the westward, returning to the south through the eastern part of Port Albert and Goderich, striking the Lake Huron shore at a point somewhat south of the town last named.

At some places the Devonian formations extend slightly beyond this line, while at others they do not quite reach it. There may also be outliers to the east and north of it, but in a region for the most part heavily drift covered they are difficult to locate, and indefinite when found. Within the area there are also localities where the Devonian is entirely wanting; for instance, at Teeswater and Anderdon. But in general the region, as outlined above, is covered by a great and continuous mass of rocks belonging to the system under discussion.

The Silurian-Devonian Contact.—The Devonian system rests unconformably on the Silurian. This contact is between beds of varying ages in both systems. The top layers of the Silurian, from Fort Erie to Goderich, show marked signs of erosion, and often evidences of weathering to a considerable depth which they had suffered prior to the deposition of the overlying strata. Arenaceous material from the sediments which form the Oriskany sandstone sifted through cracks and joints in the Silurian, and may now be found as thin vein-like seams of sand cutting through the limestone in all directions, in some cases to depths of 5 feet and more below the contact. Even where no Oriskany formation occurs this sand may be found.

The Corniferous (Onondaga) limestone usually overlaps the Oriskany sandstone, and covers a much greater area. It is, therefore, the contact between this formation and the Silurian which one observes in most places where the two systems are exposed together. When this is the case the layers of the Corniferous (Onondaga) limestone are sometimes found to be made up of rounded pebbles of the drab to buff-coloured Silurian limestones, embedded in a matrix of grey Corniferous (Onondaga) limestone. An excellent place to observe this is along the Maitland river near Goderich, where the pebbles of Silurian limestone are mingled with Devonian corals and brachiopods.

Formational Divisions of the Devonian.—The divisions of the Devonian, recognized in former studies of this region,[1] are as follows:—

[1] See Logan, Sir William E., Geology of Canada, 1863, p. 20; also pp. 359-389, and p. 932. Also Dawson, Sir J. William, Handbook of Canadian Geology, 1889, p. 175. Also Brumell, H.P.H., Geological Survey of Canada, Annua Report, Vol. V, pt. Q, 1891, p. 5.

Devonian	Upper	Chemung beds.
		Portage beds.
		(Genesee shale.)
	Middle	Hamilton beds.
		Corniferous (Onondaga) limestone.
		Oriskany sandstone.
	Lower	(Wanting.)

These subdivisions were adopted by Logan from the New York classification, but in so doing he took over the names rather than the formational units. Logan considered the Esopus (Cauda-galli) grit, and the Schoharie grit of New York, as local phases of the Oriskany sandstone which could not be distinguished from the latter in Ontario. The boundaries of the Corniferous (Onondaga) limestone he extended so as to include not only the Corniferous limestone, as then recognized in New York, but the underlying Onondaga limestone as well. In support of this union he says: 'in western Canada, we find that many of the fossils of the Corniferous limestone pass up from the Oriskany sandstone; and the intermediate Onondaga limestone, with its encrinites, can no longer be recognized as a distinct formation. We, therefore, unite the two limestones under the name of the Corniferous limestone.'[1] It is worthy of note that the same union of formations was made at a much later date in New York state. Under the name Hamilton formation Logan included all of the strata found in Ontario between the Corniferous (Onondaga) limestone and the black shales of the upper Devonian. The remaining Devonian beds were united into the Portage and Chemung group, which was treated as one division, and included the shales usually referred to the Genesee in the eastern states.

These subdivisions, with the modifications imposed upon them by Logan, fit the Devonian of Ontario very well indeed. The Oriskany sandstone, and the Corniferous (Onondaga) limestone, as found in Ontario, especially near the eastern end of Lake Erie, are almost the exact equivalents of the same formations as they are now recognized in New York state. Logan, however, seems to have included the basal layers of the Hamilton with the Corniferous (Onondaga) limestone at St. Marys and Goderich. Then too, there is a thin statum of shale near Selkirk, which indicates conditions similar to those which produced the Marcellus, and apparently at the same horizon as that formation in New York. The well records in the oil producing region of southwestern Ontario have made it possible to separate, with a fair degree of accuracy, the Portage and Chemung beds, and hence they may be given separately.

It has thus appeared expedient to continue the use of Logan's classification, with a few minor changes in the form of the names, in the present work.

The Oriskany is a coarse massive sandstone, which at places approaches a true conglomerate of small quartz pebbles. It carries a pure Oriskany fauna. Only the uppermost beds, which are of a cherty character, contain species usually found in the typical Corniferous (Onondaga), and even in these none of the most characteristic Oriskany fossils were found. Indeed, it seems quite certain that the beds, which carry true Corniferous (Onondaga) fossils, should be referred to that formation. The greatest thickness of the Oriskany sandstone observed was a trifle less than 20 feet, although it is probably somewhat thicker at other places, while at still others scarcely a foot of it is to be found.

The Corniferous (Onondaga) limestone lies unconformably on the Oriskany sandstone, where the latter occurs, and overlaps it at other places so that it rests upon the Silurian limestones. Indeed, it appears that the advancing Corniferous (Onondaga) sea destroyed a considerable part of the Oriskany sandstone, incorporating the siliceous material into its basal layers. The Corniferous (Onondaga) varies from the dark coloured, cherty limestone of the Fort Erie region, to the light grey, pure limestones of the Pelee Island and Amherstburg regions. The former is the same type as

---

[2] Geology of Canada, 1863, p. 362.

that which occurs in New York state; the latter, as that of Michigan and Ohio. The formation is abundantly fossiliferous, and this is especially true in the southwestern part of the Province. The thickness varies considerably in different parts of the area covered, but, in general, increases to the westward, while to the north its eastern thickness is maintained. At Goderich, where both contacts are shown, the thickness is about 32 feet. Since the basal portion of the Hamilton formation is a limestone, and in the greater part of the region there seems to be a gradual transition from the Corniferous (Onondaga) to the Hamilton, it is difficult to draw a dividing line between the two, while in well records this is next to impossible. It thus happens that the great thicknesses, sometimes assigned to the Corniferous (Onondaga) limestone, are likely to be in error. Fossils are abundant, and of characteristic Corniferous (Onondaga) types.

The Hamilton beds consist of soft blue shales and of limestones which approach in lithological appearance the character of the western Corniferous (Onondaga). There have been distinguished three of these limestones—a lower, middle, and upper—which are separated by considerable thicknesses of soft shale. But the number of limestone layers and calcareous bands is far greater. At no place in the Province is there more than a mere fraction of the formation exposed, but well records make its thickness approximately 350 feet, although 400 feet of strata, referred to the Hamilton, have been penetrated at Sarnia. The upper limestone, and a portion of the upper shales, outcrop in the region about Thedford, while the lower limestone outcrops at St. Marys and at Goderich; which indicates that the Hamilton beds cover a much more extensive area than has thus far appeared on any geological map of the Province. The fauna is abundant, indeed the Thedford region has long been the favourite collecting ground for Hamilton forms.

Overlying the Hamilton beds are the black shales of the upper Devonian. These are best shown at Kettle point, on Lake Huron, although they are also to be found outcropping along the Sydenham river and some of its branches. The outcropping shales are black, bituminous, and rather fissile. They contain large spherical concretions similar to those found in the black shales of this age in Ohio and New York. A few animal fossils may be found, and the sporangia of certain plants occur in great abundance, while long strap-like leaves are occasionally found. At Corunna, in Moore township, where more than 200 feet of these shales have been penetrated by the drill, they include a 20 foot bed of arenaceous material reported to be a greenish sandstone. At Cleveland, Ohio, these sandy beds outcrop along the Cuyahoga river, also along the shore of Lake Erie, and are composed of very thin layers of sandstone, alternating with soft bluish green shales (the Chagrin formation) which carry the Chemung fauna of New York. Probably this black shale deposit of Ontario represents the whole upper Devonian of the eastern part of the United States.

Economic Products.—Every Devonian formation of the Province is of economic importance. The Oriskany sandstone has been used quite extensively as a heavy building stone, to which purpose some layers are admirably suited. The Corniferous (Onondaga) limestone is burned for lime, and used in the manufacture of Portland cement. It also furnishes an excellent building stone; but by far its most important use is in supplying crushed rock for concrete and railway ballast. The greatest economic importance of the Corniferous (Onondaga), however, is as a reservoir for the crude oil of the Petrolia and Oil Springs districts. The Hamilton shales have been used in the manufacture of brick and tile, while some of the interbedded calcareous layers have found local use as a building stone. The black shales of the upper Devonian (Portage and Chemung) have not yet been used, but there is already in existence a company which hopes to recover their hydrocarbons by the process of distillation; so it is not improbable that even the black shales may contribute to the ultimate list of economic products from the Devonian.

MONTREAL RIVER DISTRICT.

(W. H. Collins.)

During the field season of 1910 the writer completed an examination of the area in Gowganda mining division upon which he has been engaged since 1908. He also began the detailed reconnaissance of a rectangle immediately south of this, 72 miles long from east to west by 48 miles from north to south. A map and report upon the former area, which has been explored jointly by the Geological Survey and the Ontario Bureau of Mines, are being prepared. When completed the work upon the latter area will furnish material for a regular map sheet similar to the already published Timiskaming (No. 138) and Sudbury (No. 125) sheets that adjoin it on the east and south, respectively. It will include all the country between W. long. 80° 20′ and W. long. 82° from N. lat. 46° 55′ to N. lat. 47° 40′. The work already done lies in the north-eastern part of this rectangle.

These two areas, which are contiguous, and in reality constitute but one, are geologically similar to the district in the neighbourhood of Lake Timiskaming. They also contain silver-cobalt ore deposits of the same type as those found near Cobalt, and in consequence, they have received much attention from prospectors during the past four years. The resultant demand for maps may be inferred from the fact that blue print copies from privately prepared compilations have found a ready sale. Geological information has been even more in demand, but could not be obtained. It was fortunate, therefore, that a larger field party than usual was provided for this year's work, as a correspondingly larger amount of much needed information was gained. However, even this acceleration is still insufficient to satisfy present requirements, much less future demands.

Efficient and ready assistance was given throughout the season by Messrs. H. C. Cooke, J. R. Marshall, E. R. Lloyd, T. L. Tanton, C. P. Sills, A.D. Macdonald, and E. J. Whittaker.

General Character of District.

TOPOGRAPHY.

The explored area lies within the Pre-Cambrian peneplain region of northern Ontario. Standing at an elevation of from 1,000 to 1,400 feet above the sea it constitutes part of an unevenly dissected plateau, which presents the characteristically gentle outlines produced by glaciation. It is essentially a hummocky rock surface, the inequalities of which appear as ridges and rounded hills from 50 to 600 feet high. A mantle of sand and gravel, deposited by glacial ice, rests upon this rock surface. Ordinarily the soil sheet is thin, and confined to the lower levels of the country, the rocky hill tops being washed bare. Its general effect, therefore, is to smooth the topographical aspect of the old rock floor; but, in a few localities, it is thick enough to bury even the hills, and there gives rise to a surface of much softer relief, more like the agricultural portions of Ontario. The townships of Lawson and Corkill, and their vicinity, are of this character. A similar area occurs in Fawcett, Ogilvie, Dufferin, and adjacent townships.

Practically the whole country is densely forested. As in other parts of the Pre-Cambrian region, lakes are very numerous, especially where the country is rocky. Heavily drift covered portions, like those above mentioned, are not so well supplied. None of the lakes, however, are large; few exceed 5 miles in length. They are drained by a large number of creeks and brooks, which form the headwaters of Montreal, Sturgeon, and Wanapitei rivers. Few of these tributary streams are large enough to be easily navigated, and only towards the edge of the area covered by the summer's work do the rivers they feed attain a considerable size. Hence canoe travel, the ordinary means of traversing the country, is exceptionally difficult.

FLORA AND FAUNA.

The forests, the natural covering of the region—as regards the kinds of trees composing them and their rate of growth—vary with the drainage, and with the depth and richness of the soil that nourishes them. So definite are these relationships that, with a little experience, the nature of the ground can be safely deduced from observation of the forest growing upon it. Practically all the low, wet lands support swamps of black spruce, with a few cedars and tamaracks. Dry, well drained soil is covered by mixed forests of white and red pine, and jackpine (*Pinus banksiana)*, balsam, poplar, white and yellow birch, and even maple. The more arid, sandy tracts are occupied almost exclusively by spindly growths of banksian pine.

Individual trees of nearly all these species grow rapidly where the soil is sufficiently deep and well drained. At many points in the district white pine, the most valuable, attains a diameter of 40 inches. However, it is seldom abundant, though there seems to be no reason why it should not be if it were planted and protected. West of Shiningtree lake it forms splendid groves, individual trees in which range from 15 to 40 inches in diameter. Cedar appears to be near its northern limit and reaches only a somewhat stunted growth. A few trees 2 feet in diameter were observed in Leonard township. Like the tamarack, cedar occurs only sparingly, and in a few localities. An immense supply of pulpwood can be furnished by the spruce forests which cover a greater part of the district. Banksian pines, under favourable conditions, grow to a size suitable for making railway sleepers.

Of the deciduous trees, the birches and poplars attain a splendid development. The sugar maple (*Acer saccharum*) seldom grows more than 6 inches in diameter and 30 feet high, but numerous individuals a foot through were seen near Gowganda junction, the present terminus of the Canadian Northern Ontario railway. A few elms occur along Wanapitei river, in the same part of the district.

A few attempts to raise vegetables—potatoes, onions, and other hardy garden stuff—have been made at Shiningtree lake, and Smoothwater lake, with very fair success. Timothy, accidentally sown along the winter road from Gowganda junction to Gowganda, was found growing well.

TRANSPORTATION.

The district may be entered either from the Timiskaming and Northern Ontario railway, or the Canadian Northern Ontario railway. The former, extending from North Bay northward to Cochrane, on the Grand Trunk Pacific railway, passes 30 miles east of the district. From Latchford station, where it crosses Montreal river, small steamers and gasoline launches ply 56 miles upstream to Elk lake, and from that point a wagon road 27 miles long reaches to Gowganda. From Timagami station the eastern side of the field is readily reached by way of Lake Timagami.

The Canadian Northern railway is built 65 miles northwest of Sudbury and is being continued in the same direction. From Gowganada Junction, the present terminus, a winter road 45 miles long communicates with Gowganda, and during the summer good canoe routes are available.

General Geology.

The general structural features of the district are simple. A complex of ancient crystalline rocks, consisting of greenschists and granites or granite gneisses, underlies everything else. The greenschists—themselves a complex assemblage of various highly metamorphosed intrusives—occur as elongated areas surrounded by the granites and gneisses, which are younger and intrusive. The surface of this crystalline basement constitutes a greatly eroded peneplain. Upon it rests a mantle of well preserved, nearly flat-lying sedimentary formations, composed chiefly of the fragmental materials that resulted from its denudation. Both basement and mantle are intruded by younger quartz and olivine diabases. All these are of Pre-Cambrian age. Subsequent erosion has developed upon them the present characteristic peneplanated surface, upon which lies a thin, discontinuous film of glacial materials.

TABLE OF FORMATIONS.

Pleistocene	Loose glacial till.
Unconformity.	
Post Huronian intrusives	Dykes of olivine diabase. Sills and dykes of quartz diabase.
Huronian	Quartzite, quartz conglomerate, arkose and arenaceous limestone. Slight unconformity. Rhyolitic lava and agglomerate. Conglomerate, greywacke, slate, arkose, and quartzite.
Unconformity.	
Laurentian	Batholithic intrusions of hornblende and biotite granites, and granodiorite and their gneissic equivalents.
Keewatin	Sheared acid and basic eruptives, iron formation and metamorphic hornblende and biotite gneisses.

KEEWATIN.

Most of the complex known as the Keewatin is of igneous origin, and consists of a great variety of extrusive and intrusive rocks, which, through subsequent metamorphism, have been altered to chloritic and sericitic schists. In their present condition originally unlike types are so much alike that microscopic examination is often required to distinguish them. But structures that indicate repeated volcanic activity are, in places, still preserved. Sheared and badly decomposed diabases in Fawcett and MacMurchy townships exhibit amygdaloidal and ellipsoidal structures, while other neighbouring types are probably altered volcanic tuffs. Similar appearances are presented by a light grey, porphyritic type that covers part of Tyrrell township. Its agglomeratic phases are unmistakable. On the other hand, a number of small bodies of harzburgite are plainly intrusive in nature, and the complex is also cut by a variety of dyke rocks, whose age, however, is possibly post Keewatin.

Small bands of iron formation exist in Leonard and Tyrrell townships.

Near its contact with the younger Laurentian granitic rocks, the Keewatin has been frayed, and rendered highly crystalline. A glistening black hornblende gneiss or schist is the most common product of this contact metamorphism.

LAURENTIAN.

Little Laurentian was encountered this season. That observed in Dufferin township and vicinity is a biotite granite gneiss, containing numerous ribbon-shaped inclusions of Keewatin hornblende gneiss.

HURONIAN.

All the sedimentary mantle that overlies the Keewatin-Laurentian basement is classified as Huronian. It is, however, capable of subdivision into a series of prevalently dark-coloured rocks, comprising conglomerate, greywacke, arkose, and banded slate, and one of essentially quartzitic nature that includes quartzitic, quartz conglomerate, and arkose. In the Cobalt district W. G. Miller found the quartzitic series resting unconformably upon the other, from which it would appear that a distinction in age as well as lithological character exists between them. In Montreal River district a similar unconformity has been found near Obushkong lake, by A. G. Burrows. In Gamble township, also on the east boundary of Ray township, slate gives place to quartzite with marked abruptness, though the actual contact planes were not located. At other points, however, there appears to be a conformable transition from slate to quartzite, thus implying that the gap between the two series is a slight one and perhaps only local.

The dark series consists basally of conglomerate, but the relative positions of the greywacke, slate, and arkose members are inconstant. In different localities the conglomerate is cemented by one or other of these materials, and succeeded above by the same. Conglomerate beds also occur higher up in the series.

The quartzitic series is composed essentially of impure quartzite, which graduates locally into a pure white quartzite, or into arkose. It also becomes conglomeratic, the pebbles being predominantly of quartz. On Smoothwater lake, and some miles south of Florence lake, there are beds rich enough in calcium carbonate to be termed limestone. The limestone is not crystalline, and, on Smoothwater lake, retains perfect ripple marks. Within a disturbed zone, extending from MacPherson lake to Smoothwater lake, the quartzite, whose elastic texture is ordinarily quite perceptible, is associated with a cryptocrystalline, chert-like variety, also ripple-marked.

Although sedimentation was the predominant Huronian process in this district, there were also local volcanic outbursts. The banded slate and arkose in Leonard township contain interbedded deposits of a coarse rhyolitic agglomerate. A small lava flow of the same pale grey, fine-grained rock occurs between Black and Spider lakes, at the north side of this township. Amygdules filled with calcite or quartz are abundant near the top of the sheet.

Over most of the area the Huronian beds lie in gentle folds, with dips seldom exceeding 30°. The chief exceptions to this rule are in proximity to the rhyolitic extrusive area, and along the disturbed zone between MacPherson and Smoothwater lakes. This zone varies in width from 1 to 4 miles, and curves gradually from northwest to nearly due west. Within it the quartzites have been faulted, folded, and locally rendered as schistose as typical Keewatin rocks. The beds on either side are only slightly disturbed.

QUARTZ DIABASE.

Diabase intrusions of the same nature as those at Cobalt, Elk Lake, and Gowganda districts occur in this area. They are either dykes, which traverse Keewatin, Laurentian, and Huronian alike, or comparatively horizontal sills, wherever the Huronian strata have offered mechanical conditions favourable for the formation of such bodies. In most cases the latter have been deeply dissected by erosive forces and possess highly irregular outlines.

The diabase composing the sills is usually coarse-grained, and has, in places, a brecciated appearance where, by partial differentiation, patches of an unusually coarse, feldspathic type are enclosed in the ordinary diabase. Small dykes of light grey or pink aplite, an acid differentiate from the original magma, traverse the sill diabase sparingly.

OLIVINE DIABASE.

All the preceding rocks are cut by occasional dykes of olivine diabase. Though somewhat similar to the quartz diabase this variety can usually be recognized by the presence of large, well formed phenocrysts of plagoiclase, the largest of which are 3 or 4 inches long.

PLEISTOCENE DEPOSITS.

The accumulations of loose sand, loam, and gravel lying upon the Pre-Cambrian rocks are glacial and unstratified. In only a few localities are they deep enough to effectively hide the old rock floor. Parts of the townships of Corkill, Lawson, and vicinity are covered with light sand to a depth of over 100 feet. A like area occupies portions of Ogilvie, Browning, Dufferin, and adjacent townships.

Glacial structures are fairly common. Morainic ridges occur south of Smoothwater lake, and in Corkill township. A symmetrical pothole 18 inches in diameter, and about the same depth, may be seen in the quartzite on the shore of Apex lake, Corley township. Boulders and glacial striæ are abundant, the latter pursuing courses varying from S 10° E to S 30° W magnetic.

Economic Geology.

GOLD.

The Keewatin area near Shiningtree and Pigeon lakes contains numerous irregular veins and stringers of quartz sparingly mineralized with pyrite. Some of these yield low gold values, in consequence of which they attract desultory attention. A considerable number of claims of this character have been taken up recently in MacMurchy township, but, so far, no promising results have been obtained.

For years placer gold has been known to exist in the sands along Vermilion river, in the district of Sudbury, though operations for its recovery have been only tentative. Some work is now in progress in Meteor lake, a few miles north of Gowganda junction. However, as the locality lay beyond the area geologically examined and was hurriedly observed at the close of the season, little can be stated regarding the probable success of the venture.

SILVER.

Prospecting for silver is being continued with some vigour. The quartz diabase sills, and their immediate vicinities, are generally regarded as the most promising ground, and practically none of this ground remains unstaked. Several new discoveries have been made during the season.

Lawson Township.—Silver is now obtained in Lawson township. The Calcite Lake Mining Co. has a shaft sunk 103 feet on a vein that cuts the diabase on Mining Location L. O. 357, and ore containing much niccolite, small amounts of smaltite and chalcopyrite, and considerable leaf silver is being mined. The property is situated near the edge of a diabase mass underlain by Huronian greywacke. Several veins have been stripped, but present work is confined to one about 4 inches wide that traverses the diabase in a direction slightly south of east. Another vein 200 feet to the north contains barite instead of calcite as its gangue mineral.

Good samples of ore were also obtained on Mining Location H. B. 42, on June 25 of this year, by Messrs. A. Perron and Chas. Richardson, of Haileybury. The property, H. B. 42 and 43, consists of a narrow ridge of diabase rising out of the deep sand which covers most of the township. A shattered calcite vein, ranging from 4 to 12 inches in width, had been traced in an easterly direction for 60 feet and a test pit sunk 15 feet, when silver was discovered. The ore consists largely of smaltite, through which flakes of silver are richly distributed.

Silver is also reported to have been found on a neighbouring claim belonging to Mr. A. Peria.

Donovan Township.—A discovery has also been made on T. C. 385, just east of Lady Dufferin lake in Donovan township. Much of the locality is swampy, but the small exposed areas of diabase appear to belong to a sill resting upon Huronian sedimentary beds. Four calcite veins, ranging from one-half to 4 inches in width have been exposed. Near the surface of one of these, which extends in an easterly direction, the calcite is mineralized by smaltite, niccolite, and native silver, for a distance of several yards. At the time of visit the title to this property was in litigation.

Two unsurveyed claims near Steele lake, on the north side of Donovan township, carry an irregular series of small veins, in which a little silver, cobalt bloom, smaltite, and niccolite have been found by Mr. D. Wollings.

Shiningtree District.—The Shiningtree district, in Leonard township, contains two discoveries. The first of these was made in May, 1909, on a group of claims owned by the Saville Exploration Co. Since then a large amount of assessment work has been performed, chiefly in surface exploration. As a result a second discovery of silver has been made, and in addition, other veins have been found to carry native bismuth, smaltite, and cobalt bloom. Both silver-bearing veins are narrow, averaging from 1 to 2 inches, and silver has been found at only one point in each.

Silver was also discovered during June, 1910, on H. S. 448, owned by Messrs. Sutcliffe, Neelands, and Herron. A group of seven parallel veins, striking at 20° magnetic, are distributed over a width of 300 feet. Three of these have been found to be mineralized with niccolite, smaltite, and chalcopyrite, and, in one, native silver has been found. Niccolite is especially abundant, this mineral occupying a width of 2 inches in one vein, for a distance of 20 feet. In the silver-bearing vein flakes of silver have been found for 15 feet along the vein, which is about 3 inches wide.

Veins well mineralized with smaltite, but as yet showing no silver, have been found upon the McLaughlin property west of Spider lake.

Leckie Township.—A few small grains of native silver have been discovered in a calcite vein on Mining Location W. D. 1126, in the township of Leckie. The vein extends 30 feet down the face of a diabase ridge in the northeast corner of the claim. Several other veins, carrying chalcopyrite and smaltite, have been uncovered. The property is owned by Messrs. Eplett and Caswell.

Rosie Creek District.—Mineralized calcite veins have also been found in Rosie creek district, in the townships of Browning and Unwin. A large portion of the area is covered deeply with sand, through which rise irregular, hilly masses of diabase. Huronian and Laurentian rocks also outcrop.

Silver is reported to have been found upon the Carufel claim, which lies just west of Saturday lake, in the northern part of Unwin. However, a visit was paid to this locality, and only a number of irregular quartz-calcite veins carrying smaltite, galena, stibnite, and chalcopyrite observed. They traverse quartz diabase of medium coarseness.

IRON.

A small area of Keewatin iron formation is exposed near the middle of Leonard township, near Wapus, or Fournier lake. To the north it disappears beneath the Huronian, while to the south the country is swampy and drift-covered. Patches of iron formation also occur in the southwestern corner of Tyrrell township, but whether continuous with the larger area around Fournier lake is problematical. The small patches in Tyrrell consist of a brilliantly coloured rock, consisting of alternating red and dark grey bands. In their neighbourhood the magnetic variation rises between 10° and 15°, but no other signs of an ore body were found.

The Fournier Lake area is composed largely of dull coloured, chloritic schists, that stand almost vertically and strike north and south. It contains a narrow ore body from 10 to 50 feet wide, that can be traced along the strike for a distance of

4,000 feet. Dip needle observations also suggest that another ore body underlies Fournier lake. The ore is a highly siliceous mixture of hematite and magnetite. Picked samples are said by Mr. Fournier to have yielded 52 per cent of metallic iron.

Practically the whole range is owned by MacKenzie and Mann, Ltd. Under the management of Mr. Fournier a well equipped camp is being established on Fournier lake. Diamond drills will be brought in from Burwash lake during the winter and exploratory drilling begun, it is expected, in January, 1911.

BARITE.

Some of the veins which cut the quartz diabase formation are filled with barite instead of calcite. Examples of such were seen in Lawson and Leonard townships. Commercially, however, they are too small for barite to be profitably extracted.

NORTHWESTERN QUEBEC ADJACENT TO THE INTERPROVINCIAL BOUNDARY AND THE NATIONAL TRANSCONTINENTAL RAILWAY.

(Morley E. Wilson.)

During the past season field work was carried on in that part of northwestern Quebec immediately adjacent to the Ontario boundary and the National Transcontinental railway. An attempt was made to gain some knowledge of the geology and mining possibilities of this region as far eastward as Kewagama lake; but detailed work was confined to an area of 800 square miles, in the vicinity of Lake Abitibi, comprising the following townships: La Reine, LaSarre, Roquemaure, Palmarolle, Hébécourt, Duparquet, Montleroy, and Duprat.

In mapping the areal geology of the district, the lakes and navigable streams were traversed in the customary manner, using the Rochon micrometer-telescope and surveyor's compass, while the smaller ponds were located and surveyed by means of chain and compass. The surveys made in this way, in conjunction with the interprovincial boundary line, and the numerous base, meridian, and township lines surveyed by the Crown Lands Department of Quebec, will furnish the necessary data for the preparation of a tolerably accurate and detailed map of the district.

I am indebted to Messrs. A. C. Simpson, N. B. Davis, J. S. Stewart, and L. E. Dagenais, who were attached to the party as student assistants, for the efficient manner in which they performed their work.

PREVIOUS WORK.

The earliest geological work in this region was an examination of the rocks exposed on the shores of Lake Abitibi, and along the Timiskaming-Abitibi canoe route, by Mr. Walter McOuat in the summer of 1872. The results of this investigation were published in the Report of Progress of the Geological Survey for 1872-73. Following this no further work was done in the area until the year 1901, when Mr. W. J. Wilson visited Lake Abitibi and made a geological survey of some of the leading waterways in its vicinity, which he described in the Summary Report of the Survey for that year.

In the summer of 1908 Mr. M. B. Baker, with a party of student assistants, made a geological examination of the Ontario portion of Lake Abitibi; his report, accompanied by a gelogical map of the district, being published in the report of the Ontario Bureau of Mines for 1909.

General Character of the District.

TOPOGRAPHY.

The country within the area mapped presents two strikingly different types of topography, a rocky hill country occurring in the southern townships and a flat clay-covered area in the north. Since the clays are of post-glacial, lacustrine deposition, they naturally occupy the depressions of the region, while the rocky, hill country forms the uplands.

The surface of the clay area presents a very uniform, flat, plain-like appearance, broken only, at wide intervals, by isolated outcrops of rock, or by hills or ridges of glacial drift. A few shallow, marshy ponds occur in this area, but throughout most of its extent lakes are entirely absent. The rivers in this district are wide, and meandering where they traverse the easily transported, unconsolidated clay, but are interrupted by rapids and waterfalls where erosion has exposed the underlying rock.

The rocky hill district, although not characterized by striking differences in elevation, possesses a very uneven surface, hills from 300 to 400 feet above the surrounding country being not uncommon. This irregularity in the rocky surface, aided in some places by scattered glacial debris, has formed numerous basins now occupied by lakes. So numerous are these in the hill country, as contrasted with the clay flats, that the rocky district can be readily delimited on the map by the relative abundance of lakes. The streams of the hill country, owing to the relatively high elevation, are usually small, and abound in rapids and waterfalls as they descend northward to the clay belt.

There are two large bodies of water in the area, the eastern part of Lake Abitibi, and Agotawekami or Upper lake. The portion of Lake Abitibi included in the district under discussion occupies a very shallow depression in the clay belt. It has an area of about 50 square miles and a depth of less than 10 feet throughout the greater part of its extent. Lake Agotawekami is a picturesque body of water, with an irregular shore line and numerous rocky islands, characters common to most of the lakes of the hill country. It has an area of approximately 16 square miles.

With the exception of a very small area in the eastern part of Duprat township, which lies to the south of the St. Lawrence-Hudson Bay divide, the drainage of the region is entirely into Lake Abitibi, and thence by way of the Abitibi and Moose rivers to James bay.

COMMERCIAL POSSIBILITIES.

The lacustrine clays, which occur so extensively in this part of northern Quebec, afford a very good soil for the growth of agricultural products, yielding excellent crops of all the hardier cereals and vegetables. A number of townships have been outlined and subdivided by the provincial government in the vicinity of the National Transcontinental railway and will shortly be opened for settlement.

TRANSPORTATION AND COMMUNICATION.

Until recent years the long canoe route from Lake Timiskaming furnished the only means of access to this region; but with the construction of the Timiskaming and Northern Ontario railway, an alternative route by way of the Abitibi and Black rivers from McDougalls chute or Matheson was rendered available. A number of steamboats and launches were maintained by the Walsh Transportation Company on the route by way of Matheson, during the summers of 1908 and 1909, but with the progress of construction on the National Transcontinental railway this service became unnecessary, and has since been abandoned, the region being now most readily reached by train from Cochrane, Ont., the junction point of the Timiskaming and Northern Ontario and the National Transcontinental railways.

General Geology.

The rocks of this region belong almost entirely to the very oldest Pre-Cambrian, consisting largely of Keewatin, greenstone and green schist, but interrupted here and there by masses of granite diorite and related rocks, presumably of Laurentian age. Both the greenstone and green schist, and the granite and diorite are intruded locally by dikes of diabase, the latter, with the exception of unconsolidated Pleistocene or Recent materials, being the youngest rocks observed in the area.

The geological succession can hence be outlined in descending order as follows:—

Pleistocene and Recent—
Post-Glacial: clay, sand, and gravel.
Glacial: boulder clay, sand, and gravel.
Unconformity.

Post-Huronian—
Diabase.

Laurentian—
Granite, syenite, and diorite.
Igneous contact.

Keewatin—
Slate and dolomite.
Greenstone and green schist.

KEEWATIN.

The Keewatin rocks of the region may be subdivided into two classes, the first consisting of greenstone and green schist, and the second of slate and dolomite; the latter, however, is of very limited extent.

Greenstone and Green Schist.—Keewatin greenstone and green schist are the prevailing rock types throughout the entire extent of the area examined. These consist of a number of more or less metamorphosed, basic rocks, of a green or greenish grey colour, which are largely, if not entirely, of volcanic origin.

The greenstone consists largely of basalt and related rocks which have been highly chloritized and carbonated, but have not been dynamically metamorphosed. They are best developed in those portions of the district remote from Laurentian intrusives, and hence occur most abundantly in the country to the south of Lake Abitibi. In many places they show a remarkable development of amygdaloidal and spheroidal structures. The amygdules which commonly occurr on the margin of the spheroids, may consist of either quartz or calcite. Some pyroclastic material, chiefly agglomerate, was observed in association with the basaltic flows.

The green schists of the Keewatin are rocks of similar origin to the greenstone, which under the action of dynamic agencies have been transformed into hornblende schist. They occur chiefly in the country to the north of Lake Abitibi, where several masses of Laurentian granite and diorite intrude the greenstone series.

Slate and Dolomite.—Slate and dolomite are now extensively developed in the area. Outcrops of dolomite were observed at a few points on the south shore of Lake Abitibi, and a band of slate along the north shore of Lake Agotawekami, but all of these occurrences are of limited areal extent. These strata everywhere have a vertical or nearly vertical attitude, but vary in strike from nearly east and west, on Agotawekami, to slightly west of north on Abitibi.

LAURENTIAN.

Acid intrusives belonging to the Laurentian outcrop at a number of points in the country to the north and east of Lake Abitibi. These embrace a number of rock types, ranging from biotite granite through hornblende granite and syenite to diorite, and hence may be described collectively as a granite-diorite series. The marked transformation of the Keewatin greenstone into green schist, in the vicinity of these rocks, and the occurrence of granitic dykes within the schist, afford ample evidence as to the relative ages of these two divisions of the ancient complex.

POST-HURONIAN INTRUSIVES.

Here and there throughout the region, more particularly in La Reine township, the Keewatin and Laurentian are intruded by dykes of post-Huronian diabase. Since there is no Huronian present in this district, the correlation of these rocks with post-Huronian intrusives in the country to the south and west is based solely on their lithological similarity to them.

PLEISTOCENE AND RECENT.

The rock surface of this region, particularly in its northern part, is to a large extent hidden beneath a thick mantle of glacial and post-glacial materials. Boulders, gravel, sand, and till occur widely scattered over the surface of the country, in the various forms of glacial and glacio-fluvial deposition, but owing to the later deposition of lacustrine clay many of these are not exposed. From sections observed in the cuts along the National Transcontinental railway, moraines and kames appear to be the most common type of glacial deposit.

The most common post-glacial deposit is a very light blue clay, occurring in uniform beds from a half inch to three-quarters of an inch in thickness, separated by distinct layers of calcium carbonate; the latter feature can be observed in all the clay cuts along the National Transcontinental railway, in La Reine and LaSarre townships. Wherever the stratified clay was seen in contact with the underlying glacial deposits it was found to lap over them, the bedding conforming to the irregularities of their surfaces, so that, even when the underlying drift cannot be seen, its presence is indicated by the undulation in the stratification of the clay.

ECONOMIC GEOLOGY.

The construction of the National Transcontinental railway, and the consequent easy transportation facilities which this will afford, makes more valuable any mineral deposit which may be found in this region. Hence a greater number of prospectors have in recent years directed their attention to the area, and have staked claims on occurrences of various minerals, chiefly of quartz and iron sulphide.

GOLD.

No extensive deposits of gold bearing quartz have yet been located, although small, irregular quartz veins, said to be auriferous, are developed in the Keewatin dolomite; but, so far as ascertained, these are too limited in extent to be of commercial importance. Some of the iron sulphide deposits also probably carry small gold values, but, like the veinlets in the dolomite, are not of workable dimensions. It may be noted in this connexion, that while the rocks of this area are largely Keewatin, they differ from the Keewatin of Larder Lake, Porcupine, and other districts where gold has been found—in the general absence of intrusive quartz porphyry, with which the occurrence of the gold is probably associated.

Country from Lake Abitibi Eastward to Kewagama Lake.

The country to the eastward of Lake Abitibi, as far as the preliminary examination has shown, is largely occupied by rocks similar in every respect to those described above for the area examined in detail. These are Keewatin greenstone and green schist intruded locally by Laurentian rocks, ranging from granite to diorite; but, in the vicinity of Kewagama lake, a fine-grained mica schist was observed, lithologically identical with the Pontiac schist, which occurs so extensively farther west, in the neighbourhood of Lake Opasatika. The occurrence of this schist on Kewagama lake is of special interest because of its association with the molybdenite deposits of that locality.

MOLYBDENITE.

The intrusion of the Pontiac schist by the Laurentian granite of Kewagama lake was accompanied by the development of molybdenite-bearing quartz veins and pegmatite, within the margin of the granite mass, and in dykes which cut the schist. The quartz veins are most abundant in the granite that forms the large peninsula which projects southward into Kewagama lake, whereas the pegmatite occurs most extensively in a granite dyke which parallels the west bank of Kewagama river.

Prospecting during the past summer has shown nearly every exposure of granite on the Kewagama peninsula to be intersected by veins of vitreous quartz ranging from a few inches to 15 feet in width, all of which carry sparsely disseminated molybdenite and bismuthinite. A specimen of this quartz, containing pyrite, collected by Mr. Frank Johnston, in the summer of 1901, and assayed by Dr. Hoffmann of the Geological Survey of Canada, yielded 117 ounces of gold per ton. This, however, was evidently a local occurrence, since other assays of quartz procured by those interested in the property have shown no gold to be present. Development work on these veins consists entirely of small open-cuts.

A dyke of granite is exposed at a number of points on the west bank of the Kewagama river, about 3 miles north of the lake, which in places becomes pegmatitic, and contains crystals of molybdenite up to 1½ inches or more in diameter, along with bismuthinite, native bismuth, beryl, fluorite, garnet, and coarse muscovite. A shaft has been sunk to a depth of 75 feet by the Height of Land Development Company, on an occurrence of this type. At another rock exposure on the property of the same Company a mass consisting entirely of molybdenite and coarse muscovite has developed along the contact of the dyke and the Pontiac schist. This mass has an average width of nearly a foot for a distance of about 30 feet, but whether it has any continuity either along the strike or in depth was not ascertained.

SERPENTINE BELT OF SOUTHERN QUEBEC.

(J. A. Dresser.)

That portion of the Province of Quebec which lies south of the St. Lawrence river is traversed in a northeasterly direction by a series of serpentines and related rocks known as the serpentine belt. This belt is important for its production of asbestos—a large part of the world's supply—and for deposits of chromite, soapstone, copper, and antimony, which it is known to contain. The principal quarry of roofing slate now in operation in Canada and some promising bodies of marble are also intimately associated with the igneous rocks of this belt.

The general features of these rocks were first ascertained and described by Sir William Logan (Geology of Canada, 1863), and later they were further investigated by Mr. R. W. Ells (Geological Survey Reports, 1886, 1887, and 1894). In 1907 and 1909, a somewhat detailed examination was made by the writer of the portion of the serpentine belt between the Chaudière and St. Francis rivers, with especial regard to the economic resources.

During the past season this work has been continued over the section between the St. Francis river near Richmond, and the Canadian Pacific railway near Eastman. The area especially examined this season is 40 miles in length, and from 3 to 9 miles in breadth. The examination of the structure was, in places, necessarily carried over a considerably wider area.

The Eastern Townships map of the Geological Survey series, enlarged to a scale of 1 mile to 1 inch, was used as a basis in mapping. The surveys necessary to delimit the geological features, and to revise the mapping of roads and streams when necessary, were made by means of the compass and telemeter.

Messrs. John J. O'Neill and J. Alphonse Belanger were assistants in the work, and gave very efficient services throughout the season. I must acknowledge our indebtedness to Messrs. Williamson and Crombie, of the Kingsbury Lumber Company, who assisted us materially at several times.

SUMMARY AND CONCLUSIONS.

The serpentine belt, which last year was described from East Broughton to Richmond, continues across the district this year examined. With the exception of two or three localities, however, it is not found very promising for the production of asbestos. The better localities are mentioned in a later part of this report, which deals with the subject of asbestos.

Copper and nickel have been mined in certain parts of the serpentine belt within this district. The former has had an important production and seems likely to be mined again.

Chromite occurs in several places which seem to warrant further prospecting.

Slate for roofing has been quarried for many years in the Trenton formation, and other deposits in the Sillery are likely to be worked at an early date.

A marble quarry has recently been opened at South Stukely.

The igneous rocks in this district, as elsewhere in the serpentine belt, form an intrusive series whose members range from diabase to peridotite and are differentiation products of a single magma. The differentiation seems to have been produced largely by gravity, the arrangement of the rocks being in order of decreasing density in sills from the base upwards, in batholiths from the centre outward.

General Character of the District.

TOPOGRAPHY.

The district under examination lies in the hilly part of southern Quebec, generally called the Eastern Townships, and which is a part of the Appalachian mountain system of eastern North America. The topography is similar to that of the Appalachian region in general; but being only on the border of that, the great uplift, the relief is less pronounced. The hills formed by the igneous intrusions of the serpentine belt are the highest, and have generally rugged profiles; while those underlain by the sedimentary rocks have more subdued outlines. The altitude is generally between 500 feet and 1,200 feet above sea-level, but some of the intrusive hills rise considerably above this height, Mount Orford, the highest point, having an elevation of about 2,800 feet.

The most constant feature of the topography is the succession of narrow ridges and valleys running in a northeasterly direction. These are cut off at intervals by broader and more mature valleys running to the northwest, such as those of the St. Francis river at the northeast end and the Yamaska near the southwest limit of this season's work. These larger rivers carry the drainage of the entire district to the St. Lawrence river.

LAKES.

Owing to the fact that the principal ice movement in glacial times has come from the northwest, thus crossing the narrow valleys, and that the intrusions of more resistant igneous rocks have also obstructed some of them, lakes are numerous in the district. Lake Memphremagog, which is only partly within the district now being examined, is the largest. It is 30 miles long and generally less than 1 mile wide. It extends some 6 miles into the State of Vermont.

Brompton lake, the next largest, is nearly 7 miles long, and less than a mile in breadth. Besides these, there are fifteen or more smaller lakes, most of which can be seen from single points on some of the higher hills. The suitability of many of these for summer resorts seems worthy of note, since most of them are comparatively easy of access and are unoccupied.

MEANS OF ACCESS AND OTHER CONDITIONS.

Railway communication for the district is furnished by the Grand Trunk line running from Montreal to Portland; the Canadian Pacific railway from Montreal to St. John, N.B.; and by the Oxford subdivision of the Canadian Pacific railway from Eastman to Windsor Mills. The last follows, or closely parallels, the serpentine belt, as does the Bolton subdivision farther to the southward.

Public highways are numerous, and a few of them are moderately good.

Much of the area actually occupied by this portion of the serpentine belt is still densely wooded, and lumbering is accordingly carried on somewhat extensively. The less rugged country on either side of the igneous belt is more largely cleared, and has been occupied for about sixty years for mixed farming and dairying. The latter industry, for which the district is well adapted, is very successfully carried on.

The region is generally heavily drift-covered, and this factor along with its wooded character makes geological work slow and difficult

General Geology.

The highlands of the Eastern Townships comprise three main anticlinal ridges running in a northeasterly direction with two broad intervening basins, each of which is about 25 miles wide. The most westerly ridge forms Sutton mountain; the more westerly hills of Brome county, the Stukely and Melbourne ridge, the higher portion of Wolfe and Arthabaska, and Harvey hill and the Handkerchief in the county of Megantic. The second ridge forms the Capelton and Moulton hills near Sherbrooke and Stoke mountain, and the Weedon hills farther to the northeast. The third ridge forms the boundary line between Canada and the United States for a considerable distance in the vicinity of Lake Megantic. All three of these contain important areas of volcanic rocks of the Sutton or porphyry greenstone series, believed to be of Pre-Cambrian age. These volcanics are flanked by very old sediments of Cambrian, or possibly Pre-Cambrian age.

The basins which separate the ridges are underlain by sediments of upper Cambrian and Ordovician (lower Trenton) age, with some small areas of Silurian, and one or two very small Devonian outliers. There are several intrusions of granite, believed to be of late Devonian age, in the basin between the Sherbrooke and the Lake Megantic anticlines, while west of the Sutton anticline intrusions of alkaline rocks form the well known Monteregian hills.

The serpentine belt extends along the east side of the Sutton Mountain anticline near the foot of the ridge formed by it. It consists of a series of igneous rocks which are generally highly basic, peridotite, pyroxenite, gabbro, diabase, and porphyrite, with lesser amounts of granite and aplite. The whole series is intrusive, and a part, at least, has been intruded since early Devonian time.

TABLE OF FORMATIONS.

Quaternary	Stratified sands, gravels, and clays. Boulder clay.
Devonian	Alkaline rocks of Monteregian type. Serpentine, peridotite, pyroxenite, gabbro, diabase, granite, and aplite.
Silurian	Shales and limestones.
Ordovician-Farnham	Graphitic argillites and limestone conglomerate.
Cambrian	Greywacke, purple and green slates ; red limestone ; quartzose grey schists and quartzites.
Pre-Cambrian—Sutton Mountain series	Porphyries and greenstones.

PRE-CAMBRIAN.

Sutton Mountain Series.

Probably the only rocks in this district that are older than Cambrian are the porphyry-greenstone series. These consist of granite-porphyry, quartz-porphyry, and amygdaloidal greenstones. All are much sheared and folded, and in the earliest geological work in the district were mistaken for sediments, from which it is often very difficult to distinguish them.

The porphyries form the core of Sutton mountain and the ridge which is its northward extension. On the Short Line of the Canadian Pacific railway they occupy the interval between Eastman village and South Stukely station. North of this line they soon pass under the Cambrian sediments, or give place to greenstones. They form the Green Mountain gneiss of the earlier Vermont geologists.

The amygdaloidal greenstones are so far altered that their original character cannot be precisely defined. It is certain that they are volcanic rocks, and occasionally a thin section shows the structure of diabase. In general they consist only of chlorite and epidote with smaller amounts of other secondary minerals.

These rocks form St. Armand Pinnacle and extend continuously northward to and beyond the St. Francis river. They are well shown at Foster Junction on the Canadian Pacific railway, where numerous amygdaloidal bands, apparently representing successive flows, can be seen. They make up the Chloritic Schist group of Logan, and their igneous origin was first suggested by Selwyn in 1879. A large number of the occurrences of the copper ores of the Eastern Townships are found in them.

CAMBRIAN.

The rocks of this system in the district are greywacke quartzite, grey quartzose schist, purple and green slate, and a few small occurrences of a red siliceous marble. As far as known they represent the lower portion of the upper part of the Cambrian.

These rocks occur along the western boundary of the serpentine belt separating it from the Pre-Cambrian, and occasionally are found on the eastern side. Outliers resting on the Pre-Cambrian are frequently found. Some highly altered sediments of this district have been previously regarded as Pre-Cambrian, and there is not always conclusive proof that they are not. But as no basal conglomerate or other evidences of unconformity have yet been found to mark the lower limit of the Cambrian, these highly altered sediments are provisionally included in that system.

ORDOVICIAN.

Farnham Series.

The black slates of the Farnham series—a member of the lower Trenton—are the principal rocks of this system. They are only clay slates, somewhat micaceous, generally carrying sufficient graphite or iron ore to give them a dark, nearly black colour, and are in places so calcareous as to be properly called graphitic limestones. At the base of this formation there is a well developed conglomerate composed of pebbles of the Cambrian greywacke and quartzite mentioned above in a matrix of Farnham slate. As the term slate indicates, the entire formation has been metamorphosed, and distinct cleavage at varying angles to the bedding planes has been induced.

This formation outcrops on the east, and more rarely on the west side of the serpentine belt. It is sometimes in contact with, and altered by, the intrusive rocks of that belt; but more frequently it is found resting upon the Cambrian sediments at a short distance from, and on the east side of the serpentine. It includes the rocks of the New Rockland and Melbourne slate quarries, and occurs between bodies of serpentine on Pratte's road in Stukely. In its conglomerate phase it is largely exposed about Key pond; and between Magog station on the Canadian Pacific railway and Mount Orford it is fossiliferous at Castle brook, and passes into conglomerate a few hundred feet to the westward.

Some small occurrences of massive limestone found in the district, as at South Stukely and at St. Anne de Stukely, probably also belong to the Ordovician system.

SILURIAN.

The Silurian system is of small extent in the district, but its occurrence is important, as it gives evidence that bears directly on the age of the serpentine series. The Silurian measures are chiefly grey and fawn coloured shales and limestones. These are found bordering Lake Memphremagog, and extend northward up the valley of Cherry river for a few miles.

Near the foot of Mount Orford, 2 miles north of Cherry River post-office, Silurian shales are cut by the intrusive rocks of the serpentine belt. Also at Tucks landing, 10 miles south of the district being described, Silurian strata are intruded by rocks of the serpentine series on one hand, and pass up conformably into strata containing early Devonian fossils on the other. They thus form a link in the proof that the intrusion of this part at least of the serpentine belt took place after the deposition of the earliest Devonian sediments.

DEVONIAN.

The Serpentine Belt.

The rocks of the serpentine belt are provisionally referred to the Devonian system. As previously stated, they are younger than the early Devonian sediments in a neighbouring locality. Their highly altered character, especially their schistose structure in places, indicates that they were intruded before the close of the folding which produced the Appalachian mountain system which probably did not continue later than Carboniferous time. Moreover, they are cut by igneous rocks of the Monteregian series which are also foliated by regional compression. It is, therefore, believed that the serpentine series was intruded in later Devonian time, which is known to have been a period of great igneous activity in the region of the Appalachian uplift, especially north of New York.

The rocks of the serpentine belt are, serpentine, peridotite, pyroxenite, gabbro, diabase, granite, and aplite. The different rock types in any single locality are parts of one homogeneous intrusion. It is believed they have been separated from one another principally during the process of cooling as a result of gravitational adjustment modified by the order of solidifying of the different minerals. Thus, on the north side of the road between Racine and Brompton lake near Mud pond there is a cliff about 150 feet high, facing the northwest. At the base of the cliff the rock is peridotite, a little higher, pyroxenite, and above these, gabbro and diabase; the latter at the top becoming very acid. This is a case of an intruded sheet or sill which has forced its way upward obliquely from the southeast and later has been exposed by a fault having a downthrow on the northwest.

In other cases these igneous rocks are in the form of stock or boss, a dome-shaped body of rock formed by the cooling of a large mass of molten material after it had slowly worked its way upward into older solid rocks. Where there has been sufficient erosion to expose the igneous rocks at some depth they are found to be arranged in the same order from the centre outwards, as is found in sheets from the base upwards. This is well shown on the Montreal road, in range A of the township of Orford, a mile east of Bonelli lake, in a nearly circular area of igneous rocks varying from a mile to a mile and a half in diameter. Serpentine occurs near the centre, partially or perhaps wholly enclosed by pyroxenite. Outside of this there is an area of gabbro wrapping around a part of the pyroxenite, and the whole is enclosed by a band of diabase which completes the occurrence, and extends to the sediments all around.

Although the entire series is often, for convenience, called the serpentine belt, serpentine really makes up only a small part of it. It is not a primary rock like the others, formed from a molten mass coming from the depths of the earth, but is merely an altered phase of the peridotite which has been so formed. It occurs principally in narrow bands coating the faces of joints and cracks which have been changed by the action of surface or deep-seated waters to which they have been exposed. Relatively to the other rocks it occupies a very small area, but as asbestos occurs only in the serpentine it is nevertheless in point of value the most important rock of the series.

The granite and aplite which are parts of the same—originally molten mass or magna—have generally been intruded a little later than the other rocks, probably after they had become solid, but while they were still heated. Consequently, they are often, but not always, more sharply separated from the other rocks than those are from one another.

The serpentine belt is nearly continuous throughout this district. From the St. Francis river it forms a ridge of hills running southwesterly to a point near the south end of Long lake in Stukely, a distance of about 30 miles. Throughout this distance there are only three short intervals in which rocks of this series are not found.

The igneous rocks of this area are partly in the form of an intrusive sheet dipping to the southeast, which has been brought into more distinct relief by a fault along its northern edge. This structure gives the intrusive rocks an exposure varying from 500 feet to 2,000 feet in horizontal breadth. Vertically they are usually arranged in the order mentioned above, the serpentine and peridotite being at the base passing upwards into pyroxenite and diabase when these are present. This fault has now been traced from the Little Nicolet lakes north of Danville to the south end of Long lake in Stukely, a distance of about 45 miles. Throughout much of this distance the fault is well expressed in the topography by a narrow steep sided valley or trench from 200 feet to 400 feet deep, which forms a rather remarkable feature of the landscape. The Canadian Pacific railway runs in this trench from the St. Francis river nearly to Kingsbury; from thence it is occupied by the Salmon river to the first range of Melbourne and farther southward it contains Gulf brook, Mud pond. and Long lake.

Besides this sheet or sill there are several larger bodies of rocks of the serpentine series in the form of stocks in the townships of Brompton. Orford, Stukely, and Bolton. The largest of these is Mount Orford, which covers not less than 10 square miles, and has a height of over 2,800 feet. It is composed at the surface of gabbro and diabase, with a little peridotite and serpentine at the western base. Another area quite as large, but of less height, lies between Brompton lake, Little Brompton, and Key ponds. It contains considerable areas of peridotite. Other occurrences are Carbuncle, Bare, and Bald mountains. which are made up mainly of the more acid rocks of the series.

ALKALINE ROCKS.

Alkaline rocks are found about 2 miles east of the village of Eastman, where a shallow cutting of the Canadian Pacific railway has exposed them for a distance of 200 feet. The exposure is surrounded by drift, but a dyke apparently from this mass, cuts the diabase of Mount Orford a couple of hundred yards away. The rocks consist of camptonite, nordmarkite, and a variety of monzonite. They form a breccia with neighbouring sediments similar to some described by R. Harvie in a recent paper to the Royal Society of Canada.[1]

The rocks are undoubtedly connected, in origin, with the Monteregian hills, and are interesting as occurring 20 miles to the eastward of Shefford mountain which has hitherto been regarded as the eastern limit of the series. They also indicate that the Monteregian hills are later in age than the rocks of the serpentine belt.

QUATERNARY.

There is a heavy covering of surface deposits over the greater part of this district, amounting, in places, to 100 feet in thickness. In general, it consists of boulder clay at the base, overlain by stratified sands and clays apparently derived from the boulder clay by the assorting action of water in early post-glacial times. No marine or other shells were found in the stratified deposits.

The general direction of glaciation has been S 5° E, but in the valleys the striæ vary greatly in direction. Thus, on the summit of Mount Orford glacial striæ are found having a direction of S 10° E; while along the Canadian Pacific railway, at the base 1,900 feet lower, the course of glacial striæ is nearly due east and west. No very satisfactory evidence could be obtained from the striæ and scorings themselves as to the direction in which the ice moved, but from the frequent occurrence of serpentine boulders for a distance of 2 or 4 miles west of the serpentine belt, it is evident that there has been movement of ice towards the west, probably in later stages of the glacial period.

Economic Geology.

Mining in this district has not yet become a regularly established industry. Copper was mined for ten years, between 1870 and 1880, or longer, with apparent success; slate has been quarried continuously for nearly forty years, and other mineral

[1] Vol. III, Third Series, 1909-10 'On the Origin and Relations of the Palæozoic Breccia of the vicinity of Montreal.'

products have received more or less attention. These operations were all undertaken while the district was remote from railways, and access was more difficult than at present. The recent extension of the Orford and Bolton subdivisions of the Canadian Pacific railway, the removal of timber, the increased settlement, and building of roads, have so far improved the conditions for prospecting and mining as to open new possibilities for the district.

COPPER.

Copper ore has long been known to occur at several places in this district. In Orford on lot 2, range XIV; lots 3 and 8 in range F; and lots 8 and 9, range A, and in Brompton, lot 28, range IX, work was done many years ago. All of these prospects have been abandoned for 30 or 40 years, and the workings so much covered that it is not possible to form any reliable estimate of the quantity of ore they may have disclosed. The fact that immediately to the south of this district, the Huntingdon, Ives, and Lake Memphremagog mines contain, or have contained, large bodies of similar ore under like geological conditions, would seem to warrant giving some attention to the properties under the present conditions of market and transportation.

The ore is principally chalcopyrite, in some cases bornite, and occurs in diabase or pyroxenite of the serpentine belt. At Orford, range A, lot 8 has bornite disseminated in pyroxenite. In several localities, especially at the Huntingdon and other mines immediately south of this area, the ore is chalcopyrite and is associated with pyrite in pyrrhotite. The pyrrhotite bodies, judging from their distribution and the character of their boundaries, are doubtless primary segregations from the country rock, which is more frequently diabase than pyrrhotite. The chalcopyrite often seems to fill small crevices, suggesting that it has been introduced later than the pyrrhotite. Further investigation is needed, however, to prove whether or not this relation is general, and also to ascertain the relations of the pyrite to the other minerals.

NICKEL.

Nickel has, hitherto, been found in only one locality in this district, namely, on lot 6, range XII, in the township of Orford, about three-fourths of a mile east of Brompton lake. Here mining operations were begun and a smelter built about 30 years ago, but the venture did not prove commercially successful.

The ore is millerite—a sulphide of nickel. The ore body occurs along the contact of an intrusion of pyroxenite into limestone. The limestone closely resembles that quarried for marble at South Stukely. The shape and size of the ore deposit could not be ascertained in the present state of the workings. Millerite, wherever found on the dump, is in crystalline calcite; but the locality having long been noted for the excellent specimens of several rare minerals that it affords, the dump has been so thoroughly picked over by mineral collectors that specimens of millerite are now exceedingly rare. The other minerals noted are chrome garnet, pyroxene, chromite, and calcite.

Mr. R. P. D. Graham, lecturer in mineralogy at McGill University, who spent some time at the locality during the past summer, has kindly undertaken to make a mineralogical study of the group of minerals obtained here. The results of Mr. Graham's investigations will appear in a later report.

CHROMITE.

No mining of chromite has yet been done in the district. The ore occurs, however, on lot 21, range VI, Melbourne, where a little prospecting was done many years ago. It is also found near the west side of Key pond in range XII, lots 3 to 8, of Orford, in a band of rock intermediate in character between peridotite and pyroxenite. The rock with enclosed masses of chromite can be traced northwards for at least 1½ miles. The area seems to be well worth prospecting.

Some chromite has also been disclosed by Mr. John McCaw, near the Brompton Asbestos mine, some 10 miles northwest of this location. As in other parts of the serpentine belt, the chromite is found in both of the localities in the outer part of the serpentine or peridotite portion of the intrusion where the rock contains a rather large proportion of pyroxene, and so is approaching a pyroxenite in composition.

ASBESTOS.

New Developments.

Since the issue of the Annual Summary Report for 1909, there has been considerable new development in the asbestos producing district at the north of the area described in this report. New concentrating mills have been completed and put into operation at the Bell, the Jacobs, and the Black Lake Consolidated Mines. The maximum capacity of these mills is from 800 tons to 1,000 tons of rock per day. The B. and A. Asbestos Company at Robertson, and the Berlin Asbestos Company near Leeds station, have built 4 cyclone mills which are also in operation on their respective properties; while the Belmina Consolidated Company, having acquired the property formerly owned by the Asbestos Mining and Manufacturing Company at Chrysotile. has re-equipped the mill and mine, and has renewed operations in both.

The Thetford Asbestos syndicate of Montreal has recently done some substantial development on lot 24, range A, Coleraine. A pit 60 feet by 50 feet has been carried to a depth of 45 feet. As far as could be judged from the walls, the rock carries a workable quantity of asbestos, an appreciable portion of which is crude. There is a boss of granite near the pit, and exposures in the vicinity show asbestos at numerous points, over an area of some 10 or 12 acres.

The present equipment consists of a cable derrick, a hoist, one steam drill, two pumps, and a 65 horse-power boiler; but an adequate mining and hoisting equipment is expected soon to be installed, and a concentrating mill built. The right-of-way has been obtained for a tram-line to connect the property with the Quebec Central railway, less than 2 miles distant.

The property is situated near the eastern side, and in the northern part of the serpentine area, which contains the principal mines of Black Lake.

Asbestos is reported to have been discovered in commercial quantities on lots 2, 3, and 4, range B, Coleraine. There was no opportunity found during the season to verify the report.

One of the most important developments for the asbestos industry, however, is the establishment by the Asbestos Manufacturing Company of large works at Lachine, Quebec. This plant—the only one of the kind in Canada—is designed to manufacture all classes of asbestos goods. When completed, the factory will have a capacity to consume about 1,000 tons of asbestos fibre per month. The plant was built by and is being operated under the management of Mr. G. R. Smith, long the manager of the Bell Asbestos mine. A more complete description of the plant and process will be given in a later report.

In the district examined this season few occurrences of asbestos have been found. On lot 22, range VI, Melbourne, about 100 feet south of the Melbourne slate quarry, a small pit was sunk some 35 years ago in the dump, of which there is a small amount of fairly good milling rock. The surrounding rock is drift covered, and the pit or shaft is partially filled with debris. It is locally reported that a small shipment of crude asbestos was made from these workings by the operators of the Melbourne slate quarry about 1876, and which was probably the first asbestos shipped from Canada.

Near Key pond some prospecting and development was done by Mr. R. H. Fletcher of Sherbrooke and others during the past season, but no very definite results were obtained.

The principal development of the district has been made by Mr. John McCaw on lot 26, range IX, Brompton township, near Brompton lake. On this property, which was somewhat extensively prospected some twenty years ago, work was resumed in the spring of 1910.

Asbestos is exposed in pits that have been opened in different parts of the property, over a distance of half a mile. In general, it may be said that the contents of the wider veins are usually hard and brittle, but that the smaller veins contain a quality of fibre that may be used. More complete development of the property probably awaits better facilities for transportation.

A little slip fibre has been obtained in the first range of Stukely, south of Long pond.

Except in the localities mentioned the rock of this district usually contains too much pyroxene to yield an asbestos-bearing serpentine.

MARBLE.

The only marble quarry in operation at the present time in the district is one which has recently been opened by the Dominion Marble Company (R. T. Hopper, Montreal, President), on lot 8, range II, South Stukely. The marble is white, with light shades of green and red in occasional bands. The green colour seems to be due to minute scales of sericite, partially chloritized; the red or pink probably to traces of iron oxide. There are few quartz veins or other features to injure the quality of the rock.

The marble rests upon, or in close association with, greenstone schists, the contact with which is drift covered. As well as could be ascertained from a few exposures, the bed of marble has a surface area of about 800 feet by 500 feet. Borings, made by the Company to a depth of 125 feet, are said to have yielded cores of good marble to that depth.

The property has been developed by means of a pit about 50 feet square, and was 30 feet deep on the first of September. The equipment consisted at that time of one boom derrick, one bar drill, and three channelling machines. Power was furnished by one 60 horse-power boiler. A spur line of railway to connect the quarry with the Canadian Pacific railway at South Stukeley, 1¼ miles distant, was begun later in the season.

The general character of this marble, and its position relative to the greenstone shict, are apparently the same as that of the quarries of the Vermont Marble Company at West Rutland, Vermont. The latter is stated in the report of the Geological Survey of Vermont for 1903-4, to contain fossils of Chazy age. No fossils could be found at South Stukely, nor other evidences to indicate the age of the rock with any degree of certainty. This, and a few smaller areas in the neighbourhood, are the only occurrences of this rock yet known in the Eastern Townships.

A red and white siliceous marble occurs at several places in the Cambrian formation, apparently interbedded with the purple slates. In range F of Orford, near Pratte's road, a body of such marble intruded by serpentine was worked for a short time several years ago. The quantity of marble was insufficient, the serpentine intrusion cutting it off at a shallow depth.

Similar rock without the serpentine intrusion is found in the Cambrian at the Kingsey slate quarry in the county of Drummond, 6 miles north of Richmond. Another occurrence of the same character, but probably underlain by serpentine, is found on lots 2 and 3 of range XI of Bolton. Each of these occurrences is some 800 feet long and from 100 to 200 feet in horizontal breadth. They are somewhat siliceous, especially around the edges, and resemble some phases of the red sand rock of northern Vermont. This is interpreted by Vermont geologists as a silicified limestone of Cambrian age.

It would seem advisable, especially in view of the present state of the Canadian market for marble, that these two occurrences should be further examined, since the mineral statistics for 1908 show that $287,587 worth of marble was imported into Canada during that year.

SLATE.

Slate of good quality both for roofing and other purposes occurs in several places in the Ordovician and Cambrian strata adjacent to the serpentine belt. In a number of these places quarries were opened between thirty and fifty years ago, but most of them have long since been closed from one cause or another, principally, it would appear, from an insufficient market at the time they were operated.

At the present time these conditions have apparently changed for the better, and the slate deposits might properly receive renewed attention.

The imports of slate into Canada for the year 1908 are stated by Mr. J. McLeish, Chief of the Division of Mineral Resources and Statistics of the Mines Branch, Department of Mines (Annual Report 1908), to have a value of $131,069; while the slate produced in Canada during the same year, all of which came from this district, is valued at $13,496.

Ordovician Slates.—The Ordovician slates occur in the argillaceous parts of the Farnham (lower Trenton) formation. They are dark, or bluish grey in colour, and have an excellent cleavage, nearly vertical, which may be at any angle to the bedding planes.

These slates have been quarried at Danville, Corris, Brompton, Melbourne, and New Rockland. The last mentioned quarry is the only one at present in operation in eastern Canada. The slate produced is of excellent quality.

The quarries at Corris, Melbourne, and New Rockland are situated so near the contact of the slates with an intrusive sheet of peridotite and serpentine as to be within the zone of alteration thus produced. The nearness to the serpentine is both a favourable and unfavourable factor. Outside of the zone of contact metamorphism the slate is soft, and lacks the strength that makes it especially valuable when slightly hardened by the intrusion; but within the contact zone, quartz veins, or flints become more numerous as the serpentine is approached, and thus tend to lessen the value of the slate. Very near the contact, too, the slate becomes a fine hornstone, too hard to be well worked; and it is then said to be sharp. The part of the rock of greatest value seems, therefore, to be near enough to the contact with the intrusive rock to secure strong slate, and far enough from it that the spaces between the flints are so large as to be worked advantageously.

The other features that injure the slate are oblique cleavages called slants, and shattered bands known as posts. These depend on mechanical deformation, and may be connected with the intrusion of the serpentine. At the Melbourne quarry, dykes of pyroxenite strike off from the intrusive rocks for 40 feet into the slate.

In its original composition, the rock may have been largely made up of good material for slate, except near the bottom of the slate beds where the basal conglomerate is found. Slabs taken from the lowest level at the north side of the main pit at New Rockland show pebbles of Cambrian sandstone and quartzite, and indicate that the bottom of the slate has there been reached.

The New Rockland quarry has been operated almost continuously since 1868. During the past eight years it has been worked by Messrs. Frazer and Davies under a lease from the New Rockland Slate Company. Some 35 men are employed, two steam drills and three derricks are in operation, steam and water-power are used. Only roofing slate is now made. The average output probably somewhat exceeds that of 1908, quoted above.

The quarrying is done in open pits, the rocks being cut down in benches. The rock is first assorted in the pit, and that suitable for splitting is hoisted and sent to the splitting sheds. There, it is cut, split, and trimmed to the sizes required, or to which it is best adapted. The usual thickness is $\frac{3}{16}$ inch, and the superficial sizes vary from 12 inches by 24 inches to 6 inches by 12 inches. While working on higher levels in a deep pit, the waste rock is allowed to accumulate to some depth in the bottom, in order to lessen the loss from breakage of good slate by falling into the pit after blasting. During winter it is an advantage to have as little of the walls exposed to the frost as possible, since the slate, once frozen, becomes valueless if it is not split when frozen. The waste rock is, therefore, removed somewhat irregularly.

Cambrian Slates.—The Cambrian slates are green and reddish or purple in colour, and where there is a mingling of these colours a handsome mottled slate results. The green colour, in all cases seen, is that known as the ever or unfading green. The slates of this formation, as far as known, have not been influenced by the action of igneous rocks. They split less smoothly than the dark slates just described, having a coarser texture, and are frequently not as strong.

The quarries that have been opened usually show large bodies of slate free from quartz veins, and sometimes having different colours in different parts of the same pit. A few buildings in the district have roofs on which these slates are said to have lain for 50 years without change of colour or serious breakage.

Very similar slates are quarried at Fairhaven, Vermont, and are the principal variety produced in the large slate industry of that State. The manner of dressing the slate there is different from that at New Rockland, probably because of different market conditions. At New Rockland thin slates $\frac{3}{16}$ inch are generally used, while at Fairhaven the purple, green, and mottled slates are split in thicknesses ranging from $\frac{1}{4}$ inch to $1\frac{1}{4}$ inches. The price varies with the thickness, an increase of about $2 per square being allowed for each additional $\frac{1}{4}$ inch. Besides being cut to proper sizes, and split to the required thickness, the slates are bored for nail or bolt holes, and the holes are counter sunk, for which an extra charge is made. These heavy slates are said to be used principally for roofing on large steel buildings of the class now being built in the larger cities.

Slate of this quality has been opened at several places in and near this district. Green slate occurs three-fourths of a mile south of New Rockland quarry; purple and green at the Kingsey quarry, 6 miles north of Richmond, also in Brompton southeast of Mud pond, and at other places in the Eastern Townships.

Prices.

Roofing slate is bought and sold by the square, that is sufficient slate to cover 100 square feet after allowance has been made for all overlapping. A square of slate $\frac{1}{4}$ inch in thickness weighs upwards of 1,000 pounds; hence the thicker grades weigh a ton or a ton and a half per square. The present prices in New Englad for slate of good quality range from $6 to $12 per square, according to thickness. In Canada most of the slate is made into the lighter or thinner grades, for which the prices are a little below those obtained in New England.

NATURAL GAS NEAR ST. HYACINTHE.

According to instructions received from the Director, a few days at the end of July were spent in examining a locality in the county of St. Hyacinthe, from which natural gas had been recently reported. The boring by which the gas was found is located $7\frac{1}{2}$ miles north of St. Hyacinthe, in the parish of St. Barnabé, range St. Amable north, lot 164. Here gas was struck at a depth of 1,860 feet, according to the driller's log.

The boring was made by Mr. W. H. Lauffer, of the firm of Ryan and Lauffer, Chatham, Ont. The equipment employed was a Standard drilling rig, a percussion drill operated by steam power obtained from a 25 horse-power boiler. The boring, which has been carried to a depth of 1,800 feet, is encased with pipes of 10 inch, 8 inch, $6\frac{5}{8}$ inch and finally 2 inch diameter. The well was capped, and a steam gauge applied which registered somewhat above 220 pounds pressure—the limit to which the gauge was graduated. The pipes were not then packed, and there was still some leakage of gas. The gas gave very little odour. There were no facilities for measuring the flow or for burning the gas.

Geological Conditions.—The surface of the district is nearly level. The immediate location of the well is on a low swell between the Yamaska and Salvaille rivers, which run in parallel courses towards the north. The interval between them is 5 to 6 miles, and the elevation varies quite regularly from 95 or 100 feet along either river to 115 feet in the central part near the gas well. The drift covering is very deep over the entire district, and rock exposures are rare. The records obtained from numerous shallow wells across this area gave the depth of the drift as 95 feet to 100 feet. The differences in elevation of the land surface may, therefore, agree with the rock surface, but this is by no means certain, and they are not great enough to be very significant features.

Five miles northeast of the boring, the Yamaska river takes an abrupt turn to the west, and thence joins the Salvaille. At this bend of the Yamaska, nearly opposite the entrance of the Chibouet river, rocks are exposed for about one-fourth mile. These rocks are shales of Hudson River age. They strike 7° to 10° east of north, magnetic, and form a very distinct anticline, having a steeper dip on the southeast. The ESE dip as measured is from 15° to 23°, while that on the WNW is generally 4° or 5°. This would place the St. Barnabé boring on the west limb of the anticline if there are no other folds in the drift-covered interval. There is also a pronounced pitch of 10° to 15° to the northward in the direction of the strike at this place. I could find no other exposure between the Yamaska and Salvaille rivers for 12 miles to the south. There is then a suggestion of a dome in the rocks 5 miles wide by 12 miles or more in length, but the evidence is far too slight to be conclusive.

The gas was struck at a depth of 1,860 feet in a band of rock composed of dark shale, crystalline calcite, and quartz. The boring was extended 20 feet deeper without noticeably increasing the flow of gas. Consequently, it seems probable that the band of rock containing calcite and quartz carries, rather than covers, the gas, and that as these are secondary minerals, it is a fracture zone in the dark grey shales which form compact beds above and below it.

The log of the well has been handed to Mr. E. D. Ingall; who has charge of the collection of boring records throughout Canada for the Geological Survey. A discussion of the horizons passed through, and an analysis of the results obtained, will be given in Mr. Ingall's report in this volume.

Discovery and Ownership.—The discovery of gas in St. Barnabé was made under circumstances that are rather unique. Mr. Henri Grenon, a farmer of St. Barnabé, having seen natural gas used while on a visit at Tilbury, Ontario, decided to look for some in his own locality. He organized La Compagnie Gaz et Petrole, St. Barnabé, Comte St. Hyacinthe, under a provincial charter, with a capital of $20,000. The president is S. Girard, and the secretary, Jos. Langevin. One hundred and nine shares were issued, and were subscribed for chiefly by farmers of the locality, leases were obtained on 7,000 acres, and contract for drilling was made with Messrs. Ryan and Lauffer, Chatham, Ontario.

The boring was located by the directors of the Company on the information that gas had been found (apparently in the soil), on this farm 70 years ago when a well was being dug for water.

Since the discovery all the leaseholds and other property of the Company have been sold to a Montreal syndicate at a substantial profit.

Borings have been made in the district during the past two or three seasons by the Quebec Fuel Company, and the Sherbrooke Oil and Gas Company, but the results are not yet made known.

RAISED BEACHES OF SOUTHERN QUEBEC.

(J. W. Goldthwait.)

Six weeks of the summer of 1910 were spent by the writer in the lower St. Lawrence valley, investigating the records of the late glacial or Champlain submergence, and of differential uplifts and subsidences since that time. Mr. William H. Weston, Jr., and Mr. Warren P. Smith, were engaged throughout the season in leveling, to determine the altitudes of the raised marine beaches at selected localities, and to aid in other ways in the exploration and surveying of the ancient shorelines The area covered by this field work includes the south shore of the St. Lawrence river from Matane, about 225 miles northeast of Quebec, southwestward past Quebec to Montreal, and thence southward to the Vermont and New York State boundaries. Work extended inland at each place somewhat beyond the position of the upper limit of marine submergence. Although the plans for this work contemplated a study of features south of the river only, it was found desirable and practicable to visit the north shore at Tadoussac, Murray Bay, and in the vicinity of Quebec. Work was begun on June 29, and ended August 6.

Problems Investigated.

The subjects to which attention was chiefly directed were these:—

(*a*) The outline of the St. Lawrence estuary during the stage of late Glacial or Champlain submergence, from the head of the Gaspé peninsula southwestward to the north end of Lake Champlain and the borders of the Adirondack highlands.

(*b*) The topographic expression of ancient beaches marking this Champlain shore, and its bearing upon the question of how promptly the region emerged from the sea after the ice-sheet had retired from the valley.

(*c*) The determination of altitudes of the highest marine beach, in feet above mean sea-level, at as many localities as practicable. This involved the correlation of beaches at different localities, and led to conclusions regarding the evenness of post-Champlain uplifts in this region.

(*d*) The beaches below the highest marine shoreline, formed during the post-Champlain emergence. Special attention was given to the question whether certain lower beaches register pauses between repeated uplifts, or whether the uplift was steady and uninterrupted.

(*e*) Marine fossil shells in the Champlain sands and clays, and their bearing upon conditions prevalent during the Champlain submergence.

(*f*) The discovery, exploration, and measurement of a great sea-cliff and terrace which borders the south shore of the St. Lawrence east of Quebec. The significance of this prominent shoreline as a record of excessive marine encroachment led to new conclusions regarding the number and character of post-glacial coastal movements in this region.

The information gathered along each of these lines of inquiry will be presented in outline under the several headings which follow.

THE CHAMPLAIN ESTUARY.

While it was impracticable to trace the shoreline of the ancient estuary continuously along the south side of the St. Lawrence for the 400 miles between Matane and the New York frontier, both because of the great length of time that would have been required and because of the obscurity of this beach for long distances, the shoreline was located at points sufficiently near to one another to allow the mapping of the approximate position of the whole, as well as to indicate what portions of the ancient coast had simple outlines and what portions were ragged.

From Matane southwestward nearly to Quebec the line which marks the limit of marine submergence runs nearly parallel to the present shore and at no great distance from it. The highest beach is nowhere more than 5 or 6 miles inland, and, on the other hand, there is no place southwest of Matane where the modern shore has been cut back beyond the position of the ancient one. Through nearly the entire distance the Intercolonial railway affords easy access to the highest beach, passing at several places within a mile of it, and crossing it at Rivière du Loup and at Ste. Flavie. At other places, especially southwest of Montmagny, the old shoreline lies 3 miles or more to the south of the railway. Along the north shore of the St. Lawrence the highest shoreline lies on the foothills of the Laurentian mountains within a very short distance of the river. The contrast in character which one sees between the north and the south shores of the modern St. Lawrence is simply a repetition of the contrast between the ancient shores; the north shore was bold and ragged, with many headlands and indentations; the south shore was comparatively straight, though broken here and there (as between Bic and Trois Pistoles) by long reef-like islands.

From Montmagny, where the modern shoreline bends westward towards Quebec, the ancient shoreline maintains its southwestward course, passing through St. Gervais and St. Anselme (20 miles southeast of Quebec), and approaching the line of the Grand Trunk railway near Ste. Julie, in Somerset. The railway follows the inner border of the once submerged region, from Ste. Julie southwestward past Arthabaskaville to Warwick, where it passes through a gap in the hills to the higher region outside. From here on the old shoreline is more irregular, and distinct traces of it are hard to find. It probably crosses the Central Vermont railway just east of Granby, and the Canadian Pacific railway near West Shefford, continuing southwestward with broken outline past Frelighsburg to the Vermont line

On the west side of Lake Champlain the shoreline returns across the boundary a few miles southeast of Covey Hill village. and passes westward with gentle curvature past Franklin Centre, entering New York again not far from Herdman.

On the north side of the St. Lawrence, between Quebec and Montreal, the highest shoreline has not been traced. From the descriptions and data of Dawson and Chalmers, however, it is evident that it lies rather far inland, and enters the Ottawa valley a considerable distance north of Montreal.

The broad lowlands south, west, and east of Montreal have sometimes been called the marine plain of the St. Lawrence valley. That this was indeed the floor of the sea at the close of the ice age none will deny. The isolated mountains which rise conspicuously from the plain—Mounts Royal, Bruno, St. Hilaire, Johnson, and Yamaska—were undoubtedly islands surrounded by deep water. Yet the flatness and smoothness of this plain and its wide extent appear to be due not so much to the smoothing of the sea-floor by long continued sedimentation upon it as to the development in pre-glacial times of a wide plain of denudation. The boundaries of the plain correspond closely with the outer limits of non-resistant Ordovician slates and shales. The shoreline topography at the borders of the plain, moreover, is so obscure and expressionless that submergence lasting long enough to allow such complete flattening of the valley floor by wholesale accumulation of clays seems contradictory. Granting that the sea-floor may constitute a more apparent record of the former submergence than the faint beaches which delimit it, one is still inclined to look upon the phrase marine plain as inappropriate in this case.

TOPOGRAPHIC CHARACTER OF THE HIGHEST MARINE SHORELINE.

The writer entered upon the field work with some expectations as to the character of the highest marine beach. Experience with the strong wave-cut terraces and cliffs of the extinct Lakes Algonquin and Nipissing[1] had suggested that here in the ancient St. Lawrence estuary, with greater depth of water and equally severe exposure to storm winds, the marine shorelines would be definite, pronounced features, visible from a distance, and at favourable places imposing in strength. This expectation was supported also by descriptions by earlier investigators in this field, both in printed form and in manuscript notes, in which distinct terraces were noted at many places. The first view of the field from an east-bound train on the Intercolonial railway out of Quebec seemed to meet the expectation, for distinct lines of rocky cliffs could be seen running horizontally through the woods along the northern slope of the line of hills that looks out over the marine plain. A very few days of detailed work on the ground, however, served to correct what proved to be a complete misconception; and as the season's work continued it became more and more evident that the highest beach, and indeed all the raised beaches except one within 20 feet of the present sea-level, are usually very weak, and often entirely without topographic expression.

A conspicuous shore terrace, marking approximately the upper marine limit, was found at the mouth of the Saguenay river at Tadoussac. This, however, is plainly a delta top, constructed by the accumulation in deep water of vast quantities of river-borne sediment at the mouth of the long fiord. No sign of wave cutting or cliffing near this delta could be found. Similar terrace-like tops were found at the debouchures of other important tributaries of the St. Lawrence, *e.g.*, at Rivière du Loup, and at Matane. With the exception of delta-surfaces like these no distinct shore terraces could be found at the upper marine limit.

Here and there terraces of other than littoral origin were found, so near the supposed altitude of highest submergence that close scrutiny was needed to make clear the fact that the bench and cliff had not been fashioned by wave action. Often this proved to be a bench of weak slate, outcropping along the strike and nearly horizontal. With few exceptions such slate benches lack even a thin covering of wave-washed material; moreover, similar benches may be found at various altitudes well above the true marine limit. It is true, however, that waves cutting against a slope of crumbling slate construct a thin beach of slivers, splinters, and finer fragments, which after long exposure to decay might appear to be too full of clay and too obscurely stratified to indicate littoral origin. Yet, granting that some of these slate benches near the accepted limit of submergence are wave-cut forms, and not merely outcrop benches, the fact remains that these benches are weak and obscure. They cannot be traced more than a few hundred yards, and the escarpments behind them are seldom so steep or continuous as to draw attention to them from a distance.

Still another pseudo shore terrace is found in border drainage channels, where a river running along the edge of the ice, against an exposed hillside, carved a portion of its bed and outer bank out of the soft drift that underlay the slope. A striking example of this, to which attention has been drawn by the manuscript notes and measurements of the late Dr. Chalmers, was visited at St. Simon. The terraces here occur in a recess behind a long line of hills, which in Champlain time constituted an island that fringed the shore for several miles. Three or four very distinct terraces can be seen from the railway, along the south side of this recess, in a situation where wave action must obviously have been very weak, because of the almost complete enclosure of the recess by the island. If waves had been able to cut distinct terraces on this protected shore behind the island, they would certainly have cut much stronger terraces and cliffs on the north or seaward side of the island; and yet, although the declivity of the latter, and its rock structure, are equally favourable to

[1] See Memoir No. 10 of the Canadian Geological Survey, 1910.

cliff-development, no wave-cut benches whatever occur there. The upper marine limit is marked by a faint beach, or rather belt of gravel, above which there is no sign of wave work. The upper marine limit thus faintly yet satisfactorily marked was found by leveling to harmonize with expectation based upon previous measurements at other localities. The terraces in the recess behind the island, which Dr. Chalmers measured in 1907, do not harmonize in any case with measurements elsewhere on the highest beach, made either by him or by the present writer. The topographic surroundings of these rejected terraces, while such as to preclude their origin by wave work, make it quite probable that they are marginal drainage channels.

Contrary to anticipation, therefore, the highest marine shoreline was found never to consist of a wave-cut terrace and sea-cliff, but generally of a low beach. Here and there, at exposed points on the ancient shore, where the original declivity was favourable and the local supply of shingly beach material was abundant, one can find beach ridges with rather distinct crests and back slopes, or topographic features still more peculiar to littoral agencies, such as hooks, overlapping spits, or pocket beaches. These, while distinct, are delicate, and when traced for short distances along the extinct shoreline, fade away against a slope whose declivity or structure prevented effective wave work. In few places have favourable conditions at the highest level of submergence conspired to promote the building up of a really strong beach. At Bic the presence of thin-bedded sandstone and conglomerate in place of the usual crumbling red slate afforded coarse gravel, out of which a fine series of beach ridges was constructed. At Murray Bay, where the glacial drift which covers the hillsides was full of hard crystalline stones, the highest beach is a well-marked ridge of gravel. And at Ste. Gervais, near Quebec, wide exposure, and a gently sloping coast oblique to the dominant storms, permitted the building of a typical line of overlapping spits, which can be followed for 3 or 4 miles towards St. Anselme. These are the only localities east of Montreal where beaches were found which equal in strength the beaches of the extinct great lakes Chicago, Algonquin, and their contemporaries. At Covey hill, near the New York frontier, an unusually fine series of beaches was built during the emergence of the region from the sea, because the gently sloping hillsides which face out over the wide, flat plain are abundantly coated with bouldery drift that is full of slabs and discoidal stones of Potsdam sandstone. The distinct imbrication of these slabs in the beaches, where the structure is exposed in cross-section, and the continuity of the ridges for long distances, fully convince one of their littoral origin, in spite of the contrast between such heavily built features and the obscure beaches which mark the continuation of this same shoreline over a distance of 400 miles northeastward to Matane.

The consistent weakness of this highest beach, therefore, at all points except in the few instances mentioned, where conditions were abnormally favourable, indicates that the sea stood only a short time at the highest level. An unwarping of the coast seems to have set in almost immediately upon the withdrawal of the ice sheet from it, allowing little wave action to be registered. It is not likely that the newly opened estuary was deepened by subsidence just after the ice sheet retired, and before the elevation of the highest beach began. Besides objections on the ground of isostacy, which seems to require greatest submergence during the deepest glaciation and emergence following close behind the thinning and disappearance of the ice sheet, there is the objection that such a reversal of movement at the stage recorded by the highest beach would have involved so long a period of time that the sea would have left a stronger record of its work along the line of highest marine submergence than is actually there. This objection gains added weight also from the consideration of the topographic strength of shorelines on a slowly subsiding coast—a subject to be discussed on a later page. The demands of isostacy, and of shoreline morphology, agree in showing that regional uplift came as a prompt response to the withdrawal of the ice sheet.

ALTITUDES OF THE HIGHEST MARINE BEACH.

The altitude of the highest shoreline was obtained at over twenty localities. Care was taken to make these measurements accurate. A German pocket level of the pattern used in the topographic work of the Survey was found to give highly satisfactory results. Small errors may be allowed for bench marks at railway stations, as given in White's Altitudes in Canada. An error, seldom if ever amounting to more than one foot, is involved in the leveling from bench mark to destination. Moreover, in selecting the point at the crest of the beach to be leveled, some allowance has to be made for the original variation in height to which the beach was built up. Combining these sources of error we may look for discordances of several feet, say 5 to 10 feet, between measurements at neighbouring localities. A comparison of measurements on this basis, roughly made during the progress of the work, and more carefully made since the completion of it, shows almost complete harmony between the measurements. In other words, the variations in altitude, with few exceptions, prove to be highly systematic, and to indicate a regional upwarping of great regularity, unbroken by dislocations, or excessive uplifts of a local nature.

The method of identifying and measuring the altitude of the highest beach was briefly this: let us suppose that we have already measured the altitude of the beach which appears to be the highest one, at two localities in the neighbourhood. From these two measurements we have already figured out the tilt rate of the highest beach, that is, the number of feet which it rises in each mile in a given direction as a consequence of the differential uplift it has suffered. Knowing the distance from the last locality to this one, we have also figured out the exact altitude at which we expect to find the highest beach. At the railway station we set the aneroid barometer according to the altitude given in White's Altitudes. Using some judgment as to the most accessible slope where the highest beach may fairly be expected to be distinguishable (with due consideration for declivity, exposure, and rock or drift structure), we explore the ground near the predicted altitude. Careful search up and down the slope usually leads to the discovery of a weak yet distinct ridge of fine gravel, the uppermost and the weakest, it may be, of several such ridges. Above it there is no sign of wave-washing, either in the shape of the surface or in the character of the soil—nothing but ledges and glacial drift. Convinced that this is the highest beach, we consult the aneroid barometer, and find that the altitude is apparently 10, 25, or even 50 feet higher or lower than we predicted it would be. Returning to the station we may or may not find that the barometer checks up. In any case, we run a line of levels from the bench mark up to the beach in question, and in most cases we find that the aneroid barometer was unreliable, and that the altitude of the beach is indeed within 5 or 10 feet of what we predicted. Thus by deliberately choosing our highest beach at an altitude which the barometer told us was wrong, we have found the beach at the right altitude. When this method of fulfilling prediction is applied with success to a series of localities in turn, one feels confidence in his correlation of the highest beach at the several localities, in spite of the topographic weakness of the shoreline.

The altitudes of the highest beach at 17 localities east of Quebec are given below:—

Matane, 174 feet.
MacNider's, 243 feet.
Little Métis, 248 feet.
Ste. Flavie, 272 feet.
Sacre Coeur, 294 feet.
Bic, 311 feet.
St. Simon, 337 feet.
Cacouna, 354 feet.

Rivière du Loup, 372 feet.
Tadoussac (delta top), 406 feet.
Ste. Alexandre, 396 feet.
Murray Bay, 433 feet.
St. Jean Port Joli, 513 feet.
Montmagny, 543 feet.
Chateau Richer, 591 feet.
St. Gervais, 623 feet.
Two miles southwest of last, 632 feet.

All measurements are referred to mean sea-level. Those at Matane, MacNider's, Little Métis, St. Simon, and Tadoussac were determined by levels run up from mean high tide mark, and have been reduced to approximate mean tide mark by rough computation. For them a probable error of 3 or 4 feet should be allowed, in addition to ordinary errors of smaller amount. In the other cases the levels were run from railway stations whose altitudes are given in White's Altitudes in Canada.

West of Quebec the identification of the highest beach was found to be difficult and at many places impossible. At Ste. Julie the highest distinct beach stands at 612 feet, but there are short belts or flattish ridges of sand and gravel farther up the hillside here, as high as 695 feet. No positive conclusion could be drawn concerning the exact position of the upper marine limit. At Arthabaskaville a distinct gravel spit was found at 593 feet. This shoreline, however, cannot be traced far in either direction. Nothing higher could be found. Beyond here the country between 400 and 700 feet is very irregular, consisting of broken lines of hills and ridges, which seem to have formed a very ragged shore when submergence was at its height, so ragged that effective wave action and continuous beach building, during so brief an interval, was impossible. At Danby flattish beach-like ridges of gravel were found at 548 feet, and at West Shefford, near the Canadian Pacific Railway station, at 490 feet. The obscurity of these fragments makes their correlation unsafe. They would require a descent of the highest marine beach from about 630 feet near Quebec to about 480 feet at Montreal. This seems to be too low, both to agree with the facts at Montreal, and to match the very clear evidence of submergence near the New York boundary.

At Montreal the upper limit of submergence has been stated from time to time by different investigators to be 470, 560, and 625 feet. The 470 foot shell deposit noted by Sir Charles Lyell, in 1841, seems unreliable as a record of post-glacial submergence, because the fossiliferous strata of gravel were said to be overlain by an unstratified formation of boulders and earth. The writer is unacquainted with the facts which led Baron de Geer to set the limit of submergence here at 625 feet. Sir William Dawson's figure, 560 feet, seems to accord better with such facts as were secured during the past summer.

A few days' search around Mt. Royal, while it revealed distinct beaches at several places, at altitudes as high as 300 feet, brought to light little satisfactory evidence of submergence at higher levels. The only place where there appeared to be a distinct boundary between the lower wave-washed slopes and the upper slope of ledge and drift is at the golf links at Westmount. Here an extensive plateau of gravel lies against the west side of the mountain. Newly dug trenches display coarse stratified gravels, to a depth of 20 feet, with boulder beds, possibly iceberg till, beneath. At the club house on the golf links the surface of this gravel plateau rises gently to a short but distinct spit, which appears to mark the limit of submergence. The altitude of this spit, determined by leveling from Westmount station, is 492 feet. The spit cannot be traced westward across the golf links, where it may have been obliterated by grading; but there is a definite steepening of the slope above this altitude, and a rather abrupt change from the sandy and gravelly soil to bouldery drift. Although the 492 foot spit at Westmount accords fairly with the measurements of doubtful beaches at Ste. Julie, Arthabaskaville, Danby, and West Shefford, the following reasons may be noted for refusing to accept it as the highest beach: (*a*) its weakness; (*b*) the fact that it stands fully 60 feet below Dawson's highest shell locality; (*c*) the difficulty this involves in accounting for a high gravel plateau, which will presently be described as occurring on the flank of Yamaska mountain, 35 miles east of Montreal; and (*d*) its position between Quebec, where the highest beach is about 630 feet above sea-level, and the New York boundary, where the sea seems to have stood as high as 523 feet. One would expect the highest beach at Montreal to stand at some altitude intermediate between 523 and 630 feet, not as low as 492 feet.

Search around two of the ancient islands southeast of Montreal, namely St. Hilaire and Yamaska mountains, disclosed, in the former case, distinct beaches as high as 493 feet, and in the latter case a high terrace-like plateau of gravels, whose top has an altitude of about 575 feet. Neither of these somewhat contradictory facts can settle the question of the limit of submergence. The 493 foot beach at St. Hilaire may not mark the highest stand of the sea, and the steep ledgy slope behind and above it offers little promise of a higher record having been left. The 575 foot terrace at Yamaska mountain appears to record approximately the level of standing water when the ice sheet which had enveloped the mountain first melted away from it. While it seems probable that this body of water was the open sea, because the mountain stands far out towards the centre of the plain, the possibility of a local ice-rimmed lakelet against the mountain side cannot be denied. It seems necessary at present, therefore, to leave open the question of the height of marine submergence near Montreal, with the assurance that it was at least 493 feet, and not improbably 560 feet. Everything considered, the latter view agrees best with the facts gathered from the New York boundary southwest of Montreal.

The precipitous, thinly drift covered slopes of the isolated mountains, or ancient islands, southeast of Montreal, discourage the search for a distinct beach at those points, where ideal conditions of exposure to storm waves would otherwise lead us to look for strong beaches. The undulating topography of the region near the Vermont frontier, where the old shoreline must have turned down around the east side of Lake Champlain, is equally discouraging. It may not become possible to discover the faint winding shoreline in this region until a thorough study is made of the details of glaciation just previous to the Champlain submergence.

The facts at Covey hill, near the New York line, have already been alluded to as pointing to a submergence of more than 500 feet at Montreal. The situation is briefly this: a series of exceedingly strong beach ridges, built of slabs and discoidal stones, is found, from an altitude of about 300 feet up to 523 feet. Above this there is nothing distinctly wave-built. In the interval of over 200 feet these beaches are packed rather closely, without any pronounced, persistent gaps. There is no especially prominent ridge among them, which might be selected as a line of division between marine beaches below and lake beaches above. Since the lowest of these beaches seem surely to be marine, because they are so far below the level of marine submergence at Quebec on the one hand and the supposed marine beach at the east end of Lake Ontario on the other hand, all must be taken as marine beaches, unless some of the higher ones of the series can be found to be discontinuous around the two sides of the Adirondack highlands. This point has been emphasized by Prof. J. B. Woodworth, in his study of the Mooers Quadrangle, for the New York State Geological Survey. The altitude given by him (and previously estimated by Dr. G. K. Gilbert) for the upper limit of marine submergence at Covey hill is 450 feet. Doubt as to the horizontality of some of the highest beaches, and erroneous measurements with the barometer from a bench mark which was itself incorrect (the top of Covey hill taken as 1,050 feet) account for their error. Bench marks left at road corners in this district by topographers of the Militia Department several years ago proved to be of very great value in the present work, making the task of leveling to the crest of the highest beach around Covey hill a rapid and easy one. It was found that the highest slab-stone beach is virtually continuous from Covey Hill Methodist church westward at least as far as Franklin Centre, a distance of 12 miles. Leveling at four places, from four different bench marks in this interval, gave these surprisingly accordant results: 524·32 feet; 523·94 feet; 523·31 feet; and 524·54 feet. The last measurement is at Franklin Centre. There can, therefore, be no question about the horizontality and continuity of the 523 foot beach along the north slope of Covey hill. Before it can be positively stated, however, that this is the marine beach, it must be traced around into the Champlain and the Ontario basins on either side, or must furnish marine shells.

As already stated, Dawson's highest beach at Côte des Neiges was 560 feet above the sea. The 575 foot terrace at Yamaska mountain seems to confirm this. It is a curious fact that a tilt line drawn from the 560 foot locality southwestward through the 523 foot beach at Covey hill passes Clayton, N.Y., at an altitude of approximately 400 feet, the altitude at which Prof. Fairchild puts the supposedly marine Oswego beach.

With due regard for unsettled questions of correlation between Quebec and Covey hill, it seems rather clear that the uplift of the Champlain, or highest marine shoreline, is greatest in the vicinity of Quebec. A profile of the upwarped marine waterplane, drawn from northeast to southwest along the axis of the St. Lawrence valley, puts the top of the bulge not far west of Quebec. This may be taken somewhat as a confirmation of Dawson's conclusion that the ice sheet was thickest near Quebec, and lasted longer there than it did either to the east or to the west of that place; for the uplift, if it consisted in the recovery of the earth from compression beneath the ice sheet, would naturally be of greatest magnitude where the overlying load was of greatest weight.

Regarding the evenness of this uplift, it may be remarked that not only did the leveling fail to disclose local vertical irregularities in the warped plane, but in many cases the successful prediction of altitude by the method described on an earlier page quite precluded the probability that post-glacial faulting, or local folding, is concentrated enough to be detected by a survey of the beaches, however accurate. In the case of St. Gervais, a line of levels was run for 3 miles nearly on the crest of the beach. It showed a variation of not over 8 feet in the 3 miles, disregarding gaps in the shoreline where spits overlapped near a deflected stream. This slight variation, moreover, was rather systematic, consisting of an increase in the height of the beach towards Quebec, as if due to the gentle regional tilting. It is of significance also that the highest beach at Murray bay matches the data from the south side of the estuary, although Murray bay is in the region of contorted Pre-Cambrian crystallines, where local orogenic movements might be looked for, if anywhere. The post-glacial upwarpings here in the St. Lawrence valley seem to have been as free from local irregularities as they were in the Great Lake region, in spite of the more varied rock-structure of southern Quebec.

The relation of this new body of data to measurements of post-glacial uplift elsewhere in the Maritime Provinces, along the New England coast, and in the Great Lakes region, is important, since it adds new light upon the extent and the shape of this comparatively recent deformation of the northern portion of the continent. A map showing isobases or lines of equal uplift over this region as a whole has been prepared in manuscript, to accompany a more complete report on the work here summarized.

LOWER BEACHES AND UNINTERRUPTED EMERGENCE.

Familiarity with the distinctly spaced shorelines of the extinct Great Lakes, and with published descriptions of the marine terraces of the St. Lawrence, had prepared the writer for the discovery of several definite and fairly continuous shorelines, separated by vertical intervals in which good wave-built features would be absent, as if to indicate that post-glacial uplifts had consisted in a number of jerks, separated by pauses of considerable duration. This conception of things, however, proved to be quite incorrect. From the highest beach, whether at 632 feet or 174 feet, down nearly to the present shore, beaches are to be found at all altitudes, where the local conditions of exposure, slope, and detritus available for beach construction were favourable. There are no prominent shorelines among these lower beaches which are remarkable for their perfection of form or for their persistency along the shore. If there is any systematic departure from a monotonous average of form and structure it is a general increase in shapeliness and sandy structure in a descending order. The coast seems to have emerged steadily from the very first, while the waves, building spits and pocket beaches at favourable places, as the configuration of the shallowing shore kept changing, gradually produced more and more distinct beaches with the shingle and sand which they drew down the slope from beach to beach. This opinion, though formed contrary to expectation, and quite independently, agrees, I have since found, with Prof. H. L. Fairchild's published conclusions based upon the slab-stone beaches at Covey hill.

It agrees also with evidence of uniform uplift as recorded by a general discontinuity of river terraces in New England valleys, and especially on the coast of Maine.

FOSSIL SHELLS.

A survey of the raised marine beaches, strange as it may seem, does not lead to the discovery of a large variety of fossil shells. Close scrutiny of shallow roadside trenches, and occasionally of deeper excavations and natural cross sections of the marine sands, usually proved fruitless. Near the highest beach, especially, marine life seems to be almost wholly unrecorded. At lower levels, where the water was deeper at first, and the conditions better for life and for its preservation by quiet burial in clays, opportunities for collecting fossils are better. In view of the boreal character of the Champlain fauna, moreover, it seems not unlikely that at the very first, when the ice sheet had hardly retired from the estuary, the conditions for life were forbidding, if not prohibitive.

At the lower levels on the beaches and the terrace near the present shore, one is liable to be misled at first by the abundance of shells turned up in the freshly ploughed fields, and in pastures which were formerly cultivated. The common use of rock weed, and other littoral vegetation, for manure makes the presence of shells near the surface of cultivated fields of no palæontological value.

At three localities shells were found in abundance in undisturbed positions. Several exposures of clay beside the road that leads from the Murray Bay pier to the village yielded innumerable specimens of *Macoma (Tellina) Groenlandica*, and fewer *Macoma calcarea*. The best of these beds were near the upper surface of the dissected clay plateau about 1½ miles southwest of the village, at an altitude of about 170 feet.

Two miles north of Port Neuf station, about 35 miles west of Quebec, a fresh roadside trench in a wooded, uncultivated district, furnished hundreds of *Saxicava arctica (rugosa)* and a few *Macoma Groenlandica*. Among the Saxicava were a number of individuals with the valves together standing erect in the attitude of growth. The undisturbed bedding of the sand was quite clear. The altitude here, by barometric measurement from Port Neuf station, is 372 feet.

A gravel pit about a mile south of Hemmingford, near the New York frontier, which Prof. J. B. Woodworth has described in his report on the Mooers Quadrangle, was visited, and from it an abundance of Saxicava shells were gathered. As Prof. Woodworth has stated, this shell-bearing deposit is remarkable, because the complete shells, standing erect in attitudes of growth, are packed tightly between coarse gravels, where one would expect they would have been jammed and crushed by the shifting of heavy stones during storms, and where there has been every opportunity since the sea retired for ground water to dissolve the shells.

THE 20 FOOT TERRACE AND SEA-CLIFF.

It has been stated above that from the upper limit of submergence down nearly to the present sea shore, fragmentary beaches are found at such a variety of altitudes as to indicate an uninterrupted emergence of the coast. The condition is quite different near the present shoreline. On the second day of field work attention was drawn by a steep sea-cliff and terrace behind the modern beach at Cacouna. The upper edge of the terrace at the foot of the cliff was leveled, and found to be from 15 to 20 feet above high tide mark. Although the cliff and terrace here displayed great strength, in contrast to the weaker beaches which had already been seen at higher levels, the extent and importance of it was not suspected until the following day, when a second visit to the shore of the St. Lawrence, this time at Trois Pistoles, 20 miles farther east, disclosed a similar sea-cliff and terrace, standing behind the present beach well out of reach of the waves, and stretching for miles along the coast. At Bic, 28 miles beyond Trois Pistoles, the 20 foot terrace and its great sea-cliff was found again, and from there on it became a familiar feature of the landscape. It extends, according to our observation, with fair continuity from Quebec eastward 200 miles to Matane. Beyond that point our survey did not extend. Throughout this distance the terrace maintains a fairly uniform altitude of approximately 15 to 20 feet above high tide. It rises and falls only so much as the original variation in its surface, and subsequent blurring by soil creep, wind blown sand, or alluvial wash, are sufficient to explain. From MacNider's eastward for over 25 miles to Matane the carriage road along the shore of the St. Lawrence lies upon this ancient terrace. Overlooking the road on the one hand is the steep sea-cliff, rising from 20 to 50 feet above the terrace, and extending in a nearly straight course, with no gaps except where a tributary stream passes down from the uplands to the terrace level. On the other hand, one looks down the gently inclined terrace surface, and out beyond high tide mark across wide tidal flats which form the outer continuation of the terrace. The shallow mud flats stretch offshore in places for 1 or 2 miles. At low tide one can look out across the bare mud flats to a wide expanse of shallow water that lies beyond, where the heads of many boulders rise out of the shallows. The waves have done very little work along the present high tide mark. Usually a low beach ridge, or at most a low sea-cliff not more than 10 feet high, separates that part of the 20 foot terrace which now lies above the sea from that part which is now submerged. Similar views of high cliff and broad half exposed terrace can be had at Little Métis, Rimouski, Bic, Trois Pistoles, Cacouna, Frasierville, Ste. Anne de la Pocatière, and many other places. The Intercolonial railway runs along the 20 foot terrace at the foot of the old sea-cliff for a few miles, midway between Bic and Rimouski. Just west of Sacré Cœur station the sea-cliff beside the railway, instead of being cut in glacial drift, has been cut in slate, and forms a precipice 100 to 125 feet high. The amount of wave-cutting along this ancient shoreline, judging from the great width of the terrace and the height of the cliff, must have been prodigious. In comparison with them the changes wrought along the present water's edge are insignificant.

At Tadoussac and Murray Bay, the only points visited on the north side of the St. Lawrence east of the Isle of Orleans, the 20 foot terrace was not found distinctly developed. Steep slopes, resistant crystalline rock, and conditions for delta-building may account, however, for its absence. The terrace and cliff are strongly developed from Quebec eastward for 25 miles, at least to Ste. Anne de Beaupré, and can be plainly seen for most of this distance from the car window of the electric railway. It is the only strong and persistent topographic feature of the gently sloping coast from Quebec eastward, the only shoreline that shows effective wave work.

Numerous hand-level measurements of the altitude of this terrace were made, and occasionally the more precise leveling instrument was used. The results show very close accordance in height over the distance of 200 miles. In the following list of altitudes the measurements refer to local high tide mark, as determined by a line of flotsam on the beach. This introduces into the figures an additional error, which may amount to 3 or 4 feet. In spite of this, however, the measurements at the widely separated localities are fairly accordant.

Rivière Blanche (10 miles west of Matane), 15 to 17 feet.
Little Métis (a beach), 19 feet.
Rimouski, 22 feet.
Sacré Cœur, 20 to 22 feet.
Bic, 19 to 21 feet.
St. Simon (a beach), 17 feet.
Trois Pistoles, 14 to 19 feet.
Cacouna, 14 to 21 feet.
L'Ange Gardien (10 miles east of Quebec), 14 to 16 feet.

There appear to be two ways of accounting for this strong 20 foot shoreline. It may record a pause in the post-glacial emergence, when the coast was stationary for a long time, and the waves were given the opportunity to encroach upon the land, or it may record a temporary reversal of crustal movement. when emergence ceased and subsidence set in, to be followed in due time by a re-elevation of 20 feet. In choosing between these explanations, the following points should be taken into account:—

(1) The evidence from higher beaches indicates that up to the time when the 20 foot terrace was cut emergence had been steady and uninterrupted, although amounting to 200 to 600 feet in this part of Quebec. It is not easy to see why after so great an uplift there should be a pause of such great duration as the sea-cliff and terrace demands, and why this should finally be followed by a second uplift, when isostatic balance appeared to have been gained. Would we not expect evidences of several such pauses instead of only one great pause?

(2) Waves, if given time enough, will develop and cut back a line of straight or gently curved cliffs along a stationary coast, but the length of time required for the perfecting of this process of cliff recession is greatly shortened if the coast in question is slowly subsiding. As Dr. G. K. Gilbert and others have remarked, the deepening water on a slowly subsiding shore facilitates the disposal of cliff debris, and enables waves to cut back at an abnormally rapid rate. This principle seems to account for the abnormal strength of the Algonquin and Nipissing shorelines in the Great Lake region; for each of these cliffed shorelines records a climax in the rising of the lakes from a temporary low water stage during the slow differential uplift of the outlet of the lakes. Although it has almost never been emphasized by an application to actual cases like these, the principle of slow subsidence as a cause of rapid cliff development is pretty well established, both by theory and by observation.

(3) There is independent evidence of coastal subsidence in the Maritime Provinces and New England, since the great post-glacial upwarping. While several lines of evidence, especially those which have been urged as indications of subsidence now going on, may be regarded as unconvincing if not actually unsound,[1] other evidences, such as submerged forest beds and stumps *in situ,* below low tide mark at many places on the sea coast can only be accounted for by subsidence. The evidence in hand does not make it so plain whether the sinking of the coast ceased long ago or is still in progress. Physiographic evidence near Boston, at Nantasket beach, was recently presented by Professor Johnson as an argument for the belief that there has been neither subsidence nor elevation of the coast at that latitude during the last two or

[1] See D. W. Johnson, "The Supposed Recent Subsidence of the Massachusetts and New Jersey Coasts." Science, Vol. 32, Nov. 18, 1910, pp. 721-723; and "Botanical Evidence of Coastal Subsidence." Science, Vol. 33, 1911, pp. 300-302.

three thousand years. There appears then to be no valid objection to the view that the general coastal subsidence which followed the great emergence was itself followed, at least in southern Quebec, by a slight re-elevation. The correlation of the 20 foot terrace and sea-cliff with the submerged forest beds and stumps seems to contradict none of the facts thus far presented and accepted.

(4) If the great terrace marks a stage of coastal subsidence between two stages of uplift, it agrees well with the conception of isostatic recovery from the released load of a vanishing ice-sheet. The first prompt upwarping may have been carried up the more central portions of the region too high: the reversal of movement may in turn have carried the region down a little too low; and a final elevation of 20 feet may have been required before equilibrium was fully established. A rhythmical balancing of this sort would seem to demand (*a*) rapid uplift, becoming slower and slower as the climax was reached and subsidence began to set in; (*b*) coastal subsidence, which, occupying the same length of time as the previous elevation, yet consisting of a relatively slight vertical change, would be expressed mathematically by a very much slower rate in feet per century; and (*c*) a still slower uplift, in which a period of time similar to the first and second was used up in the rise of the coast from sea-level to the 20 foot mark. Thus we would find ample explanation of (*a*) the weakness of the highest beach, and the increasing distinctness of the beaches in descending order; (*b*) the comparative strength and maturity of the 20 foot terrace and cliff: and (*c*) the lack of distinct shore topography at the present sea-level.

(5) The investigations of Baron Gerard de Geer, Professor W. C. Broegger, and others, in Scandinavia and Finland, have led them to conclusions which the foregoing ideas simply duplicate. Since the ice age northern Europe appears to have experienced two uplifts and an intermediate subsidence. At the time the ice began to disappear from the Baltic sea the land stood much lower than now—at Christiania 700 feet lower. Clays accumulated in the Baltic at this time, which contain fossils of a boreal fauna analagous to the fossils of the Champlain clays of North America. Emergence of the Baltic region set in at once, and continued so far that the land stood at a level higher than it now stands. The Baltic basin was converted into a freshwater lake of vast extent. Records of it are found in sands and clays which contain the freshwater *Ancylus* fauna. These clays fringe the coast of the Baltic up to altitudes above 100 feet. Following this emergence came a stage of coastal subsidence, during which the lower portion of the Baltic basin was again depressed beneath the sea, and deposits of clays and sands were made with a marine fauna which is known as the *Littorina* group. This subsidence is Broegger's *Littorina-Tapes* Senkung. The third movement, a re-elevation, brought the *Littorina-Tapes* shoreline up to its present level—at Christiania about 200 feet above the sea. Professor Broegger has subdivided this elevation into three parts, on the basis of distinct beaches, faunas, and archæological evidence, calling these divisions the Altere, Mittlere, and Jungere Tapeszeit. The rate of uplift is said to have been more rapid during the Mittlere Tapeszeit than in either the Atlere or Jungere Tapeszeit. This might be interpreted as an indication that at first the earth was only beginning to recover from the Littorina subsidence; in the Mittlere Tapeszeit the upward movement had become well established; and that towards the close of the Tapeszeit emergence a final balance was gradually reached.

The evidence of these three movements cited by the Scandinavian investigators consists of clays and sands containing the marine and fresh-water faunas and floras; submerged stumps and peat beds; and drowned valleys. While the shorelines marking each of the stages are definite enough to allow precise measurements of altitude to be taken (in the collecting and correlating of which data the Norwegian and Swedish Geological Surveys have made great progress) no attention has been called, so far as known to the present writer, to an abnormal strength of the Littorina-Tapes shoreline, or to extensive cliff recession at that level, as evidence *per se of* slow coastal subsidence.

The evidence upon which the corresponding stage of subsidence in southern Quebec now chiefly rests—the great 20 foot terrace and sea-cliff—is, therefore, entirely independent. It is of interest to note, also, that the interpretation of this sea-cliff as an evidence of subsidence was settled upon by the writer, without foreseeing at that time that the three-fold movement thus demanded would correspond to conclusions previously formed by European investigators.

Confirmation of the date of the subsidence in Canada, and of the correlation of buried stumps with the great terrace and sea-cliff, must, of course, be searched for before positive conclusions are drawn. It is apparent, however, from the virtual continuity of this terrace for 200 miles along the south side of the St. Lawrence, and from Quebec along the north side as far as the search disclosed favourable conditions for it, that this feature is not local. Its nearly uniform attitude throughout this distance leads to the same opinion. It seems to preclude such an idea as that the great cliff cutting is the result of a temporary raising of the high-water mark by the deflection of tidal currents consequent upon changing configuration of the coast. The results of such local fluctuations would be less uniform between the Gaspé peninsula and the head of the estuary at Quebec. It seems reasonable to suppose that an exploration of the coasts, with the terrace of submergence as the central idea, will demonstrate a stage of coastal subsidence of long duration and wide extent, separating the earlier, greater uplift from the later, lesser one. We would then be justified in subdividing post-glacial time into three parts, corresponding with the Ancylus, Littorina, and Tapes sub-epochs of Scandinavia.

Notes on Glaciation.

From such scattered, casual observations of striæ, roches moutonnées, and erratics as were possible during the progress of the work on the shorelines, where with so short a field season and so wide a field, concentration upon the problems of submergence was imperative, it is not safe to draw positive conclusions. In general, observation appeared to confirm the statements which have been published from time to time by the late Dr. Chalmers—at least in these respects:—

(*a*) East of Rivière du Loup, smoothed bosses of rock, usually of sandstone or conglomerate, protruding from the soft red slate which underlies the marine plain, seem to indicate a general movement of the ice sheet from south to north, as if this south side of the St. Lawrence, between Quebec and the Gaspé peninsula, had been glaciated from a centre on the Appalachian highlands. As a rule, however, the soft crumbling red and grey slates of this belt give little evidence of the direction of glaciation.

(*b*) The relative abundance of large crystalline boulders on the surface below the highest beach, in this region, suggests that material from the Laurentide mountains crossed the lower St. Lawrence largely through the agency of floating ice, during the later stages of the glacial period, while the coast was still submerged. The large number of these boulders on the present shore, where the tide-covered outer portion of the wide 20 foot terrace in many places is literally peppered with them, seems to be due largely to the same agency—floating ice, and not merely to the failure of the waves to remove boulders while the great sea-cliff was being eaten back.

(*c*) At a number of places near the modern shoreline, ledges were observed which have been heavily scoured and shaped by ice moving in a direction parallel to the shore. In some of these places—*e.g.*, Cacouna—the stoss and plucked sides seem to occur indiscriminately, at either end, and it is hardly possible to say whether the movement was from the northeast or from the southwest. As a rule, however, it seems to have been southwestward, up the valley. Out near Gaspé peninsula, about a mile east of MacNider's, a rocky island close to the shore exhibits typical rôches moutonnée outline, showing heavy glaciation here from about S 83° E to N 83° W (corrected).

Scoured bosses of trap rock beside the shore road, midway between MacNider's and Little Métis, seem likewise to show a glaciation from east to west.

The indications, therefore, favour the idea that the Atlantic peninsula, lying between the lower St. Lawrence, the Gulf of St. Lawrence, and the Gulf of Maine, had its own centre of dispersal, in the glacial period, and that along the south coast of the lower St. Lawrence pack ice, moving from the gulf up the valley, has been a strong factor in determining details both of erosion and of boulder distribution in the area of submergence.

On the other hand, our observations fail to confirm the view that local glaciers moved down the valleys of the du Loup, Trois Pistoles, Nord Ouest, Rimouski, Métis, Matane, and other rivers. These valleys, where they pass through the undulating uplands that border the St. Lawrence, are wide open rather than bold and deep. They lack utterly the features peculiar to valleys which have been deepened and widened by glacial action: and the terraces which occupy them are clearly of fluviatile origin. Regardless of evidences of valley glaciers in the deep fiords along the north shore of the St. Lawrence, it seems plain that the south shore was glaciated rather by an ice sheet.

TOBIQUE DISTRICT, NEW BRUNSWICK.

(G. A. Young.)

The district topographically and geologically surveyed during the field season of 1910 lies in northwestern New Brunswick and includes a tract of country about the forks of Tobique river. The Tobique flows in a general southwesterly direction, and is one of the larger tributaries of the St. John river, which it joins a few miles north of Perth.

Field work in connexion with the main control work was commenced in the latter part of May, under the supervision of Mr. D. A. Nichols. The main party arrived in the field during the second week of June, and field work continued until the end of September.

In the field the writer was assisted by Messrs. M. F. Bancroft, A. Boucher, J. L. Cavanagh, F. A. Huntingdon, D. A. Nichols, A. G. McIntyre, D. L. MacLeod, H. G. Morison and B. Rose, all of whom performed their duties in a satisfactory manner.

Means of Communication.—The district may be conveniently reached by means of the Tobique branch of the Canadian Pacific railway, which, leaving the main line at Perth, runs northeastward along the eastern side of Tobique river as far as Plaster Rock. From Plaster Rock a highway leads northward up the Tobique valley for about 26 miles in a straight line, to the forks of Tobique river. The district may also be entered by a canoe route favoured by tourists, sportsmen, and others, which follows the course of Nipisiguit river westward from Bathurst on Chaleur bay to Nipisiguit lake at the head of the river, crosses a low divide to Little Tobique lake, and continues down the Little Tobique to the forks of Tobique river. The section, under construction, of the National Transcontinental railway between Grand Falls on the St. John, and Moncton, crosses the Tobique a mile or so south of Plaster Rock.

Within the district, travel, except on foot, is practically limited to the one highway running northward up the Tobique valley, and to a number of rough portage roads running in various directions that have been cut out by lumber companies. The Tobique river and its larger tributaries can be traversed in canoes, but these streams are swift, and, except at high water stages, the load that may be carried in a canoe is very limited.

Location and Area.—The district surveyed in 1910 has an area of approximately 400 square miles. The southern boundary crosses the Tobique south of the mouth of Gulquac river at a point about 5½ miles north of Plaster Rock, and the northern boundary lies about 3 miles north of the forks of Tobique river. The western boundary, starting in the south from a point on Tobique river, in the northern part of the district, lies about 8 miles west of the forks of the river; the eastern boundary is so situated as to include, in the southeast, Long and Trousers lakes.

Methods of Field Work.—The field work was carried out with the intention of mapping the geology and preparing a topographical map on a scale of 2 miles to 1 inch, with contour intervals of 100 feet. In order to establish elevations and geographical positions, a carefully run transit-stadia line was carried from Plaster Rock northward into the district. For the purpose of primary control it was originally intended to run accurate transit-stadia lines along portage roads, that would form one or more circuits and yield a framework of approximately the same outline as that of the district. Because of lack of time, however, this plan was in part abandoned, the portage roads being but little better than very crooked paths along which the individual sights did not average much above 150 feet in length, with a correspondingly low rate of daily progress.

The main control, as made, consists, in part, of circuits of carefully run transit-stadia traverses, but mainly of compass-stadia traverses run by means of a transit, and with a number of observations for magnetic declination. Various secondary traverses run by compass-stadia-transit were also carried out, as well as plane-table-compass-telemeter traverses of main streams and the shores of lakes. Between points established as above, numerous traverses run by plane-table-compass and pacing were made, the relief, etc., sketched in, and elevations determined by aneroid controlled by a series of daily aneroid readings made at central points of known elevation.

The geological map work was carried on by the members of the party in the course of their topographic work. The positions of all rock exposures seen were noted, and their characters usually recorded by simply taking small specimens. The number of specimens so secured while large, is not excessive, since, except along parts of some of the larger streams and over several limited areas, rock exposures were rare.

Previous Work.—The district surveyed in 1910 is part of a much larger area represented on a scale of 4 miles to 1 inch by map sheet No. 2 NW, which accompanies a report on the region by Messrs. L. W. Bailey and W. McInnes.[1]

In 1905 Professor W. A. Parks examined a portion of the area mapped this past season and reported on it.[2] An unpublished, final report, in manuscript form, by Professor Parks, was placed at the disposal of the writer.

R. Chalmers,[3] during several seasons, studied and reported upon the surface geology of the Tobique and adjacent regions.

PHYSICAL FEATURES.

Drainage.—The Tobique district is situated within the broken, relatively elevated country of northwestern New Brunswick. The district is drained by the Tobique river and its tributaries. The river flows in a marked valley lying towards the western edge of the district, and extending in a south-southwesterly direction. Towards the north, the valley is comparatively narrow, varying in width from one mile to scarcely more than the breadth of the stream bed, and has, on both sides, faces rising sharply from 200 feet to 400 feet above the river, but broken by the valleys of numerous large and small tributaries. Towards the south, the river channel usually lies from 100 feet to 200 feet below the level of the broad, main valley, which extends for some miles to the westward beyond the limits of the sheet.

In the north, the constricted valley of the Tobique is directly continued northward by the valley of Nictor or Little Tobique river, and similar physical characters are exhibited by the valleys of Sisson branch coming from the west, of the Mamozekel from the northeast, and of the Campbell river from the east, all four streams uniting in the neighbourhood of the forks. Some 7 miles east of the forks, the Campbell river also forks, one branch, the Serpentine, coming in from the east, the other, known as the Campbell, coming from the south, where it heads in Long and Trousers lakes. Trousers lake is bordered on its western side by a group of high hills whose western flanks are drained into the Gulquac river, which, following a nearly due west course, traverses a marked valley, and enters the Tobique river towards the southwestern corner of the district.

Relief.—The Tobique district lies, in part, along the eastern margin of a tract of elevated, rolling country, sometimes spoken of as a tableland, that extends westward into Maine. East of this upland, the country lying towards the centre of New Bruns-

[1] Bailey, L. W., and McInnes, W.; G.S.C., Ann. Rept., Vol. II, 1886, Part N.
[2] Parks, W. A.: G.S.C., Summary Report for 1905, pp. 115-117.
[3] Chalmers, R.. G.S.C., Summary Report for 1899, pp. 148-155, and Summary Report for 1900, pp. 151-161.

wick is much more rugged, and the physical features of the eastern portion of the Tobique district largely conform to this type.

The vertical relief of the country is considerable in amount, the Tobique in the southwestern corner of the area being only about 350 feet above the sea, while numerous peaks and ridges rise to elevations of from 1,200 feet to 2,500 feet. Towards the northwest the country is essentially a rolling upland, cut by numerous valleys and deep gullies, and having a general elevation of between 1,000 feet and 1,500 feet above the sea. Similar topographic forms are displayed in other parts of the district, but as a whole the region is characterized by the presence of sharp ridges running in various directions and rising steeply 800 to 1,200 feet above the surrounding country. These ridges, though sometimes distinct from one another, are more often grouped, as in the case of the mountainous tract lying just east of Trousers lake. A characteristic feature of the district is the presence of isolated, conical hills, whose peaks are from 300 feet to 1,000 feet above their bases. A notable feature of the district is the presence of a valley, or series of valleys, of irregular widths, running northward through the centre of the district. Perhaps the most characteristic feature of all is the gorge-like character of the various waterways, a character shared by the courses of even very small brooks.

General Geology.

At the present time it is thought advisable to offer only a few generalized remarks bearing on the geology of the district, since a large part of the field work performed by assistants has not yet been compiled.

The Tobique district includes a portion of the southeastern border of a large tract of westerly extending country that has been described as occupied by Silurian strata. This Silurian area has been mapped by various geologists as being bordered on the southeast by a belt of Ordovician strata separating the Silurian measures from Pre-Cambrian strata, which, farther eastward, are penetrated by large bodies of granite. The district also includes the northern portion of what has been called the Tobique outlier of lower Carboniferous strata. Silurian fossils have been found at several localities within the district, and others of Devonian type (Oriskany) have been found in narrow limestone beds interstratified with black slates occurring on Campbell river. The occurrence of areas of volcanic rocks has also been noted.

At the present time, the writer is unable to offer any new facts of importance regarding the general geology of the district. Over a great part of the area the strata consist of folded and faulted measures, usually greyish in colour and varying in general appearance from slate-like to coarse sandstones and fine conglomerates. At many points acid and basic igneous rocks, including rhyolites and rhyolite-tuffs, outcrop. Some doubt is felt regarding the propriety of subdividing the strata into Silurian, Ordovician, and Pre-Cambrian, as has been done by previous students of the geology of the region.

Economic Geology.

Although it has been reported at various times that alluvial gold has been found within the area under discussion, and more particularly in the bordering regions to the east and north, no evidence was secured of the presence, or of the probability of the presence of deposits of metalliferous minerals of economic importance. All the rock exposures seen, with only one or two exceptions, proved barren of any signs of mineralization, though, in one case, a very small amount of disseminated pyrite was seen. But the character of the country is unfavourable to the prospector, since exposures of rock *in situ* are, as a general rule, limited in number and widely scattered. It is possible, therefore, that, concealed by drift, there may exist gold-bearing veins, or other deposits of economic value.

As recorded by Chalmers[1] and others, colours of gold have been recovered from the gravels of various streams, though apparently never in any quantity. At different times during a long period of years, fragments of quartz, thickly impregnated with gold, have been reported to have been found, but in no case has precise information been furnished regarding the exact, or even the approximate position of the discovery.

The general lack of mineralization within the district examined during the past year tends to discourage the idea that any valuable deposit of gold occurs within the area. The existence of colours of gold in stream gravels does not, by itself, necessarily indicate the presence in the district of workable deposits of that metal, for colours of gold may be recovered from streams in districts where there is no reason for believing that gold exists in paying quantities, either in gravels or otherwise. It is possible, too, that at least in certain cases of alleged discoveries of gold-bearing quartz, some other mineral has been mistaken for gold, and it is perhaps significant regarding all such reported discoveries, that in no case was the exact point of discovery revealed.

[1]Chalmers, R.: G.S.C., Summary Report for 1899, pp. 148-155, and Summary Report for 1900, pp. 151-161.

ARISAIG-ANTIGONISH DISTRICT, NOVA SCOTIA.

(M. Y. Williams.)

The field work of the summer of 1910 was concerned with a detailed study of a portion of Antigonish and Pictou counties, N.S., represented on geological sheets (scale, 1 mile to 1 inch) by Hugh Fletcher, and accompanying his report of 1886.

The object of the work was to determine the age and relations of the sedimentary rocks, the age, character, and relations of the igneous rocks, and with Mr. Fletcher's work as a basis, to map the area studied on the scale of ½ mile to 1 inch. In the carrying out of these plans additions were made to the base map, a careful survey was made of the iron ore prospects, and considerable work was done in connexion with the gypsum deposits.

It is a pleasure to acknowledge indebtedness to Professor Charles Schuchert, of Yale University, and to Mr. W. H. Twenhofel, Assistant Professor of Geology at the University of Kansas, for assistance and advice during the early field work. Thanks are also due Mr. George E. Corbitt for assistance in the examination of the iron prospects which are under his management.

Work in the field was begun by the writer on June 22, and continued until September 24. Field work by Mr. M. H. McLeod covered the period between July 6 and October 8. Mr. McLeod rendered valuable assistance in many ways, and took charge of the revision of the base map.

LOCATION AND AREA.

The Arisaig-Antigonish district fronts on Northumberland strait, about midway between Cape George and Merigomish harbour. The area studied extends along the coast 5 miles northeast and 5 miles southwest from Arisaig point, and about 11½ miles southeast to the Intercolonial railway, and includes the gypsum deposits south of the railway. Its area is approximately 115 square miles. The Intercolonial railway furnishes communication along the southern border of the area, while stage routes reach the interior and shore districts. Steamboat communication is somewhat irregularly maintained with Pictou and Cape Breton ports.

PREVIOUS WORK.

In Gesner's report, published in Halifax, in 1836, the rocks of Nova Scotia were classified, and those of Arisaig were included under Red Sandstone rocks. Since then Sir William Dawson,[1] Dr. Honeyman,[2] Mr. T. C. Weston, Dr. H. M. Ami,[3] and Mr. W. H. Twenhofel,[4] have done valuable work on the area, in working out time relations and structure, collecting fossils, etc. In 1886 Mr. Hugh Fletcher[5] published his report on the area. It and the accompanying maps give a careful treatment of the formations, and the general and economic geology.

[1] Quart. Jour. Geol. Soc., London, 1845; Acadian Geol., 4th Ed., 1891, and G.S.C. reports:
[2] Trans. Lit. and Sci. Soc., Halifax, 1859; Geol. Soc. Quart. Jour., vol. 20; Trans. N.S. Inst. Vol. IV, 1878 and 1887.
[3] Trans. N.S. Inst., Series 2, Vol. I; Trans. Roy. Soc. Can., Vol. VI, 1900; Bull. Geol. Soc. Am., Vol. XII, 1901; N.S. Inst. Nat. Sci., Vol. X, 1901.
[4] Am. Jour. Sci., Vol. XXVIII, August, 1909.
[5] G.S.C., Rep. 1886.

General Character of District.

TOPOGRAPHY.

Regional and Local.—The Arisaig-Antigonish district belongs to the Cobequid plateau region of northern Nova Scotia. The central highland of the district, underlain by the Browns Mountain (Cambro-Silurian of Fletcher) formation, rises in the north and east to an elevation of from 900 to 1,000 feet above the sea. The sky-line is notably even across the bevelled strata, and only in the gorges worn by the streams do we find any great deviation from a plain. A gentle slope to the southwest is perceptible. On the northwest, along a line nearly parallel with the shore, the plateau descends to the younger formations over the fault scarp of the Hollow. In many cases the descent is very steep and the brow of the scarp very regular and clean-cut. Later erosion has given the Hollow the form of a U shaped valley, along which the streams, in many cases, flow some distance before finding a gap through the lower hills. North of the Hollow, high, well-rounded hills drop away to the shore. The lower country of the Silurian area presents a knolly aspect, while old sea-beaches, up to an elevation of 120 feet, occur along the shore.

On the east and south the plateau descends rather suddenly to the rounded hills and flat lands of the Windsor (Carboniferous Limestone and Conglomerate of Fletcher) group area. Karst topography, with ponds, sink holes, and interrupted drainage, is characteristic of the limestone and gypsum areas on the south. West of James River station, the railway follows a narrow valley floored by Arisaig (Silurian of Fletcher) strata and walled in by the Browns Mountain formations. The Sugarloaf hills near Malignant cove, and Antigonish town, are rounded knobs upheld by cores of intrusive rock.

A very perfect drainage system has been developed in the Arisaig-Antigonish region, and lakes and swamps are, in general, absent. The upper portions of the stream channels cut into the metamorphic rocks, are youthful, V shaped gorges, with many rapids and falls. On the younger formations, drainage maturity is exhibited in well-graded channels, and, in some cases, meanders. However, in general, a recent downcutting has occurred through gravel previously deposited to a thickness of 6 feet or more above the present stream beds. To the northward, brooks from 3 to 4 miles long empty into Northumberland strait. To the south and east brooks attain the dimensions of rivers, and ultimately discharge into George bay.

General Geology.

TABLE OF FORMATIONS.

In the following table, new formational names proposed by various geologists, or by the writer, have been used in a number of instances, instead of the older terms of Hugh Fletcher. The work of the past season, as far as it concerns stratigraphy and the larger questions of geological structure, has served to confirm the views of Fletcher, but since the formational names used by Fletcher, in certain cases at least, implied the acceptance of views concerning correlation and general geological conditions that in all cases are not accepted by the writer, it seemed best to adopt a new scheme of nomenclature.

In the table of formations the older usage of Mr. Fletcher is indicated. The names applied to the three divisions of the Carboniferous present in the district are new terms proposed by the writer. In the case of the Devonian families, the name Knoydart, proposed by H. M. Ami,[1] has been adopted. The nomenclature of the

[1] Ami, H. M., Can. Rec. Soc., Vol. VIII, pp. 206-305 (1901).

Silurian is based on the classification put forward by Ami,[1] and W. H. Twenhofel.[2] The division of the upper Cambrian, and, possibly, Ordovician systems, are those originally proposed by Fletcher.[3]

SEDIMENTARY.

Cenozoic.

Quaternary—

1. Recent—Stream gravels and residual soils, modified glacial gravels.
2. Pleistocene or Glacial—Unstratified clay-gravel deposits.

Palæozoic.

Middle Carboniferous—

Listmore formation (Millstone Grit of Fletcher); light grey and red-brown sandstones, thin argillaceous shale, thin green conglomerate, etc.

Lower Carboniferous or Mississippian. Windsor group—

Arduess (Limestone division of Fletcher); brown and green sandy shale, flaggy sandstones, red and grey shales, (gypsum at Brierly brook), and compact grey limestones.

McAras brook (Carboniferous conglomerate of Fletcher) limy grey shale, green shale, breccia, and basal conglomerate, cut near base by amygdaloidal trap sheets.

Devonian (Lower) System—

Knoydart formation (upper Devonian of Fletcher): hard fine-grained, red, sandy shale, and hard, grey sandstone, cut by small diabase dykes.

Silurian System—

Arisaig group (Silurian of Fletcher)—

1. Stone House formation (=more or less of Ludlow of England) red shale and limestones, argillaceous limestone, and shales.
2. Moydart formation (approximates the Louisville of United States, or Wenlock of England); the red stratum or red shale, argillaceous limestone and shale.
3. McAdam formation (Rochester of United States or upper Llandovery of England): black shales and argillacous limestone; obscure basic intrusive.
4. Ross Brook formation (=Clinton of United States, or lower Llandovery of England); green shale with thin sandstones, dark papery slates, etc.
5. Beechhill Cove formation (=lower Clinton): sandstones, limestones, and shales. Rhyolite and volcanic breccia at base.

Upper Cambrian and possibly Ordovician Systems—

Browns Mountain group (Cambro-Silurian of Fletcher), including granite, greenstone, syenite or diorite stocks, and diabase and felsitic dykes—

1. Bears Brook formation: red and grey sandstone, grit and conglomerate.
2. Baxters Brook formation; red and green slates.
3. James River formation (upper Cambrian or Ozarkic): flinty slates and quartzites.

---

[1] Ami, H.M.., op. cit.
[2] Twenhofel, W. H., op. cit.
[3] Fletcher, Hugh, op. cit.

IGNEOUS ROCKS.

Post-McAras brook	Amygdaloidal trap sheets.
Post-Knoydart	Diabase dykes.
Post-McAdam	Altered, obscure basic intrusives.
Pre-Ross brook	Dark red sheared dyke, amygdaloidal trap, rhyolite, and volcanic breccia.
Post-Baxters brook, but Pre-Great fault.	Greenstone intrusives of Malignant cove, Sugarloaf area, with associated granite porphyry and felsite, basic dykes, etc.
Post-James river (upper Cambrian), but Pre-Aras brook.	Syenite or diorite rocks east of Malignant cove. Diabase dykes, James River granite; diabase stock of Antigonish Sugarloaf.

DESCRIPTION OF FORMATIONS.

Browns Mountain Group[1] *(Cambro-Silurian of Fletcher).*

The Browns Mountain rocks (Cambro-Silurian of Fletcher) form the heart of the plateau area and are the oldest rocks of the Arisaig-Antigonish district. Extending from Cape George as a narrow belt along the shore, at the east boundary of this district they widen out so as to occupy nearly all the area south of the Hollow. Their course after leaving the district is westward and southward. From near the south-east corner of the area an outlier of Browns Mountain rocks extends northeast to George bay. Residual soil covers most of the plateau, and outcrops are best studied in the brook valleys.

Four igneous stocks occur in the area occupied by the Browns Mountain group—one of granite north of James River station; a small one of diabase (field determination) in the Antigonish Sugarloaf; one of trap or greenstone in the Malignant Cove Sugarloaf; and one of syenite (?) east of Malignant cove. Diabase dykes cut the James River granite, as well as the slates and quartzites. Similar dykes are of common occurrence in the vicinity of the Antigonish Sugarloaf and are of frequent occurrence throughout the metamorphic area. Granite porphyry, felsite, and basic dykes extend south and southwest from Malignant Cove Sugarloaf area.

The rocks of the Browns Mountain group are largely metamorphosed, and have been divided by Mr. Fletcher into three formations, all of which occur in the Arisaig-Antigonish district. The lowest, or James River formation, underlies all the area of the Browns Mountain group of the district to within a radius of less than 3 miles south of Malignant cove. Quartzite, varying from massive to thin-bedded, alternates with flinty slates. In colour the quartzite is in general bottle-green; its grain is fair sized, including scattered pieces of red jasper. The slates are commonly finely banded parallel to the stratification, in general are of an olive grey colour, and in many cases are harder than steel. In places the slates are crumpled, while the quartzites, when massive, often possess one or more sets of highly inclined joint planes.

The Baxter Brook formation succeeds the James River beds to the north, extending well into the intrusive area of Malignant cove. To it belong twisted and gnarled soft red slates, giving place occasionally to creamy slates, the colour of which appears to be caused by leaching.

The Bears Brook formation outcrops about Malignant cove, and in the valley of McNeills brook. In the latter place interbedded grey-banded slates, red slates, and brown grit are succeeded across a fault plane by fine-grained sandstone. Near Malignant Cove pond, a conglomerate consisting of pebbles of rhyolite, quartz, etc., lies upon the cleavage surface of a grey slate, and includes slate fragments. Nearby a coarser conglomerate, made up of rhyolite pebbles showing almost no sorting, overlies the finer grained conglomerate with an irregular, unconformable contact. Up Malignant brook conglomerate is succeeded by silicified purple grit.

The Browns Mountain rocks have suffered much folding, and the structure is further complicated as the result of disturbances due to igneous intrusions. Owing

[1] This name is adopted because of the widespread occcurrence of these rocks over the plateau of which Browns mountain forms an important part.

to their metamorphic condition, and the scarcity of outcrops, their geologic structure has not been completely worked out. However, it may be stated that in general the axes of folding extend northeast and southwest, parallel to the great features of the region. The younger formations belonging to the Arisaig and Windsor groups lie either unconformably against the foot of the Browns Mountain plateau erosion scarps, or else they floor the valleys that have been eroded through the Browns Mountain rocks. Examples of the latter relation are seen in connexion with the McAras Brook (Carboniferous conglomerate) formation northwest of the town of Antigonish, and also in the case of the lower formation of the Arisaig group, which occupies the valley followed by the railway west from James river.

Brachiopods obtained from the iron ore of Doctor brook and from quartzose schist near the east branch of Doctor brook have been identified by Professor Charles Schuchert as *Obolus (Lingulobolus) spissa* and *Lingulella* (?), the former of which occurs at Belle isle, in Conception bay, Newfoundland. The James River formation, in which these fossils occur, is, therefore, regarded as belonging to upper Cambrian (Ozarkic) time.

Basic dykes occur widely distributed throughout the formation, are usually vertical, and mainly trend with the formation axes. They are generally under 10 feet in thickness, and from field determinations are regarded as diabase. The granite stock of James river covers an area of about 2 square miles. The rock composing it is of a fine pink colour, and is rather low in quartz. Where observed the contacts are nearly vertical. In the southern extension of this stock, diabase dykes cut the granite along joint planes. Small outcrops of a syenitic character appear to the southwest, and a few small aplite dykes cut the country rocks. The Sugarloaf hill, north of the town of Antigonish, is supported by a small stock of diabase (?). North of this point numerous small diabase dykes occur.

The greenstone stock of the Sugarloaf of Malignant cove has been forced through the red slate, which still adheres to its highly inclined sides. Northwestward the intrusives continue as much-weathered greenstone rock, seen in the many small knobs that have been pushed through, and broken the slate cover. To the southwest gradations occur between the greenstone and a granite porphyry, the ground-mass changing from purplish green to grey. Phenocrysts of pink feldspar, up to three-fourths of an inch in length, are scattered through it, while quartz is recognized in irregular patches. Over an area extending about 4 miles to the south and southwest, a light creamy felsite is intruded indifferently along or across the bedding of the slates. Its frequent occurrence in connexion with the granite porphyry suggests that it may be a phase of the general intrusion of the Sugarloaf area. Similar felsite occurs near Browns Mountain settlement. The syenite (?) stock, east of Malignant cove, a good section of which is to be seen along the seashore, consists of much weathered rock, composed of pink to white feldspar and hornblende. Dark irregular dykes penetrate it.

Arisaig Group (Silurian of Fletcher).—The Arisaig group (Silurian of Fletcher) lies northwest of the fault scarp at the Hollow, and extends from Malignant cove southwest for about 6 miles along the shore, and is then overlain by the Knoydart formation, which takes on a dip, reversed in direction to that of the Arisaig, as may be seen near the contact in McAdam brook. A fine section of this group is exposed along the shore, while the brooks of the area furnish additional exposures.

Arisaig has been chosen as the group name because of its frequent association in literature with Silurian section, and because in Arisaig brook a good section across the upper four formations of the group may be seen. Ross brook has been substituted for Arisaig as applied by Ami and Twenhofel to the second lowest formation. Ross brook flows over obscured strata of this formation, and empties near the outcrops of the lower horizon of the formation as exposed along the shore. Honeyman and Fletcher divided this group into five divisions. In 1901, Ami proposed formation names for the upper four divisions, but did not definitely fix the boundaries. These were fixed by Twenhofel[1] in 1909, and differ somewhat from the divisions as given by Fletcher. The writer has introduced the name Beechhill Cove formation, applying it to the lowest unnamed member of the Arisaig group.

The arenaceous character of the beds, and the cross-bedded sandstones seen in many places, together with ripple marks, which occur most frequently towards the top of the section, indicate near-shore conditions of deposition. As recognized by previous writers, these formations lie in a syncline, probably formed by flexure and fracture during down-faulting. The trough pitches southwest, and the formations occur in ascending order from rim to centre. Twenhofel has fixed the age of the group as embracing the time from the Clinton into the Ludlow, as is indicated in the table of a previous page, in which the lithologic characters of the various divisions are given.

The eruptive pink and greenish rocks at the base of this group were identified by Twenhofel, by means of microscopic examination and chemical analyses, as rhyolite and volcanic breccia. His slides have been examined by the writer, who quite agrees with his conclusion.

The contacts of these extrusives with the Beechhill Cove formation are apparently conformable with the bedding. In Doctor brook the strata are turned on end, the igneous rocks are brecciated, and have jointing or sheeting parallel to the contact. The sedimentaries are micaceous and schistose for some distance, and have taken on a sheeting parallel to the contact. On the shore east of Arisaig point the waves have lately exposed a contact, in which the thin sandstone beds warp around projecting rhyolite, and are compressed. The disturbance dies out within a few feet. Small dykes cut the sedimentaries for 40 or 50 yards from the contact. These dykes are light-coloured, with red blotches, and are stony to glassy in texture. A fine sheeting is assumed by the rhyolite next the contact, while the sedimentaries share the rhyolite jointing for a short distance. The contact dips at a high angle. The old character of the rhyolite, its breccia phase, and its generally conformable contacts with the sedimentaries favour the theory that the sedimentaries are the younger. However, the dynamic metamorphic conditions of the contacts—jointing, sheeting, dykes, etc., and the one instance of flexed beds—would support the theory that the rhyolite was intruded at the base of the formation as now known. Along the whole length of the rhyolite amygdaloidal trap occurs, cutting into it from the seaward side. Along the contact or cutting of the older igneous rocks there occurs a dark red dyke. It is much decomposed, and has assumed a fissile, friable character. What appears to be a part of the dyke assumes a nodular or pseudo-conglomerate character near Frenchman barn. In the McAdam formation, one, much altered, basic stock of small dimensions, occurs.

The Knoydart[1] *Formation* (upper Devonian of Fletcher).—The Knoydart formation extends southwestward from the Arisaig (Silurian of Fletcher) contact for more than 7 miles, measured along the fault line, and is overlain on the northwest by the Windsor group (Carboniferous limestone and conglomerate of Fletcher). The contacts with the Windsor group are frequently confused by minor faulting, but are unconformable, although a close approximation to parallelism in dip and strike is assumed, especially with the Ardness (Carboniferous limestone of Fletcher.) At the southwest the Knoydart overlies the Beechhill Cove formation of the Arisaig group, thus proving the unconformable contact with that group.

The red sandy slates and hard grey sandstones of this formation, as mentioned above, are unconformably related to all the other formations. The great fault separates them from the Browns Mountain group; unconformity, as shown by reversed dips across the contact in McAdam brook, separates them from the upper member of the Arisaig (Silurian) group, while at the southwest extremity they overlie the lower

[1] Am. Jour. Sci., Vol. XXVIII, August, 1909.
[1] Cf. Ami. op. cit.

member of the same group. As seen in McAras brook the lowest member of the Windsor (Carboniferous) group overlies them unconformably, while the same relations exist with the second member in Mill brook and farther west.

In the grey sandstones of the Knoydart formation Ami[1] found *Pterygotus, Pteraspis,* and *Cephalaspis.* These were identified by A. Smith Woodward and Dr. Henry Woodward, of the British Museum, who correlated the formation with the Hereford beds of the lower Devonian (Old Red sandstone). *Pterygotus* implies marine conditions, while *Pteraspis* and *Cephalaspis* imply brackish to freshwater environment. We may conclude then that these deposits were probably estuarine. That the final conditions were those of sub-aerial sedimentation seems probable from the sandy red slates seen higher up in the formation.

A few small diabase dykes cut this formation. The strata dip southwards at varying angles, but great flexures are lacking.

WINDSOR GROUP.

The Windsor strata extend in ascending order from McAras brook westward, transgressing older formations.

Extending from the east the McAras Brook (Carboniferous conglomerate of Fletcher) formation laps against the foot of the erosion scarp along the eastern edge of the plateau of metamorphic Browns Mountain rocks. The formation then continues southward between this plateau and its outlier, and swings away to the southwest as a narrow outcrop along the foot of the plateau erosion scarp. Immediately overlying the McAras Brook formation the Ardness formation (Carboniferous limestone of Fletcher) extends southward from near the southeast edge of the sheet. A short distance above the limestone the gypsum beds occur. Outcrops are then masked by soils and glacial gravels. Throughout the Windsor group outcrops are scarce, owing to the heavy mantle of gravels and soil. The shore and brooks alone give sections, and those of the latter are usually much interrupted.

The *McAras Brook Formation* (Carboniferous conglomerate of Fletcher) lies upon steeply eroded surfaces of the older formations. Fragments of these formations are common in the basal members, and in general, at the contacts, the underlying James River rocks are deeply stained with red. The red conglomerate is succeeded by soft, red and grey shales, with which the oil-shales occur.

The *Ardness Formation* (Carboniferous limestone of Fletcher) overlies the McAras Brook rocks conformably, wherever contacts have been examined. Thick-bedded, compact limestone, 20 feet or more in thickness, is succeeded by red and grey sandy shale, flaggy cross-bedded or nodular sandstone, etc. Along the south side of the area, a few hundred feet above the limestone, the gypsum beds appear. Their thickness and extent are masked by weathering, and stream erosion.

Brachiopods taken from the limestone west of McAras brook were identified by Professor Schuchert as *Beecheria Davidsoni,* Hall and Clarke, *(Terebratula sacculus,* Davidson), one of the characteristic and common species at Windsor. *Rhynchonella,* species undetermined, is rare, while *Productus* cf. *fasciculatus,* McChesney, is very common. *Productus cora,* as identified by Davidson, is also present, but it is not the true *cora* of upper Carboniferous time. Nearly all of these forms occur in the dolomite, at Windsor, in close association with this well known gypsum horizon of Nova Scotia. The evidence is, therefore, decidedly in favour of correlating the Ardness formation directly with the limestone and gypsum outcropping at Windsor.

With the one exception of the limestone beds, the characters of the Windsor group sediments indicate sub-aerial or shallow water origin. The uniformly oxidized condition of the conglomerate and shales, as shown by their red colour and lack of organic remains, apparently indicates either exposures to the atmosphere, and a periodic lower-

[1] Geol. Soc. Am. Bull. Vol. 12, pp. 301-312, 1901.

ing of the ground-water level during sedimentation, or such a poverty of shallow water marine life as to be incapable of deoxidizing the the sediment when it finally reached the sea. The entire absence of marine fossils in the red beds favours the sub-aerial interpretation. The white and grey sandstones, in places cross-bedded and elsewhere containing plant remains, indicate that they were deposited in shallow water near the habitat of the plants.

The limestone beds furnish evidence of marine conditions during their formation, while the gypsum horizons record the existence of isolated, shallow water pans.

The *Listmore Formation*[1] (Millstone Grit of Fletcher), occurring in a limited area along the shore, at the west edge of the sheet, consists of soft, friable reddish-brown sandstone, with thin argillaceous shale beds containing poor fossil plants. Ripple marks and cross-bedding are occasionally seen. Towards the top, the harder white sandstones are more common. In the area studied there is no apparent break in sedimentation between this formation and the Windsor group, and the same evidences of sub-aerial origin are seen as were noted in the case of the Ardness sandstones.

The Windsor formations have suffered only a slight amount of flexing. Some minor faulting has occurred, as is best seen in the three limestone beds described by Fletcher west of McAras brook, which are now known to be one and the same bed successively faulted to the northeast parallel to the shore. The dragged portions, and fault planes, are clearly exposed. The amygdaloidal trap sheets intruded between the beds of the McAras Brook conglomerate have probably been duplicated by faulting. The Listmore formation is practically undisturbed, and dips gently to the northwest.

Pleistocene Formations.—Overlying the younger formations are considerable deposits of glacial gravels. Erosion has modified these, and many isolated, rounded hills have thus been formed. The commonest pebbles are from the James River slates and quartzites, which occasionally show glacial scratches. The matrix is often of a clayey character, and a red, marly clay is frequently observed at the base of the deposits. The upper portions of the gravels are usually well sorted and bedded.

Glacial striæ were recorded in a number of cases. An average direction of the characteristic striæ is about S 10° E magnetic bearing, or S 34° E true bearing. The movement is assumed to have been southerly, but no critical evidence as to this is at hand.

Elevated Beaches and Stream Gravels.—Three elevated sea beaches occur along the shore east of McAdam brook in connexion with the modified glacial gravels, the upper surface of which, at many points, is assorted and bedded, with a gentle dip to the southwest. The highest of the three is about 120 feet above the present sea-level. The angular nature of the old sea-cliffs, and the undisturbed arrangement of their sea-washed gravels, indicate that the sea beaches are post-glacial. As already mentioned, about 6 feet of recent gravels occur along the graded portions of the streams, sometimes preserving on their surface one or more sets of meander cusps. Through these the streams are now cutting.

HISTORICAL GEOLOGY.

The geological history of the Arisaig district, as seen in surface exposures, begins in upper Cambrian time with the deposition of the Browns Mountain quartzites, slates, and conglomerates. These are the deposits of a shallow transgressing sea, which was followed by a long emergent period, with folding, intrusion, faulting, and erosion. Should the rhyolite pebbles of the Bear Brook conglomerate be correlated with the rhyolite of the Frenchman barn and Arisaig point, the extrusion of the latter rhyolite must have occurred before Bear Brook time. Later came the Arisaig (Silu-

[1] By Ells this formation is placed in the middle Carboniferous. G.S.C. Report 1885-E 7-33.

rian) formations, deposits of an invading sea, probably over the old rhyolite flows. It was a comparatively shallow water sea, as is shown by the arenaceous character of the sediments, cross-bedded sandstones, and the many ripple-marked zones in the shales. An emergent erosion interval followed.

Upon the bevelled formations of the Arisaig group the Knoydart (upper Devonian of Fletcher) formation was deposited in lower Devonian time, under estuarine conditions, as is shown by its mixed marine and freshwater fauna.

That the great fault along the Hollow preceded the Listmore deposition is indicated by the undisturbed condition of the Listmore formation (Millstone Grit of Fletcher) to the west of this district, as shown on Fletcher's map.

Beginning with the McAras Brook conglomerate, a shallow sea again invaded the area, washing the base of the emergent metamorphic rocks and transgressing the Knoydart formations (Devonian of Fletcher). Deeper water conditions followed, with a limestone making period. This is recorded in the Ardness (Carboniferous Limestone of Fletcher) formation with its Windsor brachiopods. Then followed emergence, and in the south of the area shallow water pans were formed, in which the gypsum beds were deposited due to excessive evaporation. Deposits of sandstone, probably subærial, continued to the base of the Listmore (Millstone Grit of Fletcher) formation, and then, after an erosion interval observed outside of the area under consideration, sub-ærial sedimentation again proceeded, and the Listmore sandstones were deposited. The wood and plant remains of this formation indicate freshwater conditions, and a somewhat luxuriant flora.

With the advent of freshwater sedimentation, an emergence began, which probably was a part of the closing Palæozoic uplift known as the Appalachian Revolution. From this time until the glacial period the records of the area are those of erosion.

Following the Appalachian Revolution the evidence does not go back of a period of peneplanation, with its implication of a long preceding erosion cycle. Whatever formations overlay the higher portions of the Browns Mountain (Cambro-Silurian of Fletcher) group and Knoydart (upper Devonian of Fletcher) formations were prebevelled across and reduced to a plain of low relief. That the Arisaig (Silurian of Fletcher) group and Knoydart (Upper Devonian of Fletcher) formation were previously down-faulted, and suffered the general peneplanation in approximately their present relation to the Browns Mountain group, is shown by the sub-equality in the elevation of their hilltops to the general peneplain level.

The effects of subsequent erosion on the metamorphic plateau, and along the contact scarps which bound it, are comparatively insignificant. Other data as to the age of peneplanation have not been obtained from the area.

After peneplanation, elevation took place, and before glacial time the younger formations were deeply eroded. This conclusion is based on the evidence of glacial striæ observed on Arisaig rocks about 500 feet below the average elevation of the plateau nearby, and recording a degree of differential erosion which seems far too large to assign to glacial action alone. Subsequently the glaciers scored and gently modified the plateau, sweeping away a large part of its surface debris and depositing it to the thickness of tens of feet over the low lying formations.

After the retreat of the ice, or during the retreat, elevation of the strand line of more than 120 feet occurred, as is shown by the sea beaches. This took place by at least three main stages, corresponding with the number of beaches. That water at least re-sorted the gravels higher than this is proved by bedded gravels at James river, more than 180 feet above sea-level. In recent times thin deposits of stream gravels have been laid down, and now another uplift is taking place, causing the streams to cut down.

Economic Geology.

Copper.—Copper stains have been observed, as recorded by Fletcher, in a number of localities. They are always connected with the Windsor (Carboniferous limestone and conglomerate of Fletcher) group, and generally are merely a green stain in sandstone connected with plant remains. Near Brierly brook two shafts have been sunk and a tunnel driven in the McAras Brook conglomerate. The shafts are said to be about 30 feet deep and the tunnel about 60 feet long. Copper ore is said to have been obtained from the eastern shaft, but from the material of the dump and the surrounding rock no workable deposits are to be expected.

Iron.—The interbedded, fossiliferous earthy hematite deposits of the Moydart formation (Niagara of Fletcher) have been opened up on Arisaig and Ross brooks, nearly one-half mile apart. That two outcrops occur in the latter brook may be due to faulting, for a disturbance in the strata is evident. The character of the ore is clearly that of a sedimentary deposit. Two feet three inches is an average thickness of the bed.

The James River formation has iron ore (hematite) deposits scattered widely through it. Northeast from Browns Mountain P.O. two showings of coarse grit, impregnated with hematite, have been prospected by Mr. Alex. J. McDonald. They are about one-half mile apart, and may or may not be related. Ore zones of from 5 to 20 feet have been uncovered, and assays are said to run from 22 to 30 per cent iron. Much quartz grit is seen in the ore, which grades into the country rock. The latter is usually of finer grain than in the ore zone. In the Iron Brook area isolated prospects have been opened up, but most of the ore is in the belt of three parallel leads, traced by Mr. George E. Corbitt for more than 2 miles. Older work has exposed ore, probably of the same zone, for nearly a mile farther east. The ore is a fine oolitic hematite, and grades rather abruptly into the quartzite of the James River formation. Passing northeastward, the leads are successively offset to the south by a series of faults of small throw, and ore of varying thickness is thus brought into proximity. Thicknesses of 8 feet and more have been exposed, but the average of the leads is much less. For assays, maps, etc., see J. E. Woodman's report of 1909, mentioned above.

The hypothesis of sedimentary origin is upheld by the continuity of the ore along the strike of the strata; its oolitic character; the fossils obtained correlating these deposits with the sedimentary deposits of Great Belle isle; and their pre-intrusive and pre-fault origin. The variations in thickness oppose the above hypothesis, but may find explanation in uneven shallow water deposition, and later faulting. From the above considerations the writer concludes that the ores belong to the sedimentary bedded deposits.

As the faults and dykes of the ore area tend to be vertical, less disturbance is to be expected with depth than with horizontal dimensions, but the indications are that the ore thickness is variable.

At the western end of the explored leads Mr. Corbitt had driven a tunnel more than 70 feet, to cross the ore zone, but had not reached ore when last information was obtained. The general development consists of cross-trenching and stripping.

Oil-shale.—Little information is to be had in this area as to oil-shale. Pits expose a good appearing, shiny, black shale in the neighbourhood of Maryvale, and the flat structure of the formation would indicate wide extent.

Gypsum.—The thick deposits of gypsum along the south border of the district are visible to all who travel on the Intercolonial railway. That they are extensive, and of good quality, is evident, and development only awaits a sufficient demand for the raw material.

Limestone.—A good quality of limestone for burning purposes is obtainable near Brierly brook, near Antigonish town, and in many places along the limestone horizon.

GOLDBEARING SERIES OF LAHAVE BASIN, LUNENBURG COUNTY, NOVA SCOTIA.

E. Rodolphe Faribault.

INTRODUCTION.

The field work of the past season, 1910, was directed to a continuation of the geological and topographical mapping of the goldbearing series of Nova Scotia. The area surveyed during the year covers the upper part of the basin of Lahave river. It extends northward from Bridgewater up to the old Dalhousie road, and comprises the northwestern part of Lunenburg county and small portions of Annapolis and Kings counties. This completes the surveys and other field work necessary to finish the Springfield sheet, No. 86, and the eastern part of the New Germany sheet. No. 85, of the series of the Nova Scotia map sheets.

My assistants were Messrs. J. McG. Cruickshank, and W. J. Wright, for the whole season, and D. S. McIntosh and M. H. McLeod for a part of the season. Field work was commenced on June 4 and continued up to the end of October

Leaving my party at work in the field in the middle of July, I was engaged for a little over two months in the Chibougamau mining region, Quebec, as one of the commissioners appointed by the Quebec Government to report on the geology and mineral resources of that region; my services having been loaned by the 'Survey', to the Quebec Government, for this purpose. I again joined my party in Nova Scotia at the end of September, and continued field work until the end of the season.

Three visits were paid, in June, October, and December, to the tungsten deposit at Scheelite, near Moose River Gold Mines, Halifax county, already reported on at some length, in the Summary Reports of the last two years. These examinations were made for the purpose of assisting the Scheelite Mines Company in planning the development work then in progress, preparatory to immediate exploitation. At the last visit the survey of the mine was brought up to date, in order to perfect details of the structure of the veins, and to locate the mine workings on the plan started last year. A copy of this plan was furnished the Company for their information. The additional information gained this year confirms the conclusions published in last year's Summary Report regarding the probable structure of the veins and ore-shoots, the existence of an important fault, and the best method of development to follow for exploitation.

CHARACTER OF THE DISTRICT.

The district surveyed presents the appearance of an undulating plain gradually rising from the sea northward, until at a distance of from 30 to 40 miles it attains elevations of 700 to 800 feet along South mountain, which forms the height of land between the Atlantic and the Bay of Fundy. Everywhere, may be seen the evidence of the action of vigorous erosion, which has resulted in the formation of hills and depressions which have a general southerly trend, bearing a little eastward towards the sea. The district is largely drained by the main Lahave river, which flows in a narrow valley on an almost straight course to the sea. The waterway is a succession of small lakes, stillwaters, rapids, and falls, and has a total descent of over 500 feet in the 27 miles between the old Dalhousie road and the head of tide at Bridgewater. The principal tributaries are, from the east, the North Branch and North river; and from the west, the West Branch, and West or Ohio river. The North Branch drains

Sherbrooke or Ninemile lake, which is 7¼ miles in length, and lies 454 feet above mean sea-level. These streams afford several important water-powers, a few of which are being partly utilized. The district is also intersected by numerous small streams, lakes, and stillwaters.

The intervals betweeen the hills are in many cases occupied by swamps and marshes, and in some instances by peat-bogs; or they form rocky barrens which afford good rock exposures; or are strewn with granite boulders and debris derived from the north. Many of the hills are of glacial debris, and seldom rise more than from 100 to 200 feet above the general level of the country. Most of these hills are well-defined, oblong, dome-shaped drumlins or long, lateral moraines of boulder-clay and till, having a general north and south trend. Terminal moraines largely made up of granite debris, and running east and west, are also represented, as in the case of the hill to the south of Menamkeak lake.

Part of the upland affords good soil for agricultural purposes, and where it is not already settled is covered with hardwood forest. The greater part of the back country is well wooded with a fine growth of spruce, pine, and hemlock, as well as hardwood; and extensive lumbering operations are carried on, principally by the Davison Lumbering Company, to the north of the old Dalhousie road. This Company operates 33 miles of railway, over which the logs are hauled to their saw-mill at Springfield; whence the lumber is carried over the Halifax and Southwestern railway to Bridgewater, for shipment by sea. A pulp-mill is also in operation at New Germany.

The Middleton and the Caledonia branches of the Halifax and Southwestern railway run through the district, and give daily communication with Halifax and Yarmouth.

GEOLOGY.

The greater part of the district is underlain by the quartzites and slates of the Goldbearing series; but towards the north and northwest these rocks are cut by granites of Devonian age, which extend northward across South mountain to the Annapolis valley, and form part of the very large granite area which constitutes the backbone of the western counties of the Province. A small isolated mass of greenish grey granite was located far away from the main area, at a place situated 2 miles east of Italy Cross station, and one-fourth of a mile north of the outlet of Wallace lake. At this locality, a recent conglomerate has been prospected for gold.

In the absence of fossils and other conclusive evidence, it has been customary to provisionally refer the Goldbearing series to the lower Cambrian, though on account of their similarity to the quartzites and slates of the Avalon peninsula of Newfoundland, which have been assigned to the Pre-Cambrian, as well as for other reasons, it is possible that they may be Pre-Cambrian.

The series as exposed in different parts of the Province has been estimated to have a total thickness of over 5 miles. This great series of rocks falls naturally into two lithologically distinct conformable divisions: a lower one, called the Goldenville quartzite; and an upper one, called the Halifax slate.

The Goldenville division is mostly made up of thick beds of grey, altered quartzose-sandstone or quartzite, locally called "whin"; interstratified with beds of dark clay slates, which are quite numerous at certain horizons, but almost wanting at others, especially at the top of the division. At many places, and more especially near granite intrusions, these rocks are much altered, and have become schistose, with a development of very minute scales of mica along the planes of schistosity, which gives them a characteristic glistening appearance when split. The Goldenville division has a thickness of over 3 miles of strata in the eastern part of the Province.

The Halifax division is composed entirely of argillaceous slates, in some cases arenaceous, and with occasional flinty layers holding iron pyrites. Dark grey layers occur sparingly, and are sometimes found to be slightly calcareous, especially when occurring at the base of the division. The lower beds are olive green in colour, and are followed by others of dark grey colour which gradually give way to a great thickness of glistening bluish-black, foliated, graphitic, soft clay slates, often pyritous, overlain by banded, black and grey arenaceous slates. The thickness of the Halifax division has been estimated at over 2 miles of strata.

After their deposition these sedimentaries were uplifted and folded into a succession of anticlines and synclines following northeast and southwest courses. They were then subjected to extensive erosion, which removed the upper part of the folds and gradually planed the surface down to its present attitude, exposing the edges of the uptilted, once deeply buried strata. The rocks, generally, dip at high angles, ranging from 45° to 90° from the horizontal.

In view of the intimate relation existing between the structure of the anticlinal folds and the occurrence of the gold-bearing quartz veins, special attention was paid to the location and structure of the anticlines and synclines. A section across the folds along Lahave river from Bridgewater to the old Dalhousie road gave a succession of five major anticlines and synclines in a distance of 25 miles. Minor folds were also observed along the crest of some anticlines, especially for the first 4 miles above Bridgewater, where the strata have been plicated into a succession of small folds or undulations. Going up Lahave river the five anticlines are met with in the following order from south to north:—

(1.) *Leipsigate Anticline* crosses the river at Bridgewater where it is composed of several minor folds in slate well exposed along the west side of the river. These folds converge westward as they approach the Leipsigate gold district, where they join and form a broad dome along which the Goldenville quartzites are brought to the surface and extend to the west. The most southerly of the minor anticlines extends eastward through the Blockhouse gold mines where the Goldenville quartzites are again brought to the surface on a smaller elliptical dome one mile long by a quarter of a mile wide. From these two domes situated, respectively, west and east of the river, the anticline pitches towards the river, forming a cross syncline which is strongly marked and extends north and south along the river, affecting the other folds similarly but to a less degree.

(2.) *Spondo Anticline* crosses the river 4½ miles north of the first anticline and half a mile south of Mossman station. It extends eastward to the granite, passing the south end of Big Mushamush lake and through the Spondo gold prospect, where a large saddle-shaped vein has been uncovered. Westward, it crosses Wile and Fire lakes south of Baker settlement. It shows nothing but slate along its whole course. A minor anticline between the above two anticlines was located in grey slate at Waterloo, where it crosses Frederick and Matt lakes, but it could not be traced eastward to Lahave river on account of the drift.

(3.) *Northfield Anticline* crosses the river at Northfield station 3 miles north of the second anticline. Traced eastward it crosses the north end of Big Mushamush lake and continues through Caribou lake where the slates are superseded by the quartzites which are brought up to the surface along a broad dome extending to the granite. West of the river the anticline passes near Clifford post-office where it converges with the adjoining north syncline in dark grey slate.

(4.) *Pleasant River Barrens Anticline* is situated 4½ miles north of the third anticline, and crosses the river at an island 2¼ miles north of Riversdale station, where the lower quartzites appear at the surface on a westerly plunge of the fold and spread out towards the east beyond Newburn and New Cornwall to the granite. It crosses the outlet of Indian lake and the north end of Church lake where numerous cross veins and a few interbedded veins have developed. West of the river the quartzites are overlain by the upper grey slates on the transverse syncline which is here strongly marked;

but, a short distance farther west, the quartzites again appear at the surface on a broad elliptical dome, on the eastern end of which the gold mining district of Pleasant River Barrens has been located.

(5.) *Cherryfield Anticline* occurs at a distance of 9½ miles north of the fourth anticline where it begins at the granite contact on the main river, directly east of Cherryfield station, and extending eastward, crosses the Sarty road at the school house and the Sam Moore road half a mile south of the bridge over North river, and ends at the granite, 3 miles farther east. This anticline brings to the surface lower beds than any other fold in the district, exposing at the surface a thickness of 2½ miles of the Goldenville quartzite, which extends southerly for 3½ miles to the Halifax slate, and northerly beyond the next syncline to the granite along the old Dalhousie road. The strata dip at angles increasing from 25° to 80° on the south side of the anticline, and from 25° to 65° on the north, and appear to form a very narrow dome near the Sarty school house, where quartz veins have been uncovered.

Some interesting granite contacts are well exposed at a few points along the boundary line, one of which may be observed at Dog falls on the west side of Lahave river, below the bridge, half a mile north of Cherryfield station. As a general rule the quartzites are altered quartz-mica schists, but the strata show no local disturbances as a result of the granite intrusion.

Evidence of dislocation and faulting has been observed, however, at many places, especially in the vicinity of large projections of the granite into the sedimentaries, but the disturbances are apparently the result of movements that took place subsequent to the irruption of the granite. At Upper New Cornwall—between Otter lake, the northeast end of Big Mushamush lake, and the south end of Church lake—the strata are much disturbed, and there is probably an important fault running northerly in the direction of Union Square, Morton Corner, and Sarty, along which the western block has moved south with reference to the east one. Towards the south, this fault probably runs along the eastern shore of Big Mushamush lake and passes through Slaughenwhite island and Farmville towards Blockhouse. Along this course much brecciated country rock and quartz is shown. The cross veins operated at Blockhouse are probably a zone of fractures on the southern extension of this fault.

Economic Geology.

GOLD.

Leipsigate Gold District.—Two gold mining districts, Leipsigate, and Pleasant River Barrens, are situated in the area surveyed. A detailed survey of Leipsigate was made in 1904 and a report on that district was included in the Summary Report for that year, pages 321-329, together with a plan on the scale of 500 feet to 1 inch, published separately. After 1904, operations were continued until 1908 on the Micmac fissure vein by the Mimac Gold Mining Company, and a depth of 596 feet has been attained. When in operation the Micmac mine proved a good producer, and there is every reason to believe that under good management it should still continue to yield well. In 1905 and 1906 some work was also done at the Owen mine on the same vein. A little prospecting was done in the northern part of the district by Simeon Erust and others, but no important discovery has been made since the survey of 1904.

Pleasant River Barrens Gold District.—The district is situated in Lunenburg county, on the Pleasant River road, 15 miles north of Bridgewater, between Rhyno and Shingle lakes, on the eastern end of a broad elliptical dome of quartzites, which is 4 miles long by 2 miles wide, and is surrounded and overlaid by the slates of the Halifax division. The auriferous quartz veins occur at the outer edge of the dome in slate layers interstratified between thick beds of quartzite (which often stand out prominently and form a succession of parallel ridges with intervening swales) curving gradually around the eastern part of the dome and dipping towards the southeast, east, and northeast at angles of 20° to 40°. The district has been idle for the last twelve years, hence only a cursory examination could be made of the old workings. Several veins have been uncovered, a few of which have been developed, but none of them have been exploited, except to a limited extent. The more important veins are the Dunbrack, Mill, Pine Tree, Brignell, Ernst, and Bent leads. A specially rich but narrow pay-streak was worked for a short time on the Dunbrack lead at the intersection of an angular vein dipping north 60°. One fissure or cross vein, was also discovered by James Deal, crossing the strata in a southwesterly direction. Most of the work was done in the eighties and nineties, and three stamp-mills are reported to have been erected.

On the east side of the river, gold-bearing veins have been uncovered and prospected at several places, but the results obtained appear to have been unsatisfactory. The most important veins developed are the following:—

On the southeast side of North river, 2 miles east of Meisner post-office and three-fourths of a mile east of O. Acker's house, a vein was discovered in 1892 by Thomas Acker, and worked by a Windsor company to a depth of 40 feet; a five-stamp mill was built and 60 tons of ore crushed, but the prospect was finally abandoned. The vein is 1 to 10 inches thick, dips north 78°, and is interbedded in altered quartzite, in contact with the granite. In 1909 a few other parallel veins were prospected by David Lawrence.

At Upper New Cornwall, at Rocky point on the northeast shore of Big Mushamush lake, two veins were opened in or about 1888 by Freeman Millet, in slate between walls of quartzite. On the north vein there is a pit 21 feet deep, and on the south one, two pits 24 feet deep, but the whole prospect is now flooded by the lake.

Farther north, half a mile south of Indian lake, on the east side of the road, a vein 12 inches thick cutting across the quartzite was prospected by W. H. Prest with two shafts 25 feet deep, and some ore was crushed at the Blockhouse mill. Numerous other cross veins have been located between this prospect and the foot of Indian lake along the fault passing in this vicinity. Ore-shoots may possibly occur at the intersection of some of these cross-veins with the interbedded veins which are found along the Pleasant River Barrens anticline at the foot of Indian lake and the north end of Church lake.

COPPER.

Over twenty years ago, at Dalhousie East, Kings county, situated 10 miles northeast of Springfield station, on the west side of Crossburn road and three-fourths of a mile north of Old Dalhousie road, a shaft was sunk to a depth of 165 feet on a copper-bearing vein in granite. At the surface the vein appears to strike S 25° E magnetic, and dip vertically. Samples picked up at the mouth of the shaft show the ore to be chalcopyrite and chalcocite in a gangue mostly composed of granite and quartz. An analysis of the samples made at the Mines Branch gave 1·05 per cent of metallic copper, but did not show the presence of gold, silver, nickel, tin, or tungsten, for which elements they were tested. Irving Smith, who occupied the farm on which the shaft was sunk, and also worked at the mine, furnished the following information: The vein was discovered about the year 1876 by Ainslie Wilson, and the shaft was started in 1890 by a Bridgewater company. The shaft measures 14 by 8 feet, is 165 feet deep, and is timbered to a depth of 100 feet. At the cropping the vein was 12 inches wide, and proved rich to a depth of 20 feet, where large crystals of quartz were found, after which it decreased in size and value, and at the depth of 100 feet it began to dip towards the east, and its size became less than 2 inches. At a depth of about 20 feet, a drift was driven 12 feet one way and a few feet the other. The vein has not been traced at the surface, because its outcrop is probably of very limited extent; as in the case of the King vein at Lake Ramsey, near New Ross. Drift of similar ore is reported, however, to have been found half a mile farther north in the direction of the vein, half way between Irving Smith's present house and Sixtymile lake, where also traces of copper were found on an outcrop of granite.

IRON OCHRE.

A deposit of yellow and red ochre was found at Auburndale, along Heckman brook, on the west side of Lahave river, and 4 miles north of Bridgewater. The deposit is said to be 1 to 2 feet thick, and 50 tons taken from John Penney's farm were shipepd to Halifax in 1908.

WHETSTONE.

A quarry of slaty rock suitable for the manufacture of whetstones was opened in 1901 by George McFaden of Bridgewater, at Parkdale, Lunenburg county, at the outlet of Whetstone lake, 9 miles northeast of New Germany. The rock is composed of beds of hard, greenish, grey, siliceous and argillaceous slate, occurring at the base of the Halifax slate division; the strata dips south at an angle of 75°. After about two years operation, McFaden sold the quarry to a Maine company, which continued operation for a short time, and erected a building for machinery, which, it is said, never reached the quarry on account of financial difficulty. The quarry is now 3 to 6 feet deep, 12 feet wide, and 25 feet long.

TIN AND MANGANESE AT NEW ROSS.

At New Ross, Lunenburg county, some distance east of the district surveyed last summer, two important veins, one bearing manganese and the other tin and copper, were opened last summer.

A vein of manganese recently discovered by Ernst Turner in granite, 2 miles to the north of Wallaback lake, and 8 miles north of New Ross, has been opened by a Windsor company, under Dr. H. W. Cain's management, with a shaft to a depth of 145 feet; and it is reported, with very satisfactory results. The vein varies in width from 4 to 18 inches and dips nearly vertically. The ore, which carries streaks of red hematite near the surface, is found to be exceptionally free from iron at a lower depth. An assay of some samples gave only 0·1 per cent of iron, with 5 to 6 per cent of carbonate of baryta. A similar vein of manganese, occurring at a distance of 1¼ miles to the south, was exploited a few years ago by Dr. Cain, but has not yet been reopened.

A tin-bearing vein, also recently discovered by Ernst Turner, at Mill Road, 4 miles north of New Ross, has been prospected under the management of A. L. McCallum. It has been proved to a depth of 20 feet, and for a length of 250 feet, while the float has been traced half a mile towards the north. The vein is 24 inches wide, mostly made up of quartz, merging with granite at the sides, and carries at the middle a streak of rich ore from 3 to 5 inches wide. Several assays of the ore made by Mr. McCallum have given from 10 to 30 per cent tin, and 8 per cent copper, present in the form of cassiterite and chalcopyrite, with association of tungsten-bearing and zinc minerals. Several other veins occurring in this vicinity, and showing copper, molybdenite, etc., have not yet been prospected.

TUNGSTEN.

A new discovery of tungsten ore, in the form of scheelite, has been made by W. H. Prest, at Middlefield, Queens county, near the Fifteenmile Brook gold mine, and prospecting was started last fall in order to trace the float to the parent vein.

WATER AND BORING RECORDS.

(*E. D. Ingall.*)

During the past year the work of collecting records of deep wells was continued substantially along the lines originally adopted: by correspondence, following information as to borings, obtained through newspaper or other channels. Whenever time permitted, letters were written; as personal correspondence was found best in the opening of negotiations for the desired co-operation of those in control of operations.

Having obtained promises of samples and information from drillers and operators, constant watchfulness is found necessary, as well as further correspondence, in order to ensure, in many cases, the acquisition of complete sets of samples, and other data. It is important to get notification of the cessation of boring operations, or even of their temporary suspension; as great confusion arises in attempting to keep in touch with boring operations over the whole of Canada, unless the drillers keep the Geological Survey officer in charge promptly posted. Ready-addressed, postage free notification cards, for reducing the work entailed upon the driller to a minimum, are always sent out, and it is hoped, as the value and needs of this work become better known, that the methods of co-operation may continue to improve.

Accompanying requests to drilling operators, for co-operation, as well as in response to requisitions received at the Geological Survey, bags, etc., for the return of drillings samples have been sent out.

In all work which must be done by correspondence, it has been invariably found, that but a small percentage of the circulars or letters sent out bring replies. Naturally, with people busily engaged in commercial enterprises, any effort entailed without prospect of immediate personal gain is apt to evoke only slight and intermittent response. Then too, professional men are apt to hesitate before giving for public use, information upon the exclusive possession of which their success largely depends. It is all the more gratifying, therefore, to have met with considerable response in the form of full sets of drillings and particulars, from a number of operators of important deep wells in various parts of the country.

Amongst these may be mentioned two deep wells which were drilled in the eastern Ontario Palæozoic basin—at Plantagenet, and Carlsbad Springs. Both these were bored in hopes of proving workable pools of gas or oil. The first named penetrated to the top of the Potsdam, and the other is yet in progress. The information regarding these two wells—together with that previously obtained of wells located near Ottawa, and at Chesterville, and Monklands—should give important results when the final and careful working out of the logs, lithologically and palæontologically can be accomplished. With this end in view, a number of short trips were made in the Ottawa district—in company with Dr. Percy Raymond—Invertebrate Palæontologist to the Survey—in order to acquire a better acquaintance with the detailed features of the geological column as shown at various points in the escarpments developed along the Ottawa River valley. A number of these sections, as measured by Dr. Raymond, have been prepared by him for publication.

The only other field work consisted of a trip to Farnham, Quebec, in connexion with two deep borings put down by the Militia Department, in search of water for the supply of their camp at that place. It was thought possible that some data might be found in the district throwing light upon the structural geology, and consequently upon the chances for a water supply, and that there might be some visible evidence of fracture effects in connexion with the Great Champlain fault, believed to pass a few miles to the eastward. It was found, however, that the covering of drift practically masked all such, hence the drilling had to be located without them, and, unfortunately, the experiment was without practical result.

A like experiment to the foregoing was prosecuted by the Militia Department, at Longueuil Barracks, near Montreal; but although interesting geological data were obtained, this well also proved unsatisfactory from an economic standpoint.

Through the efforts of Mr. J. A. Dresser, of the Survey, a partial log was obtained from the boring at St. Barnabé, near St. Hyacinthe, in the Eastern Townships of Quebec. This hole is of especial interest, having proved the existence of a pool of natural gas under a fair pressure. Particulars of the results of a hurried examination of this district will be found in Mr. Dresser's preliminary report on page 218.

The technical problems which arose in connexion with the above-mentioned wells entailed considerable research into the geological literature relating to the region, the structural features and varying thicknesses, and lithological characters of the formations. The need of further data, whether gained through borings or by a continuation of the field research already made, is constantly brought to mind in this connexion.

Owing to the liberality of Dr. Henderson of the Maritime Oilfields Co., there has been added to our official records, a very full set of logs of the 15 wells bored by that Company near Moncton, New Brunswick, the locations of the holes being also marked on a map. Sets of samples of drillings from these holes have also been donated. Later, when opportunity presents itself to thoroughly work out the data available in this group, results of importance to a further understanding of the intricate geology of this district should accrue.

The public interest in borings for gas and oil in the northwestern provinces has been very prominent of late years, and sets of drillings have been acquired from a number of points scattered over that extended region.

A function of the Water and Borings Division that is receiving growing recognition is that of preparing technical memoranda in answer to the inquiries of operators regarding geological conditions and economic possibilities for gas, oil, or water, in various parts of the country where boring work is contemplated. The needs of the various and quite numerous inquirers have been met, as far as possible; the necessary investigation of the very extensive technical literature, on their behalf, occupying a very considerable portion of the time available for the routine work of the branch.

Considering the time and funds available for the collection and interpretation of boring data, and for rendering assistance and advice in furtherance of this branch of the country's exploratory activities, the results attained are quite encouraging, and give hope of an extension of usefulness in the future, as the operators are reached, and a wider appreciation established amongst them of the need and value of the work

SECTION OF MINERALOGY.

(Robt. A. A. Johnston.)

The work performed in this section has been of the same general character as that of previous years. Nearly 600 specimens have been received, examined, and reported upon, and in addition, detailed examinations have been made of a number of interesting minerals, the results of which are given hereunder.

HEXAHYDRITE, A NEW MINERAL.

The material which forms the subject of the following note was forwarded to the Geological Survey by Mr. F. Sones, Gold Commissioner at Clinton, British Columbia, with the information that it had been found on the east coast of Bonaparte river, about half-way between Cargill and Scottie creeks, in the district of Lillooet, British Columbia. The sample was made up of two specimens, one of which, measuring 4 inches in length by 2 inches in thickness, consisted of the mineral about to be described along with some scattered remnants of decomposed rock matter; the other specimen, a much larger one, consisted for the most part of decomposed rock matter of a character like that just mentioned. It has a schistose structure, but it has so far decayed that its original composition is completely obscured and little more than a residue of silica remains. It is not at all unlikely, however, that the original of this rock has furnished the basic constituent of the associated mineral.

The mineral occurs in the form of seams and scattered patches in the altered rock matter just described. Some of these seams attain a thickness of nearly half an inch. In general they present a moderately coarse columnar structure; occasionally, however, the mineral is seen to assume a delicately fibrous form. In the material at hand no distinct crystals have been observed, and the cleavage, although clearly prismatic, is not very well defined. The mineral is readily friable, and breaks with a fine, subconchoidal fracture. It has a pearly lustre, and its colour is white, modified by a delicate green tint; it is opaque even on very thin edges, and has a bitter, saline taste.

Before the blowpipe, on charcoal, the mineral swells and emits bubbles of vapour, but does not melt, and ultimately leaves an infusible mass, which has no effect on moistened turmeric paper. When moistened with a solution of cobalt nitrate and reignited the mass becomes pink. In the closed tube it yields a large amount of water which reacts neutral to test papers. It dissolves readily in cold water, yielding a clear solution; after addition of ammonium chloride this solution does not give a precipitate with either ammonia or ammonia carbonate, but when a solution of sodium phosphate is added to the ammoniacal solution a copious white precipitate of ammonium-magnesium phosphate is thrown down. The aqueous solution when acidulated with hydrochloric acid gives, with barium chloride, an abundant white precipitate of barium sulphate.

The specific gravity of the mineral, at 15° 5 C. was found to be 1·757, and an analysis of selected material, which however still contained some included silica, gave the following results:—

Sulphur trioxide	34·52
Magnesia	17·15
Water	46·42
Insoluble matter (silica)	1·78
	99·87

Omitting the included silica it will be found that the composition of the mineral agrees very closely with that required for the hexahydrate of sulphate of magnesium, $MgSO_4 6H_2O$, which hitherto has only been known as a product of the laboratory. The agreement will be made plainly evident by a reference to the following figures, in which column I. represents the composition of the mineral under discussion, and column II that required by theory for the normal hexahydrated salt:—

	I	II
Sulphur trioxide	35·19	35·09
Magnesia	17·48	17·54
Water	47·33	47·37
	100·00	100·00

As this is the first instance in which this salt has been recorded as occurring in a state of nature, this substance is entitled to be regarded as a new mineral, and the name hexahydrite is proposed for it, in allusion to the six molecules of water which enter into its composition.

AWARUITE, ALMANDITE, AND MAGNETITE.

(1.) In the Summary Report of the Geological Survey for 1908, page 168, reference was made to a specimen of nickel-iron alloy found in the sluice boxes of the gold washings of Hoole cañon, Pelly river, Yukon. At the time of writing the report

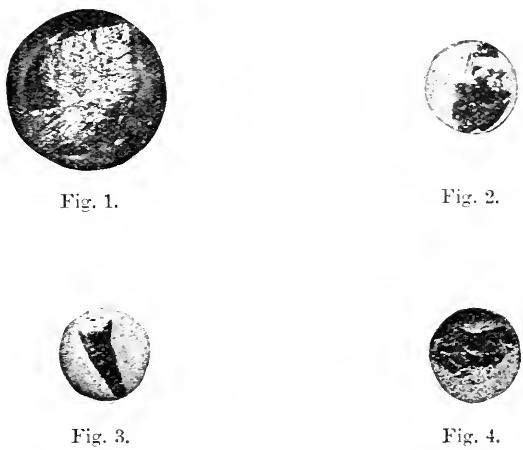


Photo by Miss W. K. Bentley.

Fig. 7. Grains of Awaruite from Hoole cañon, Pelly River, Yukon. Magnified 6 diameters.

mentioned, the examination of the specimen was incomplete and the term ferro-nickel was applied to it provisionally. The complete examination now warrants its being placed definitely under the species awaruite. It was found amongst the heavier materials carried down in the sluice boxes of the locality mentioned, and attracted attention by reason of its inertness towards the amalgam plates used for the extraction of the gold. It was thought that it might possibly be platinum.

As received by the writer from Mr. Joseph Keele, of the Geological Survey, who submitted it for examination, it constituted only a fraction of one per cent of the concentrates, which, with the exception of the mineral under consideration and a few quartz grains, consisted of fine grains of magnetite, and a pale reddish garnet, which on close examination has proved to be almandite.

The awaruite is in the form of irregularly shaped grains, a very few of which simulate an octohedral form. Some of the grains are more or less flattened, and at times show an indistinct lamination. A few are elongated into wire or rod-like forms, while others are cone-shaped. Few of the individual grains exceed a millimetre in diameter, while the majority are much smaller. The largest grain observed had a diameter slightly in excess of two millimetres. Some of the rod-like forms had a length of three millimetres, with a thickness of much less than a millimetre.

In order to determine the presence or absence of a definite crystalline structure a few of the larger grains were mounted in sealing-wax and ground with emery on a glass plate until they showed well polished surfaces. These were then exposed for intervals of fifteen minutes to the vapours of dilute nitrohydrochloric acid. By this means the progressive action of the acid vapours could be conveniently observed. At first several series of concentric rings were developed, and as the corrosive action progressed it could be seen that the grains were made up of a number of minute particles, each of which enclosed a nucleus of a white siliceous material, thus indicating a sort of sporadic structure for the individual grain.

The grains as they occur in the sand have a pale yellowish tarnish, which is easily removed by agitation and rubbing in alcohol, revealing a steel-grey colour as that of the mineral. They are malleable and under the hammer readily flatten into thin scales, and are somewhat sectile, yielding rather readily to the impress of an ordinary steel knife-blade. They are also strongly magnetic, and occasionally exhibit marked polarity, not only clinging together, but also to the grains of magnetite with which they are associated, as well as to articles of steel with which they may be brought into contact. Hydrochloric acid acts on the mineral, but slowly even on warming; but with dilute nitric acid the mineral readily passes into solution, even in the cold.

The specific gravity of the mineral, at 15·5° C, was found to be 7·746, while the composition was found to be as follows:—

Nickel	74·34
Iron	21·35
Cobalt	1·34
Copper	0·48
Phosphorus	0·08
Sulphur	0·03
Insoluble matter	1·72
	99·34

After deducting the insoluble matter the centesimal composition of the alloy is found to be as follows:—

Nickel	76·16
Iron	21·87
Cobalt	1·37
Copper	0·49
Phosphorus	0·08
Sulphur	0·03
	100·00

Magnetite.—In view of the association of magnetite with the awaruite it became of interest to determine whether the former might or might not contain metallic constituents other than iron. Accordingly 2·75 grammes were submitted to examination, but no unusual constituent was found to be present. The specific gravity of the magnetite, at 15·5° C, was found to be 5·065.

Almandite.—The almandite, with which the awaruite and magnetite just described are associated, is in the form of minute angular grains, frequently rounded on the edges. They have a pale reddish colour, and vitreous lustre. They were found to have a specific gravity of 3·991, at 15·5° C, and on analysis to possess the following composition:—

Silica	37·7
Alumina	21·1
Ferric oxide	2·4
Ferrous oxide	31·9
Manganous oxide	1·5
Magnesia	5·1
Calcium monoxide	none
	99·7

AXINITE.

(2.) The material for this analysis was collected by Mr. Charles Camsell of the Geological Survey, at Nickel Plate mountain,[1] Osoyoos mining division, Yale district, British Columbia, during the season of 1908, and was referred to in the Summary Report for that year at page 168. It occurs on the western slope of the mountain, in the form of dark hair-brown crystals and crystalline masses at the contact between monzonite and sedimentary beds.

This material was selected with great care, and consisted entirely of small fragments of crystals free from any associated minerals. These fragments were subtranslucent and possessed a highly vitreous lustre; they were found to have a specific gravity of 3·296, at 15·5° C, and on analysis to possess the following composition:—

Silica	42·18
Boron trioxide	5·22
Alumina	18·12
Ferric oxide	0·98
Ferrous oxide	7·20
Manganous oxide	3·89
Zinc oxide	0·09
Calcium monoxide	19·91
Magnesia	1·43
Water	0·35
	99·37

Mr. R. L. Broadbent has been occupied throughout the year solely in museum work. Much of his time has been taken up with the listing and packing of the mineral collections preparatory to removal to the Victoria Memorial Museum, matters which have demanded the utmost care and vigilance.

Very considerable additions have been made to the Canadian and foreign collections in the mineral section of the Museum, as will be seen from the accompanying lists.

ALTERATION PRODUCT AFTER AMPHIBOLE.

(3.) At various times recently there have been brought to this office for examination and report, from different localities in the Gatineau valley, in the Province of Quebec, specimens of waxy or clay-like alteration products, all bearing, in outward characters at least, a very close resemblance to each other. They also appear, as far

[1] For a full description of this occurrence see Memoir No. 2, Geological Survey Branch, Department of Mines, Canada, page 148.

as could be determined from qualitative chemical analysis, to be of nearly identical chemical composition. In most cases, however, the material was either too small in amount or too impure to admit of quantitative examination.

The specimen below referred to was brought to this office for examination by Mr. W. A. McIsaac, and was collected on property belonging to Mr. P. Lannagan, situated in the township of Egan, Ottawa county, Que., about 15 miles northwest of River Desert post-office. As previously indicated, however, similar material has been noticed elsewhere in the district, particularly in the townships of Aylwin and Wright.

The material is closely associated with and very generally mixed with more or less very dark green or greenish-black amphibole, from which it has undoubtedly been derived by alteration; the amphibole and its derivative occur in scattered patches in rocks composed of coarse masses of white quartz and feldspar.

It has a characteristic wax-like texture and slightly soapy feel, and adheres strongly to the tongue; the colour, which is uniform throughout, is a pale yellowish-grey.

Before the blow-pipe it fuses with great difficulty only on thin edges; in the closed tube it yields a large amount of water, and with no perceptible change in the colour of the material. It is decomposed with separation of gelatinous silica by dilute hydrochloric acid, even in the cold.

Its specific gravity, at 15·5° C, was found to be 2·162, and after deducting 5·31 per cent of admixed unaltered amphibole its composition was found to be as follows:—

Silica	42·76
Alumina	4·32
Ferric oxide	2·57
Calcium monoxide	1·92
Magnesia	25·30
Water	23·13
	100·00

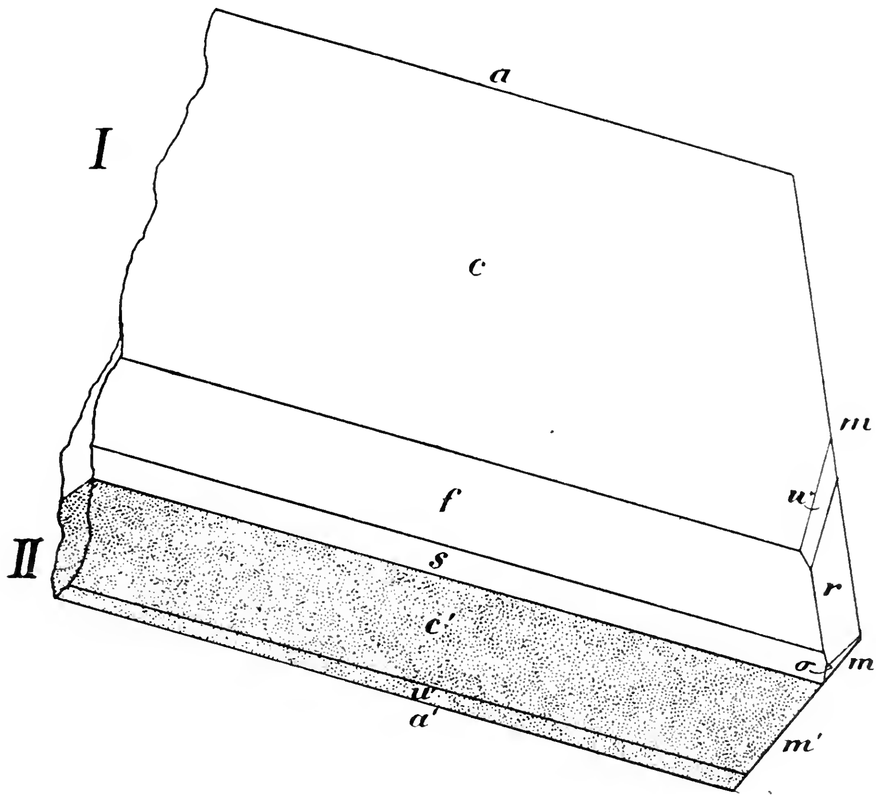
The above composition agrees closely with that of saponite, to which species the material is probably referable, although it displays some inconsistencies in respect of its behaviour before the blowpipe, and with reagents.

LINARITE.

(4.) Some very fine specimens of this mineral were collected by Mr. O. E. Leroy, of the Geological Survey, during the season of 1909, at the Beaver group, Beaver mountain, Slocan, West Kootenay, British Columbia. It occurs, along with anglesite, in individual crystals and in crystal groups, along the walls of cavities in an ore body consisting of coarsely crystalline galena and chalcopyrite. Some of the crystals attain a length of nearly half an inch; one very perfect one has been the subject of crystallographic investigation by Professor V. Goldschmidt, of Heidelberg, Germany, and Professor W. Nicol, of Queens University, Kingston, Ontario, the results of which are inserted below. The crystals have a vitreous lustre and a deep azure blue colour. Some of the thin tabular forms are subtransparent.

The specific gravity, at 15·5° C, was found to be 5·23, and the chemical composition as follows:—

Lead sulphate	75·17
Cupric oxide	19·88
Water	4·73
	99·78



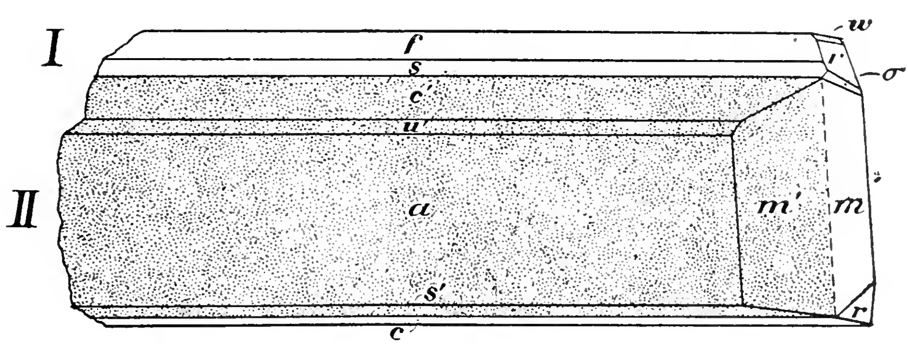


Fig. 5.

Drawn by W. Nicol.

Fig. 7.—Crystal of Linarite, Beaver Group, Beaver Mountain, Slocan, West Kootenay, B.C.

The measurement was carried out under the direction of Prof. Goldschmidt, in Heidelberg, and the drawings were made by Prof. Goldschmidt's assistant, Mr. R. Schroeder.

It is probable that these linarite crystals are the first from a Canadian locality to be described. They rest in a cavity surrounded by galenite, copper pyrites, and the decomposition products of these, viz., limonite and anglesite. Since it was not permissible to remove the crystals from the mass, it was necessary to carry out the measuring operations *in situ*. This was satisfactorily accomplished on the two-circle goniometer.

An almost perfect crystal of the dimensions 3 × 2 × 6 mm. was measured. The beautiful blue crystal which is elongated in the direction of the orthodiagonal rests with the end of the ortho axis protruding from the druse and presents, therefore, a prismatic habit. The other crystals in the druse possess the same habit. The crystal is a twin according to the well known twinning law for linarite, viz., twinning-plane and combination face, the front pinacoid a =∞ 0 (101). Fig. 1[a] shows a top view of the crystal and fig. 1[b] a perspective view. The faces are drawn to correspond as nearly as possible with the original crystal.

The individual I (behind in the figure) is larger and richer in faces than the individual II (in front). Both meet in a very flat reentrant angle formed by the faces s=o (001) of individual I and ć= − 10 (¯101) of the individual II. The angle s a ć measured, is 2° 8′ (calculated 2° 34′). The plane of junction of the two individuals is plainly visible as a fine sharp line indicated in the figure by dotted lines.

OBSERVED FORMS.

Letter	s	a	m	σ	u	f*	c	r	w
Symbol	o	∞o	∞	02	+10	$-\frac{1}{4}$o	−10	−1	$-1\frac{1}{2}$
Miller	001	100	110	021	101	$\bar{1}04$	$\bar{1}01$	$1\bar{1}1$	$\bar{2}12$

COMBINATION.

Crystal I	s	a	m	σ	•	f	c	r	w
Crystal II	s	a	m	•	u	•	c	•	.

All the faces are smooth and brilliant and give good signal reflections.

This twin crystal shows a new form: f = $-\frac{1}{4}$o (101). The facet is broad, well-bordered, and gives an excellent signal reflection.

Measurement and calculation correspond well.

Measured	= 90°	ρ = 8° 22′.
Calculated	= 90°	ρ = 8° 23′.

The form is, therefore, assured.

It may be here noted that linarite has been observed in a specimen brought in lately from Table mountain, near Atlin lake, British Columbia, by Mr. D. D. Cairnes, of the Geological Survey. In this instance the crystals, which are small, occupy a small cavity in a specimen consisting of a calcareous ganguestone more or less impregnated with galena and chalcopyrite.

DIAMOND.

This mineral has been found as a constituent of a rock occurring on the eastern slope of Olivine mountain, about 2 miles to the southward of Tulameen river, Yale district, British Columbia. The specimen in which it has been observed was collected by Mr. Charles Camsell during the season of 1910, and at his request has been under examination with a view to determining the mineralogic constitution of the chromium ore which it contains.

The rock is essentially an altered peridotite, nearly all of the original olivine being now represented by a massive and somewhat easily friable serpentine, varying in colour through a pale yellow to a dirty yellowish white. Through this rock the chromium ore is distributed in the form of small veinlets and scattered patches and grains. Superficially the chromium ore does not present any unusual characters, and responds to the ordinary tests for chromite; a preliminary examination made upon some of the finely pulverized material which had been separated by means of a heavy solution showed, however, that it was readily separable into two portions—a magnetic and a non-magnetic portion—by the aid of an ordinary magnet. These two portions were found to be approximately equal in amount.

The non-magnetic portion was first submitted to analysis, and in order to effect its decomposition it was fused with about four times its weight of carbonate of sodium, for several hours; after cooling, the melt was digested in water, and the sodium chromate which had been formed was removed by filtration and washing; the insoluble portion was then digested with hydrochloric acid to remove oxides of iron, magnesium, etc.; there still remained a very considerable amount of a brownish residue, which was subjected to a repetition of the process just described, but without any sensible diminution in its amount, which was found to equal 3·63 per cent of the sample employed. A weighed sample of the magnetic portion was then, subjected to similar treatment, and a residue identical in character was obtained, but equalling 9·06 per cent of the sample employed. This residue was then tested with hydrofluoric acid, but this reagent had no effect upon it. Fusion with bisulphate of potassium likewise produced no result; fusion with peroxide of sodium resulted in the formation of a black graphitic material. Its specific gravity could not be determined satisfactorily, but by means of a solution of the double nitrates of thallium and silver it was found to be in excess of 3·3. Under the microscope the residue was seen to be made up of sharply angular particles, many of which exhibited a distinct octohedral form, and, as shown by Mr. Camsell, were perfectly isotropic; they were found to be very hard and when mounted on a small piece of wood scratched sapphire with facility, thus indicating a hardness of 10, which is that of diamond. They have been found by Mr. O. Higman, chief electrician of the Department of Inland Revenue, to transmit the X rays without interruption, a fact which in itself alone points conclusively to the identity of this substance with the mineral diamond.

Several attempts have been made to extract the diamonds in unbroken forms by acting on large quantities of coarsely broken material with various solvent reagents, but with indifferent success. It has been found that when a very active reagent, such as bisulphate of potassium, is employed to remove the chromite, the individual crystals crumble into dust from internal strain before they can become accustomed to the changed conditions incident upon their release from the matrix in which they have been enclosed. Better results have been obtained by the use of carbonate of sodium, but the action is very slow. In a number of instances while using this reagent the interesting phenomenon was observed of the breaking up of individual diamonds from internal strain upon being released from the matrix.

The largest individuals so far extracted do not exceed in size that of a pin head; some of them are perfectly colourless while the others exhibit various brownish tints.

In one large sample of the rock which was worked down for diamonds, one or two particles of native gold, and several particles of native platinum were found accompanying the diamond residuum.

Mr. A. T. McKinnon has, as in former years, rendered conscientious service in assembling and despatching the educational collections which have been distributed by the Department. During the season just closed he has collected some fourteen tons of material for use in these collections. This is in addition to three tons which have been purchased for the same purpose.

The thanks of the Department are due to the following gentlemen for much kindly assistance and donations of material in connexion with the educational collections: Mr. M. J. O'Brien, Renfrew, Ontario; Mr. Bush Winning, Ottawa, Ontario; Mr. Thomas Morrison, Bancroft, Ontario; Mr. John Collins, Bancroft, Ontario; Mr. Charles Bulpit, Bryson, Quebec; Mr. J. H. Gillespie, Parrsboro, Nova Scotia; Mr. John Higson, Stellarton, Nova Scotia; Mr. Harry Piers, Halifax, Nova Scotia; Mr. George Stewart, Springhill, Nova Scotia; Mr. E. R. Reader, Bryson, Quebec; Mr. Wm. Parker, Buckingham, Quebec. Mr. Geo. H. Aylard, New Denver, British Columbia, has also, at the request of Mr. O. E. Leroy, donated 1,000 pounds of pure galena from the Standard mine near Silverton.

The following additions have been made to the Canadian division of the mineral section of the Museum:—

DONATIONS.

Amalgamated Asbestos Corporation, Limited, Montreal, Quebec—

Large specimen of asbestos ore from the British Canadian mines, Thetford, Megantic county, Quebec.

Mr. A. C. Andresen, Ottawa, Ontario—

Specularite from Foster, Brome county, Quebec.

Mr. D'Arcy Arden, Ottawa, Ontario—

Native copper, bornite, pyrrhotite, and chalcopyrite from the head of White river, Yukon.

Dr. A. E. Barlow, Montreal, Quebec—

Emplectite from the Floyd mine, Buck township, Nipissing district, Ontario; and the following products of the ores of the Cobalt mines: porcelain plate coloured cobalt-blue, cobalt anode, cobalt speiss, slag from smelting cobalt speiss, coarse cobalt speiss, finished cobalt speiss, blue cobalt silicate, cobalt chloride, cobalt nitrate, cobalt oxide, cobalt sulphate.

Captain Bartlett (ss. *Roosevelt*) per Captain J. E. Bernier—

Cherty quartzite from Cape Columbia, Ellsmereland.

Mr. W. A. Begg, Haileybury, Ontario—

Quartz with pyrite, magnetite, and native gold, from the north half of lot 6, concession III of the township of Tisdale, Sudbury district, Ontario.

Mr. George Clarke, Sandon, B.C.—

Massive stibnite, Alturas claim, North Fork Carpenter creek, Slocan district, West Kootenay, B.C.

Mr. Fritz Cirkel, Montreal, Quebec, per Dr. Eugene Haanel—

Collection of asbestos and asbestos products of the Thetford mines, Megantic county, Quebec.

Mr. M. T. Culbert, Cobalt, Ontario—

Claucodot and galena from the O'Brien mine, Cobalt, Ontario.

Mr. Louis St. Cyr, Ottawa, Ontario—

Native sulphur from township 80, range 2, west of the 6th meridian, Alberta; agate pebbles from Peace river, Alberta; lignite from township 77, range 6 west of the 6th meridian, Alberta.

Mr. E. T. Ellis, Ottawa, Ontario—

Concretions of hematite from Clifton, Gloucester county, New Brunswick.

Mr. R. R. Hedley, Victoria, British Columbia—

Native copper with associated rocks, from Battle bluff, opposite Cherry creek, Kamloops, British Columbia.

Mr. George B. Hull, Ottawa, Ontario—

Molybdenite from Turnback lake, Abitibi district, Quebec.

Mr. E. A. Jacobs, Victoria, British Columbia—

Massive pyrite from the B. C. Copper Company's property, Wellington camp, Grand Forks, West Kootenay, British Columbia.

Mr. S. R. Lanigan, St. Réné de Amherst, Quebec—

Fine group of quartz crystals from Amherst township, Ottawa county, Quebec.

Messrs. Lindsay Bros., London, Ontario—

Sphalerite from lot 30, concession III, Albermarle township, Bruce county, Ontario.

Maritime Oilfields Company, Moncton, New Brunswick—

Petroleum from No. 3 and No. 5 wells on the Petitcodiac river, 10 miles south of Moncton, New Brunswick.

Mr. A. J. Morrow, Eganville, Ontario—

Beryl from Lynedoch township, Renfrew county, Ontario.

Mr. Morley Ogilvie, Ottawa, Ontario—

Auriferous quartz from the Dr. Reddick mine, Larder lake, Nipissing district, Ontario.

Mr. D. S. Sawyer, Ottawa, Ontario—

Large specimen of gold ore from the Dr. Reddick mine, Larder lake, Nipissing district, Ontario.

Mr. L. A. Smart, Winnipeg, Manitoba—

Chemawinite from Leaf lake, Saskatchewan.

Mr. A. D. Tennant, Stewart, British Columbia—

Pyrite and chalcopyrite from Montrose tunnel, and chalcopyrite with pyrite from Red Cliff tunnel, Stewart, Portland canal, British Columbia.

Mr. Wm. Tomlinson, New Denver, British Columbia, per Mr. O. E. Leroy—

Slickensided galena showing torsion cracks from the Standard mine, Fourmile creek, West Kootenay, British Columbia.

Mr. J. T. C. Thompson, Ottawa, Ontario—

Two specimens of native silver with erythrite; one specimen of crystallized quartz with native silver; one specimen of aplite; all from the Lucky Godfrey mine, Willet township, Nipissing district, Ontario.

COLLECTIONS MADE BY OFFICERS AND EMPLOYES OF THE DEPARTMENT OF MINES.

Mr. R. W. Brock—

Specimens of auriferous quartz from the Timmins and Cragg mines, Porcupine, Nipissing district, Ontario.

Mr. D. D. Cairnes—

Tetrahedrite from the Brothon claim, Hoboe creek; stibnite from Taku arm; galena and chalcopyrite in quartz from Munroe mountain; galena, chalcopyrite, and tetrahedrite from the White Moose claim; ore from the Laverdière group; ore from Crater creek; tetrahedrite in quartz from the Alvine claim; ore from the Reds group; tetrahedrite and chalcopyrite from the Dundee claim; galena, chalcopyrite, and linarite from Table mountain; gold ore from the Engineer mine; ore from the Lawsan group, Bighorn creek; ore from the Holy Cross claim, Hoboe creek; native copper from Copper island, Atlin lake; all of these localities are situated in the Atlin mining division of British Columbia.

Mr. Charles H. Clapp—

Finely vesicular rock (lava?) from Village valley, Mayne island, B.C.

Mr. W. H. Collins—

Native iron found in gossan at Smoothwater lake, Gowganda, Nipissing district, Ontario; native silver from the Lucky Godfrey mine, Willet township, Nipissing district, Ontario.

Mr. D. B. Dowling—

Lower Cretaceous sandstone impregnated with magnetite, from Pine creek, a branch of Waterton river, Alberta; series of coals from the Jasper Park collieries, eight samples; coal from Keywood claim, Brulé lake, Jasper park, Alberta; lignite from Tofield, Alberta; lignitic coal, near mouth of Oldman river, Athabaska river, Alberta; coal from near Muskeg river, a branch of Smoky river, section 2, township 57, range 7, west of 6th meridian, Alberta, received from Mr. J. R. Akin, D.L.S.

Mr. J. A. Dresser—

Idocrase from the American Chrome Company's property, Black Lake, Megantic county, Quebec.

Mr. Joseph Keele—

Series of bricks: Red Cliff Brick Company, Red Cliff, Alberta; Alberta Portland Cement Company, Sandstone, Alberta; Edmonton Brick Company, Edmonton, Alberta; P. Anderson and Co., Edmonton, Alberta; Eureka Coal and Brick Company, Estevan, Saskatchewan, two specimens; the Stephens Brick Company, Portage la Prairie, Manitoba, two specimens.

Mr. O. E. Leroy—

Sphalerite from the Lucky Jim mine, Slocan, West Kootenay, British Columbia; linarite, anglesite, galena, and chalcopyrite from Beaver mountain, Slocan, West Kootenay, British Columbia; quartz crystals, siderite, and pyrite from the Ohio claim, Lyell creek, Slocan, West Kootenay, British Columbia; mispickel in quartz-schist from Marcus and Gilbert's claim, Poplar, Lardeau, West Kootenay, British Columbia; quartz replacing limestone, from the Mother Lode mine, Deadwood, British Columbia.

Mr. A. T. McKinnon—

Olivine and spinel from lot 52, range V, Bigelow township, Ottawa county, Quebec.

Mr. H. Ries—

Series of bricks: Minto, Queens county, New Brunswick, two specimens; Salmon bay, Grand lake, Queens county, New Brunswick, two specimens; Flower cove, Grand lake, Queens county, New Brunswick, three specimens; Albert mines, Albert county, New Brunswick; Murphy brook, Middle Musquodoboit, Halifax county, Nova Scotia, three specimens; Smalls brook, Woodbourne, Pictou county, Nova Scotia, two specimens; Brook's brickyard, New Glasgow, Pictou county, Nova Scotia, two specimens; Bailey brook, Pictou county, Nova Scotia, two specimens; Joggins, Pictou county, Nova Scotia; Coxheath. Inverness county, Nova Scotia, three specimens; Inverness, Inverness county, Nova Scotia, three specimens; Port Hood, Inverness county, Nova Scotia; Pugwash, Cumberland county, Nova Scotia; Shubenacadie, Cumberland county, Nova Scotia; Cranberry head, Cape Breton, Nova Scotia, two specimens; Glace bay, Cape Breton, Nova Scotia; Toronto mine, Sydney, Eden Siding, Ashby, Port Morien, and McKinnon harbour, Cape Breton county, Nova Scotia, each one specimen.

Mr. Morley Wilson—

Molybdenite and beryl from Turnback lake, Abitibi district, Quebec.

PURCHASES.

Boulder creek, Atlin, British Columbia, three gold nuggets; series of specimens of alluvial gold from locations in Atlin, B.C., Yukon, and Alaska, as follows: Dominion creek (4 above), Yukon; Gold hill, Yukon; McKee creek, Atlin; Bear creek (8 below), Yukon; Lower Jack Wade (Fortymile river), Alaska; Gold-run (22), Yukon; Eldorado (No. 6), Yukon; Last Chance creek, Yukon; Dominion creek (4 above), Yukon; Bonanza creek (38 above), Yukon; Sulphur (31 above), Yukon; Monte Cristo, Yukon; Lovett gulch, Bonanza creek, Yukon; Bonanza creek (26 above), Yukon; Bonanza bench (20 above), Yukon; French Hill, Yukon; Lower Dominion (13 above), Yukon; Hunker (17 above), Yukon; Wright creek (13 above), Yukon; Pine creek, Atlin; Lower Dominion (4 above), Yukon; Poverty Bar (12 below), Bonanza), Yukon; Upper Dominion (4 below), Yukon; Sulphur (17 below), Yukon; Victoria gulch (No. 2), Yukon; Seventymile, Yukon; Monte Cristo gulch, Bonanza creek (8 below), Yukon; Gold-run (39 and 40), Yukon; Bonanza bench (30 below), Yukon; McQuesten, Yukon; Hunker (11 below), Yukon; Hunker (below) Yukon; Anvil creek, Nome; Chicken creek, Fortyninemile river, Alaska; Anvil creek, Nome.

Cobalt, Nipissing district, Ontario: Cobaltite from the Evans mine; smaltite and native silver from the Coniagas mine; native silver from the Silver Leaf mine; native silver from the Nipissing mine.

The following additions have been made to the foreign division of the mineral section of the Museum.

DONATIONS.

Mr. R. A. Daly, Boston, Massachusetts, U.S.A.—

Specimen of Pele's Hair collected by Mr. H. E. Wilson, Homapo, at a point 4 miles south of Kilauea crater, Hawaii.

Miss M. B. McLeod, Tarbustad, South Africa, per Mr. W. J. Wilson—

Quartz, pseudomorph after crocidolite, from Prieska, Transvaal; mica-schist from Buluwayo, Rhodesia.

Mr. Justice Prows, St. Johns, Newfoundland—

Coal from a location 14 miles inland from Forteau, Straits of Belle Isle, Newfoundland-Labrador.

Mr. Thomas Vanes, Ottawa, Ontario—

Kauri gum and coal from Huntley mine, New Zealand; auriferous quartz from Waihi mine, New Zealand.

EXCHANGES.

Mr. W. E. Christianssen, Keystone, South Dakota, U.S.A.—

Series of specimens from the Black hills, South Dakota, U.S.A., as follows:—Amblygonite from the Spodumene Lode mining claim; cuprocassiterite from the Etta claim; spodumene; lepidolite from the Spodumene mining claim; leucopyrite from the Bob Ingersoll claim; graphite from an abandoned tin deposit; wolfram ore from the Seminole claim; apatite from the Spodumene mining claim; cassiterite; beryl from an old abandoned tin prospect; rose quartz; cassiterite and lollingite from the Etta mine; petalite from the Spodumene mining claim; tin ore from the Road Agent group; garnets in slate, common in district; chalcopyrite from the Christianssen Consolidated Copper Company's prospect; triphylite from the Nickel Plate mine; pyritic ore, common in veins and ore-bodies of the district; columbite from the Bob Ingersoll mine.

Mr. P. Walther, 44 Sanderson Road, Fesmond, Newcastle-on-Tyne, England—

Miscellaneous collection of minerals as follows: olivine bomb, Eifel, Germany; augite bombs, Eifel, Germany; cuprite and chrysocolla from Copiapo, Chili; native coke, Scotland; Atacamite from Chuquaiamata, Chili; sulphate of magnesia and copper from Chuquiamata, Chili; witherite from Fallowfield, Northumberland, England; native tantalum from the Altai Mountains, Siberia; copiapite with chalcanthite from Antafagasta, Chili; barytocalcite from Alston Moor, Cumberland, England; brochantite from Chuquiamata, Chili; trona (white and pink) from Mogard lake, East Africa; adamite from Chili; zincocalcite with olivinite from Chili; witherite from Alston Moor, Cumberland, England; alstonite from Fallowfield, Cumberland, England; barite from Fallowfield, Cumberland, England; delvauxite from Follinggraben, Steirmark, Austria; manjak from Trinidad; malachite from Chili; dioptase from Copiapo, Chili; chalcanthite on brochantite from Chuquiamata, Chili; chalcopissite from Chili.

PURCHASE.

Native gold from Idaho, U. S. A.

PALÆONTOLOGICAL DIVISION.

(Lawrence M. Lambe.)

During the first half of the year, while continuing to fulfil the duties of Palæontologist and Zoölogist, much of my time was devoted to re-examining collections of invertebrate fossils, described by the late Dr. Whiteaves, and others, for the most part in Geological Survey publications, but which had not been exhibited through lack of museum space. It was found necessary to go over these collections carefully, labelling the specimens as determined, and to recognize and indicate the type and figured material, so as to allow of the collections being catalogued.

Other collections which had been reported on in a more general manner, principally by Dr. Whiteaves, and which it was not necessary to catalogue, were labelled and set aside, or boxed up and placed in storage.

A considerable portion of my time has been given to supervising the cataloguing of the exhibited fossil collections, and of those collections reported on and described, but not as yet placed on view, which was begun in November, 1909, by Mr. W. J. Wilson, assisted by Miss A. E. Wilson, and completed in October of this year. The fossils are catalogued as now exhibited, viz., zoölogically according to formations. Running numbers beginning at one hundred, have been used, and each specimen has been numbered in oil paint; type specimens in addition bear a small red circle in paint; cotypes are indicated by a green circle, and figured specimens by a red cross. In the case of a number of specimens, on one tablet, of the same species and from the same locality, letters follow the number, as for example, 101 *type,* other specimens on the same tablet 101*a*, 101*b*, etc. In the card catalogue, each card, corresponding in number to the specimen to which it refers, gives the following information, viz., the genus and species, the locality, formation, name of the collector with the date of collection, also whether the specimen is a type, cotype, or figured specimen, etc., with any further information thought desirable. The Geological Survey is now, for the first time, in possession of an accurate and comprehensive record of its described collections of fossils in the shape of a card catalogue, which later can be used in connexion with the installation of these collections in the Victoria Memorial Museum, in whatever manner they may be arranged.

On the completion of the above card catalogue, and with a view to the publication of a catalogue of the type and figured specimens of fossils now in the possession of the Geological Survey, Mr. Wilson and Miss Wilson, under the writer's and Dr. Raymond's supervision, began, and are now engaged in work preliminary to a compilation of this character. With the catalogue of the fossil types, etc., will appear a complete bibliography of all palæontological writings based on specimens belonging to the Geological Survey.

In view of the early date at which the collections might be removed to the new building it was considered expedient to have the large, described, but as yet unexhibited, collection of vertebrates from the Judith River formation of Alberta (which includes many generic and specific types) packed and ready for removal. It was necessary to spend some time in repairing many of the larger fragile specimens of this collection before they could be placed in boxes. The collection as a whole is now ready for removal, and can be easily handled without danger of breakage. This collection of vertebrates, together with those of invertebrates already mentioned, and some recent zoölogical material, fill seventy-five large boxes.

This autumn, labels for use in the Victoria Memorial Museum, have been prepared for all the fossil vertebrates to be exhibited.

A collection of thirteen specimens of Pelecypoda (mostly casts of the interior) from Texada island, B.C., collected by Mr. R. G. McConnell in 1909, was received from him in March of this year and reported on. Eight species of seven genera are represented in this collection, which was made from an outlier of Cretaceous rocks half a mile east of Cook bay.

The fifth part of Contributions to Canadian Palæontology, vol. III (quarto) on 'Palæoniscid Fishes from the Albert Shales of New Brunswick,' was published in August of this year.

A short paper on a recent discovery in connexion with the parietal frill of the Cretaceous dinosaur *Centrosaurus apertus* was prepared and published in the December number of the Ottawa Naturalist.

A Bibliography of Canadian Zoölogy for 1909 (exclusive of Entomology), was written during the early part of the year, and presented at the annual meeting of the Royal Society of Canada for publication.

ADDITIONS TO THE PALÆONTOLOGICAL AND ZOÖLOGICAL COLLECTIONS DURING 1910.

Mr. Lambe reports the following accessions to the Survey collections:—

Received from members of the Geological Survey as follows—

McConnell, R. G.—

Twelve specimens of Pelecypoda, collected in 1909, from an outlier of Cretaceous rocks, half a mile east of Cook bay, Texada island, B.C.

Wilson, W. J.—

Six pieces of carbonaceous limestone holding remains of amphibians, from a sigillarian stump, from the Coal Measures near Joggins mines, N.S.

Small collection of plants from the Coal Measures at Joggins mines, N.S.

About 1,000 specimens of Carboniferous plants from Minto, Sunbury county, N.B.

Leach, W. W.—

Thirteen specimens of *Taxodium distichum miocenum,* etc., from Omineca ming division, B.C., Driftwood river, 7 miles from its mouth. Tertiary (Oligocene).

Two specimens of fossil plants from Bulkley river, B.C., about 10 miles from its mouth.

Camsell, C.—

Two specimens of Tertiary plants from White lake, Okanagan valley, B.C.

Received from other sources—

By presentation:—

Grant, Col. C. C., Hamilton, Ont.—

Twenty-one fossils from the glaciated chert beds of the Niagara formation at Hamilton, and one fossil from the Clinton formation at the same place. Four sponges in chert nodules from the Niagara formation at Hamilton, Ont.

Wilmer, Lieut.-Colonel L. Worthington, Lothian House, Ryde, England—

112 English Cretaceous and Tertiary fossils, mostly pelecypods and gasteropods.

Farmer, Wilfred, near Indian Head. Sask.—

Anterior caudal vertebra of a Mosasaurian reptile. obtained from gravel at a depth of 20 feet below the surface, in digging a well. about 20 miles south of Indian Head, and 4 miles north of Odessa, on the line of the Canadian Northern railway. Judging from shale adhering to the bone it is probable that the specimen comes from the upper shales of the Pierre formation.

St. Cyr, J. B., per Dr. E. G. D. Deville, Surveyor General, Ottawa—

An imperfect specimen of *Scaphites ventricosus?* (Meek), and a fragment of impure limestone showing cone-in-cone structure, collected by Mr. St. Cyr, in 1909, on Brulé river, a tributary of Peace river, about 25 miles south of Dunvegan, Alta.; of Cretaceous age and probably from the Benton formation.

Altschel, J.—

Three seperate fragments of *Baculites ovatus,* Say. from Athabaska river, 36 miles below Athabaska Landing; upper Cretaceous (?Pierre-Foxill formation).

Brown, R. H., 36 Kent street, Halifax, N.S.—

One photograph of fossil fern (*Neuropteris cordata* or *angustifolia*) from the roof of main seam of coal, Princess pit (Sydney No. 1), Sydney mines, 1903. Coal measures.

Conroy, H. A.—

Part of a molar tooth of Mammoth, from a clay bank on Loon river, 40 miles from its mouth, a tributary of Peace river, Alta.

Evans, W. B., Minto, Sunbury county, N.B.—

Small collection of Carboniferous plants from the Rothwell Coal Co.'s mine, Minto, N.B.

Adami, Professor J. G., McGill University, Montreal, Que.—

One specimen of a fish, part of the crustacean, and a fragment of a cephalopod from the lithographic stone deposits of Bavaria (Jurassic).

Morrison, John M., and Bannerman. John B., Carcross, Yukon—

Through an error in last year's Summary Report a fine skull of the Pleistocene horse, from No. 34. Gold-run creek, Yukon, was stated to have been acquired by the Geological Survey by purchase, whereas it was presented to the Museum by Messrs. Morrison and Bannerman.

By purchase:—

A very large specimen of *Aphrocallistes whiteavesianus,* Lambe, brought up on a cod hook near Nanaimo, B.C., and having the following dimensions: breadth 21 inches, height 15 inches, thickness from back to front 15 inches. A small fragment of this specimen was received by the Geological Survey in March, 1908.

A well preserved skull, without the mandible, of *Arctotherium cfr. simum,* Cope, from Pleistocene deposits on Gold-run creek. Yukon: obtained in frozen ground at a depth of 40 feet from the surface.

In addition Dr. Raymond reports the following accessions to the collection of invertebrate fossils since July 1, 1910:—

By presentation:—

Dr. Ray S. Bassler, U. S. National Museum, Washington, D.C.—

Three specimens *Beatricea gracilis,* Ulrich. From the Lowville at Bellefonte, Penna. Acc. No. 37.

Col. C. C. Grant, Hamilton, Ontario—

Three small collections (25 specimens). From the Niagara cherts at Hamilton, Ontario, Acc. No. 6.

Mr. Elfric Drew Ingall, Buena Vista road, Rockcliffe, Ont.—

Collection of fossils from the trenches on Manor road and Buena Vista road, Rockcliffe, Ontario. Acc. No. 3.

Mr. W. C. King, Auditor General's Department, Ottawa, Ontario—

One specimen *Isotelus arenicola,* Raymond. From the Chazy at Britannia, Ont. Acc. No. 1.

Mr. C. E. Oliver, Hedley, B.C., through Mr. Charles Camsell—

Four imperfect specimens of a large *Prionocyclus* from the Cretaceous on Mamloos creek, a tributary of Roche river, Similkameen district, B.C. Acc. No. 38.

Mr. Stewart Macroe, West Selkirk, Manitoba—

Eight specimens Ordovician fossils from the drift at York Factory. Acc. No. 22.

Mr. A. McNeill, Department Interior, Ottawa, Ontario—

Two fossiliferous nodules from Green creek, near Ottawa, Ontario. Acc. No. 20.

Mr. W. J. Wilson, Ottawa, Ontario—

One specimen *Isotelus gigas,* Dekay. From the Trenton at Hull, Quebec. Acc. No. 7.

By purchase:—

Rev. J. M. Goodwillie, Metcalfe, Ont.—

A collection of invertebrate fossils, principally Ordovician, Silurian, and Devonian, from various localities. About 4,000 specimens. Acc. No. 8.

Mr. George Noel, 33 Ottame St., Hull, Quebec—

About 30 specimens of invertebrate fossils from the Trenton at Hull, Quebec. Acc. No. 11.

Collected by officers of the Survey:—

Cairnes, D. D.—

Five specimens from the Cretaceous at Bee mountain, Atlin district, B.C. Acc. No. 35.

Camsell, Charles—

One fossiliferous fragment of Carboniferous rock found loose on Eagle creek, Tulameen district, B.C. Acc. No. 41.

Dowling, D. B.—

Small collection of Jurassic fossils from The Gate, Fiddle creek, Alberta. Acc. No. 24.

Dresser, J. A., and Raymond, P. E.—

About 25 specimens lower Cambrian fossils in pebbles of a conglomerate at St. Philippe de Neri, Kamouraska county, Quebec. Acc. No. 17.

Fossiliferous pebble of Trenton age from gravel on shore at St. Denis, Kamouraska county, Quebec. Acc. No. 18.

Ingall, Elfric Drew, and Raymond, P. E.—

Small collection fossils from the Beekmantown, Chazy, Lowville and Black River, at Rockland, Ontario. Acc. No. 14.

Small collection fossils from the Lowville and Chazy at Aylmer, Quebec. Acc. No. 15.

Small collection fossils from the Lorraine at Hawthorne, Ontario. Acc. No. 16.

Johnston, W. A.—

One specimen *Ormoceras allumettense* (Billings), and one of *Stromatocerium rugosum*, Hall, from the Black River in Orillia North tp., Ont. Acc. No. 42.

Keele, J.—

One specimen *Scaphites* from the Cretaceous at Seaby siding, 2 miles east of Kananaskis, Alberta. Acc. No. 12.

Leach, W. W.—

Seven specimens fossils supposed to be from the Cretaceous, from the Bulkley river, B.C. Acc. No. 34.

McInnes, W.—

Seven specimens Ordovician fossils, 1 from Pelican lake, 2 from Bigstone lake, and 4 from Deschambault lake; 3 specimens Silurian fossils from Cumberland lake; all in Saskatchewan. Acc. No. 19.

Raymond, P. E.—

Fourteen lots of fossils from the Chazy, Lowville, Black River, Trenton, and Utica, in the vicinity of Ottawa. Acc. Nos. 4, 5, 9, 10, 13, 23, 25, 31, 32, 33, 36, 39, 40, 44.

Three lots of fossils from the Beekmantown and Chazy at and near Grenville, Quebec. Acc. Nos. 26, 27, 43.

Two lots fossils from the Chazy at Quebec Junction, and Bordeaux, Quebec. Acc. Nos. 28, 29.

Six fossils from the Chazy and Lowville at Point Claire, Island of Montreal, Quebec. Acc. No. 30.

Wilson, W. J.—

Four slabs with fossils from north of Coal Mine point, Joggins Mines, N.S. Acc. No. 21.

INVERTEBRATE PALÆONTOLOGY.

(P. E. Raymond.)

Since I joined the staff on July 1 of the present year, the greater portion of my time has been spent in becoming familiar with the collections of invertebrate fossils, and selecting a series of specimens for exhibition in the new museum. In connexion with this work about 1,200 new identification labels were prepared in order to make the naming of the species conform to the modern nomenclature.

Early in October three days were spent with Mr. Dresser, collecting fossils from the conglomerates in Kamouraska county, Quebec, and late in the same month, and early in November, several days were spent in studying the stratigraphy and collecting the fossils of the Chazy formation at Aylmer, Ottawa, Grenville, Quebec Junction, Bordeaux, and Point Claire. These latter studies are still incomplete, but enough facts have been obtained to show that the lower 125 feet of the Chazy formation in the Ottawa valley, as defined in the Geology of Canada, 1863, is of upper Chazy age, while the black and buff limestones above belong to the Black River group.

The following collections have been examined and reported upon:—

Mr. Charles Camsell—

A few Carboniferous fossils found in a loose fragment on Eagle creek, Tulameen district, B.C.

Mr. D. B. Dowling—

A few specimens from the Jurassic at The Gate, Fiddle creek, Alberta.

Mr. J. A. Dresser—

Lower Cambrian fossils from the conglomerates at St. Philippe de Neri, Kamouraska county, Quebec.

Mr. W. McInnes—

A small collection from the Ordovician and Silurian, at a number of localities in Saskatchewan.

Mr. W. J. Wilson—

A few species from the Carboniferous at the Joggins mines, N.S.

PALÆONTOLOGICAL WORK IN SOUTHERN NEW BRUNSWICK.

(*W. J. Wilson.*)

In continuation of the work done in southern New Brunswick during the summers of 1908 and 1909, a few weeks, in 1910, were spent in the Grand Lake coal basin, Sunbury county, collecting fossil plants at the Minto coal mines. A short time was occupied in examining the rocks along the shore at Mispec and Cape Spencer, St. John county, where plant remains had been said to occur. Part of a week was occupied examining the rocks at Tidnish head, Nova Scotia, and a portion of Sir W. E. Logan's section at the Joggins shore, N.S. From all of these places collections were made where fossils could be found.

I am again indebted to Dr. G. F. Matthew for information about the rocks at Mispec and Cape Spencer; to Mr. Wm. McIntosh, curator of the Museum of the Natural History Society of New Brunswick, for the opportunity of examining type specimens of fossil plants; to Mr. W. B. Evans, manager of the Rothwell Coal Co., Limited, Minto, for some good specimens of fossil plants donated to the Museum, and for much valuable assistance in collecting; and to Mr. Bruce Barnes of the Northfield Coal Co., Limited, and the officers of the King Lumber Co., both of Minto, for valuable assistance in collecting from their mines.

Most of the time was spent at Minto, and adjacent mines, where a collection of about 1,000 specimens was made. The plant remains were found in the dumps of shale from the mines. The most prolific fossiliferous beds lie above the coal, and extend upward 10 or 15 feet, but in most cases only a foot or two of shale is removed with the coal, so that the best fossils rarely come to the surface. The shale is a fine-grained, dark grey rock, which when first removed, is firm and solid, but when exposed to the air and sun at once begins to crack, and in a short time disintegrates and crumbles to a fine powder. On this account the shale containing fossils has to be collected and carefully wrapped up as soon as it is thrown out, or else it falls to pieces and the fossils are lost. Some specimens can only be preserved by coating them with oil or shellac. Many of the fossils obtained at Minto will make good museum specimens, while all will be useful for study and comparison. The following are some of the genera and species collected at this locality:—

Neuropteris scheuchzeri, Hoffman (*N. hirsuta,* Lesqx).

Single leaves beautifully preserved are numerous at the King Lumber Co.'s mine. 'A well known fern marking a definite horizon of upper Carboniferous rocks.'[1]

Lepidophyllum cf. *brevifolium,* Lesq.

Detached leaflets are common in all the mines. They are supposed to be part of the fruit of *Lepidodendra,* and are arranged around a common axis, forming a cone-shaped body. A part of one of these cones was found showing the Sporangia and attached leaflets. The latter are triangular, short, pointed, and from half to three-fourths of an inch long. They are attached to the cone by a triangular base much smaller than the leaflet. These leaflets closely resemble *L. brevifolium* figured by Lesquereux,[2] only they are larger, and the sides of the triangle are usually straight instead of concave as in the figure referred to. Zeiller, in speaking of leaf-

[1]Fossil Plants, Seward. Vol. I, p. 45.
[2]The Geology of Pennsylvania by H. D. Rogers, p. 876. Plate XVII, fig. 6.

lets of *L. lanceolatum,* says: 'They are found most often isolated, but sometimes attached in greater or less numbers about a common axis, although no complete cone has been found.[1] This is also an upper Carboniferous form. Several species of *Sphenopteris* were found, one closely resembling *S. latifolia,* Brongn, and may be *S. latior* of Dawson, occurs in well-preserved fronds at the seven different mines from which collections were made. *Pecopteris* is represented by several species, and is common. *Sphenophyllum schlotheimii,* Brongn, is common, and *S. emarginatum* occurs less frequently. *Cordaites borassifolia,* Brongn, very common but usually in fragments. It is hard to get a complete leaf. *Alethopteris lonchitica,* and probably one more species, are common at the Rothwell Coal Co.'s mine, and occasionally met with at the other mines. *Stigmaria,* with rootlets attached, was found at the Gibbons mine. *Lepidodendra* occur at some of the mines in well preserved specimens, apparently of different species. Specimens of *Lepidophloios, Sigillaria, Cyclopteris, annularia,* and *equisetum* were occasionally found. Fruits are fairly common, especially one resembling *Cardiocarpum bisectum,* Dawson. At the Rothwell Coal Co.'s mine a large fruiting frond closely allied to *Antholithes rhabdocarpi,* Dawson, occurs on a slab with fronds of *Alethopteris.*

The above species were noted in the field and are only provisionally determined, as there has been no opportunity to study the collection in detail.

The shore at Cape Spencer and Mispec, in St. John county, was examined, since it was thought desirable to determine if there were any fossils in the rocks exposed there, but a somewhat careful search revealed none. It may be said, however, that owing to the rough and precipitous character of the cliffs, considerable stretches of the shore were inaccessible on foot, and consequently were not examined.

A day was spent examining the rocks along the shore at Tidnish head and vicinity, Nova Scotia, to see if there were any indications of plant remains in the coarse red sandstone. None, however, were seen in the small area traversed.

It has been suggested to the writer that a systematic collection of fossil plants should be made from the Joggins section, by examining each bed and noting the contained fossils. Such a collection would show the characteristic forms and vertical range of the plants in this great section, and would furnish criteria for the palæobotanical classification of the Coal Measures of the Joggins and adjacent basins, and help in the elucidation of the collections of fossil plants made from the rocks along the New Brunswick shore. In order to see if such a collection could be made, if opportunity offered in the near future, two days were occupied at the Joggins comparing Sir W. E. Logan's section with the beds as now exposed on the shore. Although over sixty years have elapsed since the section was made, during which time considerable changes have taken place through erosion, it was possible to correlate the beds as they now are with the printed section, and it seems quite practicable to use Logan's section for marking the specimens from each bed, thereby saving the time required in making new measurements.

While at the Joggins shore a few specimens of *Lepidodendra, Lepidophloios, Sigillaria, Alethopteris lonchitica, Antholithes,* and *Lepidostrobus* were collected. A number of reptilian remains were secured from the stump of an erect Sigillaria, and are in Mr. Lambe's hands for future study. From a carbonaceous bed on the shore a number of invertebrates were obtained. These were submitted to Dr. Percy E. Raymond, who reports several specimens of each of the following species: *Naiadites carbonarius,* Dawson, *Naiadites elongatus,* Dawson, *Spirorbis carbonarius,* and a number of undetermined ostracods.

---

[1] Elements of Palæobotanique, p. 187.

NATURAL HISTORY DIVISION.

(John Macoun.)

During the past office season, while special ornithological work occupied my time, Mr. James M. Macoun, my assistant, devoted his time chiefly to the classification and systematic arrangement of the various collections which had accumulated. This botanical work was nearly completed when he left for Hudson bay early in July. The material collected on Vancouver island was worked over by Mr. C. H. Young and myself, and with the assistance of American and Canadian specialists, many of the specimens were taxidermically prepared, identified, and arranged according to their respective orders, and the new species determined. Dr. Dall, of the Smithsonian Institution, Washington, D.C., to whom over fifty species of shells were sent, reported that seventeen of them are new to science, and many others new to the Vancouver Island fauna; he also mentioned that the fauna on the outer coast of Vancouver island indicated warmer water than that of the Gulf of Georgia. Mr. Frank F. Collins, of Malden, Mass., who is writing a report on the seaweeds, makes the same statement.

Our collections of the marine fauna of the Atlantic coast being inadequate, and there being a demand for a separate catalogue of the flora of the Maritime Provinces, I was instructed to make collections during the summer in Nova Scotia, and from its coast waters.

On May 10, Mr. C. H. Young and I left Ottawa and proceeded to Yarmouth, N.S., where we commenced work on May 14. Mr. Young was instructed to make his collections chiefly from the sea, while I worked on land. Specimens were gathered principally along the south coast. A month was spent at Yarmouth, six weeks at Barrington Passage and vicinity, and the remainder of Mr. Young's time on the islands off the mouth of Lahave river. My collections were mostly made in the neighbourhood of Yarmouth, Barrington Passage, Bridgewater, Springhill, in the Annapolis valley, and at Digby.

Mr. Young obtained many fine marine specimens, a very large part of the series of animal life being gathered in the waters of the Atlantic coast of Nova Scotia; while my own collections covered the whole botanical field. For a partial list of our collections see column III, in the schedule attached.

In the beginning of November, 1909, Mr. W. Spreadborough was re-engaged, and instructed to proceed to the Biological Station at Nanaimo, Vancouver island, B.C., and collect sea birds and marine animals generally. His collection from Departure bay is large and valuable. See column I of the appended lists.

Early in the summer of 1910, Mr. Spreadborough was further instructed to proceed to Skidegate, Queen Charlotte islands, B.C., to gather natural history specimens of all kinds. He remained at work two and a half months, and made extensive collections, both on land and sea. See column II. A collection of plants was made, which is of great value, for no plants have been received from Queen Charlotte islands since Dr. Dawson's investigations in 1878.

Mr. Young's time since his return has been constantly occupied in packing, sorting and preserving the numerous specimens collected by himself and by Mr. Spreadborough during the past season.

Since my return from the field, I have been occupied writing on the flora of the Maritime Provinces: Dr. A. H. MacKay, Superintendent of Education, Nova Scotia; Dr. G. U. Hay, of St. John, New Brunswick, and Mr. Lawrence Watson, of Charlottetown, Prince Edward Island, are assisting me in every possible way.

LIST OF SPECIMENS COLLECTED.

	Departure bay, B.C.	Skidegate, Queen Charlotte islands.	Yarmouth, N.S. Barrington Passage, N.S. Lahave islands, N.S.
	I	II	III
Mammals	26	8	13
Birds	289	34	24
Birds' eggs		7	45
Nests			11
Sea turtle			1
Shells	340	2,000	4,950
Insects			500
Fishes		200	35
Sea spiders		1	4
Lobsters			5
Crabs and shrimps	19	165	65
Hermit-crabs		20	35
Isopods		20	180
Sponges	4	45	25
Barnacles		10	10
Starfishes	90	165	45
Sea worms		225	40
Sea slugs		75	4
Hydrozoa		40	13
Jelly fishes		3	
Tunicates and ascidians		95	125
Corals		45	20
Wasp's-nest			1
Breast-bones of seabirds	80		
Snakes			15
Toads and lizards			5
Sea-urchins		15	65

During the winter and spring of 1909-10, Mr. J. M. Macoun worked over a very large series of plants, and before he left for Hudson bay in July, he had nearly all the old collections, together with the herbarium, about ready for removal to the new museum. The number of sheets mounted last winter, and placed in the herbarium was 2,473. None have been mounted this autumn. The number of specimens distributed to museums was 5,303. This increase in the number of specimens available for distribution was caused by the older collections being worked over. Only 626 sheets are recorded as having been received during 1909; but there are at least 2,000 specimens in bundles which remain unopened. As usual, correspondents send specimens to be named, and 814 of these were examined for various persons in all the provinces of the Dominion. The correspondence has increased very largely this year owing to the fact that the scope of our work has widened. Miss Stewart, who keeps the record, reports 792 letters between November 25, 1909, and the same date in 1910.

New forms were collected both on the Atlantic and Pacific coasts during the past season, and specialists are now at work on some of the orders. Dr. W. H. Dall, of the Smithsonian Institution, Washington, D.C., U.S.A., reports that we have five new species of shells this year.

One feature of Mr. C. H. Young's work this year deserves special mention. We had been told that cod subsisted largely on small shell fish, but Mr. Young has disproved this notion, for he discovered that their food consists largely of hermit crabs and large shell-fish; while the haddock subsists almost exclusively on small shell-fish.

No less than 48 species of shells were obtained from haddock stomachs. Seventy species, in all, were found living on the Lahave banks.

Additions to the Museum Collections, 1909.

By purchase:—

Smith, Cecil, Quathewski cove, B.C.—
Cougar (*Felis couguar,* Kerr), March 15, 1909.

Morehouse, Avery, Zealand station, N.B.—
Two deer heads (deadlock), (*Odocoileus americanus,* Ex.) from near Woodstock, N.B., 1907.

Auston, A. R., Carcross, Yukon—
Fannin's Mountain Sheep (*Ovis Fanninii*), Dec., 1909.

Groh, Herbert, Experimental Farm, Ottawa—
Virginia Rail (*Rallus virginianus*) caught near Britannia, Ont., April 23, 1910.

Porter, H. E., Whitehorse, Yukon—
Bull, cow, and calf of Osborn's Caribou (*Rangiferrosbornii*) from Lake Arkell, Y.T.

Ewe and lamb of Dall's Mountain Sheep (*Ovis dalli,* Allen) from Arkell, Y.T.
Columbia Mountain Goat (*Oreamnos montanus columbianus,* Allen) from Arkell, Y.T.

Stimpson, J., Banff, Alta.—
Big-horn Mountain Sheep (lamb) (*Ovis cervina,* Des.), April, 1910.

Allen, E. C., Yarmouth, N.S.—
Skua (*Megalestris skua*), N. Yarmouth, N.S., March, 1910.

By presentation:—

Saunders, W. E., London, Ont.—
Pilot snake (*Coluber obsoletus,* Say.), Point Pelee, Ont., Nov. 29. 1909.

Speechly, Dr. H. M., Pilot Mound, Man.—
Nest of Ruby-throated Hummingbird (*Trochilus colubris*), Feb. 5. 1910.

Dowling, D. B., Geological Survey, Ottawa—
Trout (*Salvelinus stagnalis,* Fab. = *Salmo hoodii,* Rich.) from north branch Brazeau river behind Nikanassin range, August, 1909.

Experimental Farm, Brandon, Man.—
Bull and cow of Yak (*Bos grunniens*), March 1 and 15, 1910. Both died at Experimental Farm.

Hinton, D. W., Duncan creek, Yukon—
Flying Squirrel (*Scuiropterus yukonensis,* Osgood) from south side of Mayo lake, Y.T., April, 1910.

Criddle, Norman, Treesbank, Man.—
Nest and four eggs of Orange-crowned Warbler (*Helminthophila celata*), June 15, 1910.

Allen, John A., Geological Survey, Ottawa—
Beaver cutting on *Aspen* from Beaverfoot valley, Leanchoil, B.C., August, 1910.

Grant, Lady, Ottawa—
Tarantula's nest from California.

Thorburn, Mrs. J., Ottawa—
Venus's Flower Basket (*Euplectalla*), from Cuba.

FLORA AND FAUNA OF WEST COAST OF HUDSON BAY.

(J. M. Macoun.)

Pursuant to instructions I left Ottawa June 30 and joined the steamer *Stanley* at Halifax July 2, the Deputy Minister of Marine and Fisheries having kindly offered to convey me to Churchill on that boat. We reached Churchill July 25, and after engaging one man, I pitched my tent near the Hudsons' Bay Company's post, 4 miles south of the Royal Northwest Mounted Police detachment. Before leaving North Sydney I arranged with the captain of the schooner *Jeanie* that, with the permission of the officer commanding at Churchill, I should go north on that vessel from Churchill to Wager inlet. The *Jeanie* was chartered to transport police supplies and the portable houses which were to be erected at several points along the coast. This arrangement gave me exceptional facilities for studying and collecting specimens of the flora and fauna of the coast north of Churchill, that being the object of my visit to Hudson bay.

The *Jeanie* reached Churchill in due course, and I went on board and was ready to sail August 23. During the month spent in the vicinity of Churchill my camp was moved from place to place for convenience of working, and a very complete collection of plants was made. Small mammals and birds were also collected, but the latter were moulting at that time, and only skins for purposes of identification were secured. Although the Geological Survey has in its herbarium a few plants from Churchill, they had never been studied as a whole, and I was greatly surprised to find no indications there of an arctic flora. Since my return the whole collection has been gone over. It does not include a single species that can be called arctic, while in the same latitude, on the east side of Hudson bay, and indeed as far south as Big river, many truly arctic species are found. The flora at Churchill is made up of plants found farther south, the only difference between the flora of Churchill and of York being that fewer species are found at Churchill. In natural history the most interesting fact noted at Churchill this year was the absence of field mice and lemmings, usually so abundant there. It is known that an epidemic similar to that which attacks hares also destroys the smaller rodents, and my notes this year will serve as a basis for future observations. Dr. T. N. Marcellus, to whom I gave my traps at Churchill, has consented to report on this subject next year.

Houses were erected at Eskimo point, and Rankin inlet, as we went north, and I had two days for collecting at each place. We also touched at Daly bay. Two days were spent at Fullerton as we went north, two as we came south, and nine days at Wager inlet. Large collections were made at each place, and very full notes taken. The Eskimo also furnished me with valuable information relative to the habits and distribution of birds and mammals. While the flora at Churchill included no arctic species, that of Wager inlet was essentially arctic. The collections made at intermediate points show the intermingling of the arctic with the more southern flora, and we can now indicate the northern and southern limits of many species on the west coast of Hudson bay about which nothing was known previously. This I consider the most important part of my work from a scientific point of view, and the same facts, in my opinion, show conclusively that there are no cold currents striking the west coast of Hudson bay. The flora changes from south to north, just as we would expect it to change as higher latitudes are reached. This is not the case on the east side of the bay, where, as I have said, the flora indicates low summer temperatures as far south as James bay.

We were ready to leave Wager inlet on September 8, but a strong wind blowing into the harbour in which we were anchored made it impossible to get out. The wind was stronger the next day, and one anchor chain broke at 5 p.m., the second one giving way at 10.30. We were then about half a mile from the shore, but the vessel was safely beached, and at daylight when the tide was low we walked ashore. As we expected to reach Churchill at a date when bad weather might be expected, Capt. Bartlett had asked me to have all my baggage placed on board, and the collections made at Churchill were also with me. These were landed at Wager inlet without damage, but as the boats were heavily laden when we started south from Wager inlet, rock specimens and the marine material had to be left there. The tank containing these specimens was the only thing on board that could be used to carry fresh water in the boats, and its contents would have had to be left in any case, on that account. A week was consumed at Wager inlet in repairing the boats, and it was not until September 16 that we started for Fullerton, reaching there without incident on the 19th. The whaling schooner, *A. T. Gifford*, Capt. Geo. Comer, had gone into winter quarters the previous day, but Supt. C. Starnes, who had gone north to Fullerton on the *Jeanie*, arranged with Capt. Comer for transport to Churchill, and we were landed there September 25.

As at that late date there was no chance of getting out from the bay by watei there was nothing to do but wait until winter travel was possible. Quarters were given me by the police detachment, and for the first month I employed myself in collecting such birds as could be procured. As soon as there was sufficient snow I left Churchill with two hunters who were going up the North river, and for two weeks had a permanent camp about 15 miles up North river, 35 miles from Churchill. From this camp I covered the whole country within walking distance, and from obseravtions made at this place, and during shorter trips up the creeks running into Churchill river, I can report that there is a considerable quantity of good spruce on all these rivers and creeks, and also along Button bay. There will be difficulty in transporting this timber to Churchill, but it is there, of good size and quality, and in considerable quantity.

The caribou were very abundant this year, the food supply for men and dogs for the whole winter being secured before December 1. Wolves were very numerous, coming into the settlement, although deer were so plentiful. Three caribou, of which I made specimens, were left at the camp referred to, but are to be brought out to Churchhill during the winter.

No attempt to cultivate even vegetables is now made at Churchill, but formerly turnips, potatoes, etc., were grown successfully. A few cattle were also kept. Dried potatoes and canned milk and butter now supply the needs of the natives. There is good pasture in the summer, but hay grass is not plentiful.

During the time I was on the schooner *Jeanie* attempts to catch fish were made nearly every day but without success. The crew was made up of Newfoundland fishermen, and during the passage through Hudson strait and across Hudson bay similar attempts had been made, but no fish were caught. There is an abundance of fish at Churchill for local needs in the summer season, the first whitefish (*Coregonus Artedi*) being taken about June 25. From that date until near the end of July they increase in numbers, growing scarcer after that time until the ice begins to take along the shore. The first salmon are taken about July 1, and are plentiful only during that month, disappearing about August 15. A few capelin are caught early in the season, and during our passage through the bay in July many of these fish were seen in brackish pools on the floating ice.

The Churchill river last summer opened in midchannel on June 11, and remained open. It closed December 5. The first boats from York Factory reached Churchill July 6.

The usual time for leaving Churchill for Split lake is November 24, and at that time I was ready to start with two men. The weather was still comparatively warm, however, and the Churchill river open. The freezing across of the river is considered the earliest date at which inland streams and swamps can be crossed, and it was not until December 5 that a start could be made, heavy snow storms and comparatively mild weather causing the delay. From Churchill to Split lake I travelled in company with Mr. Bachand and his party. From Split lake to Gimli I was either with him or the crew of the wrecked *Jeanie,* one dog train carrying my specimens and supplies. The specimens weighed about 200 pounds, just the amount that can be carried in excess of dog feed by one train. I arrived in Winnipeg January 16, and left the same day for Ottawa, reaching here January 18.

ANTHROPOLOGICAL DIVISION.

I.

Report of Field Work, Sept.-Dec., 1910.

(E. Sapir.)

The plan of the anthropological division of the Geological Survey includes field work among the native tribes of Canada for the purpose of gathering extensive and reliable information on their ethnology and linguistics; archæological field work; publication of results obtained in these investigations; and exhibitions in the museum of specimens illustrative of Indian life and thought. All of these lines of work are important, but perhaps none is so pressing as that first mentioned.

It is planned to make an ethnological and linguistic survey of several of the tribes of Canada. A beginning was made in the fall of 1910, among the Nootka Indians of the west coast of Vancouver island. The ethnology and linguistics of the northwest coast are comparatively well known through the researches of Boas, Swanton, and others; within this area, however, the Nootka have been but little studied.

The time spent in actual work among these Indians was from Sept. 20, to Dec. 6, 1910. Owing to the fact that the complexity of Nootka life and thought makes it difficult to get an adequate idea of the tribe—or rather, group of tribes—by visiting many villages within a short time, it was decided to concentrate work on one point of the Nootka territory. For this purpose the Nootka Indians living in the neighbourhood of Alberni, B.C., were selected. They embrace two tribes, the Tsishya'ath and the Hopach'as'ath, the former claiming the Broken Group islands of Barkley sound as their original home, while the latter were localized in the region of Somass river and Sproat and Great Central lakes. Though these two tribes have intermarried to a great extent, and carry on their ceremonies in common, each still keeps up its tribal individuality.

A good deal of time was spent on the Nootka language, one of considerable phonetic difficulty and complexity of structure. The linguistic work comprised not only direct inquiries into grammatical form, but also, and indeed mainly, collection of mythological and ethnological texts. These were taken down in strictly phonetic form and were then carefully interpreted word for word, supplementary grammatical material being often obtained in connexion with text forms. It is believed that such texts are valuable not only from a linguistic standpoint, as they illustrate native speech in actual idiomatic use, but also from a strictly ethnological standpoint, expressing, as they do, the native point of view in matters of custom and belief. The most valuable of the texts are a long and rather detailed legend of the chief's family of the Ts'ishya'ath, beginning with the creation of man and the deluge and ending with the recent genealogy of the present chief, and an equally long origin myth of the wolf ritual or Tlokwana, the most important religious ceremonial of the Nootka Indians. As one of the results of the linguistic inquiry may be noted the amassing of new data bearing on the problem of the linguistic relationship of Kwakiutl and Nootka.

The ethnological work consisted in collecting data on various topics of importance; witnessing several ceremonies that were performed during the time spent in the field; and collecting museum specimens: in connexion with the two latter further ethnological data were collected. Among the topics that were investigated with some detail are the native geography of Barkley sound and Alberni canal, personal names, inheritance of family privileges, secret rituals for the attainment of power in hunting and fishing, the wolf ritual, the ts'ayeq or doctoring ritual, and potlatches. A set of 67 songs was taken down on the phonograph. These were sung by various Indians, and include different types of songs, among them songs for success in whaling, lullabies, potlatch songs, announcement songs, gambling songs, wolf ritual songs, doctoring ritual songs, and others. The songs have been put into the hands of Mr. J. D. Sapir for transcription into notes. Among the ceremonies witnessed were four girl's puberty rituals, all of which ceremonies offered distinct traits of interest; a potlatch to which the Ho'ai'ath Indians of Numukamis bay had been invited; and the wolf ritual, which lasted eight days. The whole of the last ceremony was seen and careful notes taken; during part of its performance I was the only white man allowed to be present. A large number of face paintings used in the wolf ritual was secured from one of the older Indians; they are done in crayon colours.

The museum specimens obtained are not very many in number (upwards of 90) but illustrate many sides of the material and ceremonial life of the Nootkas. They embrace such objects as whaling harpoons and lanyards, whaling spear, sea-lion harpoons and lanyards, fish spear, native boxes, club of bone of whale, cedar-bark shredders, fish clubbers, bows, cedar-bark garments and ornaments, deerskin leggings and moccasins, snowshoes, wedges, ear and nose ornaments, masks, ceremonial whistles, and others. Leggings, moccasins, and snowshoes, all of which were peculiar to the Hopatc'as'ath, practically an inland tribe, have not yet, so far as known, been observed in ethnological literature as found among any of the Nootka tribes.

It is believed that a satisfactory beginning was made of a scientific study of the Nootka Indians. So rich and complex is the field, however, that several years of field work are necessary before anything like a complete account of these Indians can be presented.

II.

Work Among the Arctic Eskimos.

Letters from V. Stefansson, who for several years has been living with the Eskimos of the Arctic, engaged in anthropological studies for the American Museum of Natural History and the Canadian Geological Survey, were received before the close of the year. The last one, under date of April 26, was carried from Cape Lyon by an Eskimo. Mr. Stefansson was then on his way to Coronation gulf. He reports a hard and unfortunate winter. On account of the failure of the hunt, he and his Eskimo companions were at times forced to subsist on snowshoe lashings, skins, and bed-skins. During one period of privation, the Eskimos consumed all of the mammalian zoölogical specimens that had been collected. Parts of the outfit had to be abandoned, but all records and instruments were preserved. Dr. Anderson and one Eskimo had pneumonia, and ten of the eighteen dogs died. At the time of writing, a good game country had been reached, and no further trouble with regard to food was anticipated. Regarding plans for the summer, he writes:—

'We expect to spend the summer with the Coronation Gulf Eskimos, if we find them, and may try to visit Southern Victorialand, if we learn it is inhabited. No systematic mapping of the coast will be tried, for we find Dr. Richardson's work satisfactory in general. He is not to blame for "River la Ronciere," which clearly is non-existent. We have spent a month hunting caribou in its supposed delta and have travelled by sled every mile of coast from the tip of Cape Bathurst to the tip of Cape Parry (as well as most of that distance by skin boats, etc., in summer), and can testify that no stream over 20 miles long other than Horton river (of Franklin's second journey) enters the sea between the two capes.

'The unlikeliness of the delivery of this letter to you causes me to make it brief. I will only add that both Dr. R. M. Anderson and myself hope to get home in the autumn of 1911; we shall then have been three and a half years on the present undertaking.'

MAPPING AND ENGRAVING DIVISION.

(C.-Omer Senécal.)

The personnel of the mapping and engraving division is at present composed of a chief officer, nine draughtsmen, and a clerk. Towards the close of the year 1910 competitive examinations of draughtsmen were held by the Civil Service Commission in order to fill vacancies created by the resignation of two members of the staff, the writer, in company with two officers of the Department of the Interior, acting as examiners. First-class draughtsmen were selected, and it is expected that shortly the staff will be considerably reinforced.

As in former years, the work assigned to this division consisted mainly in the compilation and drawing of original maps and diagrams of all kinds to illustrate geological memoirs, their preparation for reproduction by various processes, their revision for publications, etc., and general geographical work.

Three hundred and eighty-five letters, memoranda, specification sheets, reports, etc., relating to the work of this division, were sent out; while 351 were received.

The meetings of the Geographic Board of Canada were regularly attended by the writer, and place-names appearing on Geological Survey maps were as usual submitted for approval. Lists of approved names are published in the Annual Report of the Board, and from time to time in the *Canada Gazette*. The writer has been appointed on the Executive Committee for the year 1911.

The following 13 maps and drawings are at present in various stages of progress in the hands of the King's Printer. Several editions are expected to be issued within a very short time:—

Victoria Topographical sheet, British Columbia series.
Saanich Topographical sheet, British Columbia series.
Lardeau, B.C., Topographical map.
Phœnix, B.C., Topographical map.
Phœnix, B.C., Geological map.
Jasper Park, Alta., Relief topographical sketch.
Jasper Park, Alta., Stereogram of sections.
Thetford-Black Lake Mining district, Quebec.
Lake Timiskaming mining region, Quebec.
Millstream iron ore deposit, New Brunswick.
Nipisiguit iron ore deposit, New Brunswick.
Province of Nova Scotia, general geography.
Kingsport Geological sheet, No. 84 N. S. series.

There are also several page-size illustrations for memoirs in the printer's hands.

A list of the maps, diagrams, etc., published during the past year, is appended herewith.

List of Map Editions received from the King's Printer during the Year, 1910.

Series A.	Publication Number.	Title.	Number of Accompanying Memoir.	Remarks.
......	1042	Dominion of Canada—Scale, 100 miles to 1 inch	......	Minerals. 3rd edition.
......	1084	" " — " "	......	Geology. 2nd edition.
10	1103	Yukon Territory—Tantalus coal area. Scale, 2 miles to 1 inch	5	Areal geology.
11	1104	" " —Braeburn, Kynocks coal area. Scale, 2 miles to 1 inch	5	" "
1	1095	British Columbia—Hedley map. Scale, 1,000 feet to 1 inch	2	Topography.
2	1096	" " Hedley map. Scale, 1,000 feet to 1 inch	2	Geology.
3	1106	" " —Hedley. Mineral claims on Henry creek. Scale, 800 feet to 1 inch	2	Areal geology.
4	1105	" " —Hedley. Golden Zone mining camp. Scale, 600 feet to 1 inch	2	Economic geology.
......	1125	" " —Hedley. Structure sections. Scale, 1,000 feet to 1 inch	2	Geology.
......	1126	" " —Hedley. Natural section, Nickel Plate mountain. Scale, 450 feet to 1 inch	2	Economic geology.
......	1127	" " —Hedley. Section, No. 3 Tunnel, Nickel Plate mine. Scale, 100 feet to 1 inch	2	" "
......	1128	" " —Hedley. Section running N 70° E, across Nickel Plate mountain. Scale, 450 feet to 1 inch	2	" "
......	1129	" " —Hedley. Section, No. 4 Tunnel, Nickel Plate mine. Scale, 200 feet to 1 inch	2	" "
......	......	" " —Sheep Creek mining camp, West Kootenay. Scale, 1 mile to 1 inch	......	Sketch geological map.
......	......	" " —Deadwood mining area. Scale, 400 feet to 1 inch	......	Topography. Advance edition.
......	1099	North West Territories—Pelly, Ross, and Gravel rivers. Scale, 8 miles to 1 inch	......	Exploratory.
5	1117	Alberta—Edmonton map. Scale, $\frac{1}{3}$ mile to 1 inch	8	Topography.
6	1118	" —Edmonton map. Scale, $\frac{1}{2}$ mile to 1 inch	8	Economic geology.
7	1132	" —Bighorn Coal Basin. Scale, 2 miles to 1 inch	9	Geological reconnaissance.
......	1145	" Bighorn Coal Basin. Birdseye view	9	" "
9	1089	North West Territories and Ontario—Albany, Severn, and Winisk rivers. Scale, 8 miles to 1 inch	......	Exploratory.
......	993	Northwestern Ontario—Country traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake. Scale, 4 miles to 1 inch	......	" 2nd edition.
8	1090	" " —Lake Nipigon map. Scale, 4 miles to 1 inch	1	"
12	1112	Quebec—Country traversed by National Transcontinental railway in Abitibi district. Scale, 4 miles to 1 inch	......	Areal geology. Exploratory.
......	1078	" —St. Bruno map. Scale, 800 feet to 1 inch	......	Topography.
......	1079	" " " "	......	Geology.
14	1134	Nova Scotia—Hall harbour. Sheet No. 99, Kings county. Scale, 1 mile to 1 inch	......	Areal geology.
		Also 11 zinc cut diagrams and illustrations for various reports.		

LIBRARY.

(J. Alexander, Acting Librarian.)

During the calendar year, 3,152 publications were received as gifts or exchanges, including—besides periodicals—maps, reports, and publications of foreign Geological Surveys, together with memoirs, transactions, and proceedings of scientific societies.

149 volumes were purchased, costing $534.62, with 400 Gaylord pamphlet binders at a cost of $26.65.

352 volumes were bound, and 88 periodicals were subscribed for.

202 letters relating to the work of the library were sent out, with 696 acknowledgments of publications received as gifts.

In addition to the current cataloguing work, about 1,500 cards have been re-written and brought up to date.

PUBLICATIONS.

The following Reports have been Published since January 1, 1910.

No.

1006. Report on a Traverse through the Southern part of the North West Territories, from Lac Seul to Cat lake, 1902. By A. W. G. Wilson. Published January 10, 1911. } Bound together.

1080. Report on a Part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers. By W. McInnes. Published January 10, 1911.

1059. Report on a Geological Reconnaissance of the Region traversed by the National Transcontinental railway, between Lake Nipigon and Clay lake, Ont. By W. H. Collins. Published February 18, 1910.

1077. Memoir No. 7: On Geology of St. Bruno mountain. By J. A. Dresser. Published June 24, 1910.

1082. Memoir No. 6: On the Geology of the Haliburton and Bancroft Areas, Ont. By F. D. Adams and A. E. Barlow. Published September 22, 1910.

1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont. By A. W. G. Wilson. Published December 20, 1910.

1093. Memoir No. 2: On the Geology and Ore Deposits of Hedley Mining Camp, B.C. By Chas. Camsell. Published November 2, 1910.

1097. Report on a Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories. By Joseph Keele. Published June 24, 1910.

1101. Memoir No. 5 (Preliminary): On the Lewes and Nordenskiold Rivers Coal district, Yukon. By D. D. Cairnes. Published December 15, 1910.

1107. Report on the Geological Position and Characteristics of the Oil-shale Deposits of Canada, Part II. By R. W. Ells. Published February 24, 1910.

1109. Memoir No. 3: On Palæoniscid Fishes of Albert Shales, N.B.: being Vol. III (quarto) of Contributions to Canadian Palæontology. By Lawrence M. Lambe. Published August 17, 1910.

1115. Memoir No. 8: Preliminary Report on the Edmonton Coal fields. By D. B. Dowling. Published February 13, 1911.

1120. Summary Report, 1909. Published July 7, 1910.

1139. Memoir No. 11: On Triangulation of Vancouver island, B.C. By C. H. Chapman. Published November 25, 1910.

1141. Memoir No. 12-P: Contributions to Canadian Palæontology, Vol. II, Part iii. Canadian Fossil Insects. By Anton Handlirsch. (5) Insects from the Tertiary Lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906. Published January 30, 1911.

1143. Memoir No. 14: Description of Shells collected by John Macoun at Barkley sound, Vancouver island, B.C. By Messrs. W. H. Dall and Paul Bartsch. Published January 16, 1911.

1144. Reprint of J. A. Dresser's Preliminary Report on the Serpentine Belt of Southern Quebec: being pages 180-193 of Geological Survey Summary Report, 1909. Published July 27, 1910.

1146. Notes on Canada. By R. W. Brock. Published August 4, 1910.

SPECIAL REPRINTS.

(I.) Bibliography of Canadian Zoology for 1907, by Lawrence M. Lambe. Transactions of the Royal Society of Canada, Vol. II, 3rd series, 1908-9 (1909).

(II.) The Nepheline and Associated Alkali Syenites of Eastern Ontario, by Frank D. Adams and Alfred E. Barlow. Transactions of the Royal Society of Canada, Vol. II, 3rd series, 1908-9 (1909). Published April 21, 1910.

New Contributions to Canadian Bryology, by N. Conr. Kindberg, Ph.D., Upsala, Sweden. The Ottawa Naturalist, Vol. XXIII, November, 1909, and January, 1910.

Description of a New Species of Ammonite, of the Genus Stepheoceras, from some rocks presumably Jurassic age, in the Nicola valley, B.C., by Dr. J. F. Whiteaves. The Ottawa Naturalist, May, 1909.

Appendices A. and C. of MacMillan's Arctic Explorations—
A.—Palæontology, by Lawrence M. Lambe.
B.—Botany, by James M. Macoun.
Published February 2, 1911.

On Two New Trilobites from the Chazy near Ottawa, by Percy E. Raymond. The Ottawa Naturalist, November, 1910. Published November 28, 1910.

Note on the Parietal Crest of Centrosaurus Afertus, and on a Proposed New Generic name for Stereocephalus Tulus, by Lawrence M. Lambe. The Ottawa Naturalist, December, 1910. Published January 10, 1911.

FRENCH TRANSLATIONS.

(M. Sauvalle.)

No.

999. Preliminary report on Gowganda Mining Division, District of Nipissing, Ont. By W. H. Collins. Published August 24, 1910.

1035*a*. Coal Fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia. By D. B. Dowling. Published March 17, 1911.

1038. Report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake. By W. H. Collins. Published January 27, 1910.

1069. Report on Exploration of East Coast of Hudson bay. By A. P. Low. Published April 20, 1910.

1072. Summary Report, 1908. Published January 17, 1911.

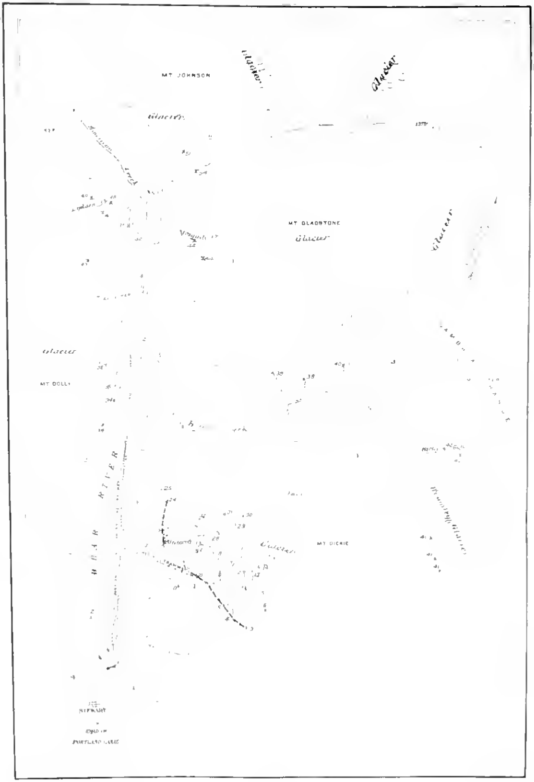
1086. A Descriptive Sketch of the Geology and Economic Minerals of Canada. By G. A. Young: with Introductory by R. W. Brock. Published June 16, 1910.

1114. Report on a Geological Reconnaissance of a Portion of Algoma and Thunder Bay districts. By W. J. Wilson. Published September 13, 1910. } Bound together.

1119. Report on the Region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont. By W. H. Collins. Published September 13, 1910. } Bound together.

Canada
Department of Mines
GEOLOGICAL SURVEY

BRITISH COLUMBIA



LEGEND

Symbols

Note

TUNNELS and PROSPECTS

Jumbo
Chicago No
Chicago No2
Excelsior
Portland Wonder
Sunbeam

MAP 21 A

Sketch Map of

PORTLAND CANAL MINING DISTRICT

BRITISH COLUMBIA

Scale of Miles

1144.

1146.

(I.)

(II.)

New

Desc

Appe

On

Note

No.
999.

1035

1038.

1069.

1072.
1086.

1114.

1119.

ACCOUNTANT'S STATEMENT.

The staff of the Geological Survey at present employed numbers 72. During the calendar year the following changes have taken place:—

Appointments—

P. E. Raymond, E. Sapir. S. G. Alexander, J. J. Carr, C. A. McDonald.

Resignations—

J. F. E. Johnston, O. O'Sullivan, F. O'Farrell.

The funds available for the work. and the expenditure of the Geological Survey for the fiscal year ending March 31, 1910, were:—

Details.	Grant.	Expenditure.
Appropriations..	$349,956 50	
Civil list salaries..		$100,766 34
Explorations and surveys..		81,413 23
Experimental borings for gas, oil, etc....		25,282 00
Printing, engraving, and lithographing.		31,540 43
Books and instruments..		5,228 80
Specimens for Museum..		5,471 54
Stationery, mapping materials, etc.. ..		4,785 02
Wages of temporary employes...		677 19
Incidental and other expenses..		8,031 60
Unexpended balance..		86,759 75
	$349,956 50	$349,956 50

(Signed) JNO. MARSHALL,
Accountant.

All of which is respectfully submitted.

I have the honour to be,
Sir,
Your obedient servant,

(Signed) R. W. BROCK.

INDEX.

A

B

C

T

CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

SELECTED LIST OF REPORTS AND MAPS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE GEOLOGICAL SURVEY.

Report of the Mines Section:—

No. 245.	Report of Mines Section,		1886.	No. 662.	Report of Mines Section,		1897.
272	"	"	1887.	698	"	"	1898.
*300	"	"	1888.	718	"	"	1899.
301	"	"	1889.	744	"	"	1900.
334	"	"	1890.	800	"	"	1901.
335	"	"	1891.	835	"	"	1902.
360	"	"	1892.	893	"	"	1903.
572	"	"	1893-4.	*928	"	"	1904.
602	"	"	1895.	971	"	"	1905.
625	"	"	1896.				

Mineral Production of Canada:—

No. *414.	Year 1886.	No. *422.	Year 1893.	No. 719.	Year 1900.
*415	" 1887.	*555	" 1894	719a	" 1901.
*416	" 1888.	*577	" 1895	813	" 1902.
*417	" 1889.	*612	" 1896.	861	" 1903.
*418	" 1890.	*623	" 1886-96	896	" 1904.
*419	" 1891.	*640	" 1897.	924	" 1905.
*420	" 1886-91	*671	" 1898.	981	" 1906.
*421	" 1892.	*686	" 1899.		

Mineral Resources Bulletin:—

No. *818.	Platinum.	No. 860.	Zinc.	No. 881.	Phosphate.
851.	Coal.	869.	Mica.	882.	Copper.
*854.	Asbestos.	872.	Molybdenum and Tungsten.	913.	Mineral Pigments.
857.	Infusorial Earth.	*877.	Graphite.	953.	Barytes.
858.	Manganese.	880.	Peat.	984.	Mineral Pigments (French).
859	Salt.				

Report of the Section of Chemistry and Mineralogy:—

No. *102.	Year 1874-5.	No. *169.	Year 1882-3-4.	No. 580.	Year 1894.
*110	" 1875-6.	222.	" 1885.	616	" 1895.
*119	" 1876-7.	246	" 1886.	651	" 1896.
*126	" 1877-8.	273	" 1887-8.	695	" 1898.
*138	" 1878-9.	299	" 1888-8.	724	" 1899.
*148	" 1879-80.	333	" 1890-1.	821	" 1900.
*156	" 1880-1-2.	359	" 1892-3.	*958	" 1906.

*Publications marked thus are out of print.

REPORTS.

GENERAL.

745. Altitudes of Canada, by J. White. 1899.
*972. Descriptive Catalogue of Minerals and Rocks, by R. A. A. Johnston and G. A. Young.
1073. Catalogue of Publications: Reports and Maps (1843-1909).
1085. Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. = 1 in.
1086. French translation of Descriptive Sketch of the Geology and Economic Minerals of Canada, by G. A. Young, and Introductory by R. W. Brock. Maps No. 1084; No. 1042 (second edition), scale 100 m. =1 in.
1107. Part II. Geological position and character of the oil-shale deposits of Canada, by R. W. Ells.
1146. Notes on Canada, by R. W. Brock.

YUKON.

*260. Yukon district, by G. M. Dawson. 1887. Maps No. 274, scale 60 m. =1 in.; Nos. 275 and 277, scale 8 m=1 in.
*295. Yukon and Mackenzie basins, by R. G. McConnell. 1889. Map No. 304, scale 48 m. =1 in.
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. Map No. 688, scale 2 m. =1 in.
884. Klondike gold fields, by R. G. McConnell. 1901. Map No. 772, scale 2 m. = 1 in.
*909. Windy Arm, Tagish lake, by R. G. McConnell. 1906. Map No. 916, scale 2 m. =1 in.
943. Upper Stewart river, by J. Keele. Map No. 938, scale 8 m. =1 in. } Bound together.
951. Peel and Wind rivers, by Chas. Camsell. Map No. 942, scale 8 m. =1 in. } Bound together.
979. Klondike gravels, by R. G. McConnell. Map No. 1011, scale 40 ch. =1 in.
982. Conrad and Whitehorse mining districts, by D. D. Cairnes. 1901. Map No. 990, scale 2 m. =1 in.
1016. Klondike Creek and Hill gravels, by R. G. McConnell. (French.) Map No. 1011, scale 40 ch. =1 in.
1050. Whitehorse Copper Belt, by R. G. McConnell. Maps Nos. 1,026, 1,041, 1,044-1,049.
1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. =1 in.
1011. Memoir No. 5 (Preliminary) : on the Lewes and Nordenskiöld Rivers coal field, Yukon, by D. D. Cairnes. Maps Nos. 1103 and 1104, scale 2 m. = 1 in.

BRITISH COLUMBIA.

212. The Rocky mountains (between latitudes 49° and 51° 30′), by G. M. Dawson. 1885. Map No. 223, scale 6 m. =1 in. Map No. 224, scale 1½ m. =1 in.
*235. Vancouver island, by G. M. Dawson. 1886. Map No. 247, scale 8 m. = 1 in.
236. The Rocky mountains, geological structure, by R. G. McConnell. 1886. Map No. 248, scale 2 m. =1 in.
263. Cariboo mining district, by A. Bowman. 1887. Maps Nos. 278-281.
*271. Mineral wealth, by G. M. Dawson.
*294. West Kootenay district, by G. M. Dawson. 1888-9. Map No. 303, scale 8 m. =1 in.
*573. Kamloops district, by G. M. Dawson. 1894. Maps Nos. 556 and 557, scale 4 m. =1 in.
574. Finlay and Omineca rivers, by R. G. McConnell. 1894. Map No. 567 scale 8 m. =1 in.

---

* Publications marked thus are out of print.

743. Atlin Lake mining division, by J. C. Gwillim. 1899. Map No. 742, scale 4 m. = 1 in.
939. Rossland district, by R. W. Brock. Map No. 941, scale 1,600 ft. = 1 in.
*940. Graham island, by R. W. Ells. 1905. Maps No. 921, scale 4 m. = 1 in; No. 922, scale 1 m. = 1 in.
986. Similkameen district, by Chas. Camsell. Map No. 987, scale 400 ch. = 1 in.
988. Telkwa river and vicinity, by W. W. Leach. Map No. 989, scale 2 m. = 1 in.
996. Nanaimo and New Westminster districts, by O. E. LeRoy. 1907. Map No. 997, scale 4 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling.
1093. Geology, and Ore Deposits of Hedley Mining district, British Columbia, by Charles Camsell. Maps Nos. 1095 and 1096, scale 1,000 ft. = 1 in.; No. 1105, scale 600 ft. = 1 in.; No. 1106, scale 800 ft. = 1 in.; No. 1125, scale 1,000 ft. = 1 in.

ALBERTA.

*237. Central portion, by J. B. Tyrrell. 1886. Maps Nos. 249 and 250, scale 8 m. = 1 in.
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-1. Map No. 336, scale 48 m. = 1 in.
703. Yellowhead Pass route, by J. McEvoy. 1898. Map No. 676, scale 8 m. = 1 in.
*949. Cascade coal-fields, by D. B. Dowling. Maps (8 sheets) Nos. 929-936, scale 1 m. = 1 in.
968. Moose Mountain district, by D. D. Cairnes. Maps No. 963, scale 2 m. = 1 in.; No. 966, scale 1 m. = 1 in.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1035a. French translation of coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.
1115. Memoir No. 8-E: Edmonton coal-field, by D. B. Dowling. Maps Nos. 1117–5A and 1118–6A, scale 2640 ft. = 1 in.

SASKATCHEWAN.

213. Cypress hills and Wood mountain, by R. G. McConnell. 1885. Maps Nos. 225 and 226, scale 8 m. = 1 in.
601. Country between Athabaska lake and Churchill river, by J. B. Tyrrell and D. B. Dowling. 1895. Map No. 957, scale 25 m. = 1 in.
868. Souris River coal-field, by D. B. Dowling. 1902.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.

MANITOBA.

264. Duck and Riding mountains, by J. B. Tyrrell. 1887-8. Map No. 282, scale 8 m. = 1 in.
296. Glacial Lake Agassiz, by W. Upham. 1889. Maps Nos. 314, 315, 316.
325. Northwestern portion, by J. B. Tyrrell. 1890-1. Maps Nos. 339 and 350, scale 8 m. = 1 in.
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. Map No. 664, scale 8 m. = 1 in. } Bound together.
705. Lake Winnipeg (east shore), by J. B. Tyrrell. 1898. Map No. 664, scale 8 m. = 1 in. } Bound together.
1035. Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia, by D. B. Dowling. Map No. 1010, scale 35 m. = 1 in.

NORTH WEST TERRITORIES.

217. Hudson bay and strait, by R. Bell. 1885. Map No. 229, scale 4 m. = 1 in.
238. Hudson bay, south of, by A. P. Low. 1886.
239. Attawapiskat and Albany rivers, by R. Bell. 1886.

*Publications marked thus are out of print.

244. Northern portion of the Dominion, by G. M. Dawson. 1886. Map No. 255, scale 200 m. =1 in.

267. James bay and country east of Hudson bay, by A. P. Low.

578. Red lake and part of Berens river, by D. B. Dowling. 1894. Map No. 576, scale 8 m. =1 in.

*584. Labrador peninsula, by A. P. Low. 1895. Maps Nos. 585-588, scale 25 m. =1 in.

618. Dubawnt, Kazan, and Ferguson rivers, by J. B. Tyrrell. 1896. Map No. 603, scale 25 m. =1 in.

657. Northern portion of the Labrador peninsula, by A. P. Low.

680. South Shore Hudson strait and Ungava bay, by A. P. Low. Map No. 699, scale 25 m. =1 in.
713. North Shore Hudson strait and Ungava bay, by R. Bell. Map No. 699, scale 25 m. =1 in.
} Bound together.

725. Great Bear lake to Great Slave lake, by J. M. Bell. 1900.

778. East Coast Hudson bay, by A. P. Low. 1900. Maps Nos. 779, 780, 781, scale 8 m. =1 in.

786–787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900.

815. Ekwan river and Sutton lakes, by D. B. Dowling. 1901. Map No. 751, scale 50 m. =1 in.

819. Nastapoka islands, Hudson bay, by A. P. Low. 1900.

905. The Cruise of the *Neptune*, by A. P. Low. 1905.

1006. Report of a Traverse through the Southern Part of the North West Territories, from Lac Seul to Cat lake, 1902, by A. W. G. Wilson.
1080. Report on a Part of the North West Territories, drained by the Winisk and Upper Attawapiskat rivers, by W. McInnes. Map No. 1089, scale 8 m. = 1 in.
} Bound together.

1069. French translation report on an exploration of the East coast of Hudson bay, from Cape Wolstenholme to the south end of James bay, by A. P. Low. Maps Nos. 779, 780, 781, scale 8 m. =1 in.; No. 785, scale 50 m. =1 in.

1097. Reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon, and North West Territories, by Joseph Keele. Map No. 1099, scale 8 m. =1 in.

ONTARIO.

215. Lake of the Woods region, by A. C. Lawson. 1885. Map No. 227, scale 2 m. =1 in.

*265. Rainy Lake region, by A. C. Lawson. 1887. Map No. 283, scale 4 m. = 1 in.

266. Lake Superior, mines and mining, by E. D. Ingall. 1888. Maps No. 285, scale 4 m. =1 in.; No. 286, scale 20 ch. =1 in.

326. Sudbury mining district, by R. Bell. 1890-1. Map No. 343, scale 4 m. =1 in.

327. Hunter island, by W. H. C. Smith. 1890-1. Map No. 342, scale 4 m. = 1 in.

332. Natural Gas and Petroleum, by H. P. H. Brumell. 1890-1. Maps Nos. 344-349.

357. Victoria, Peterborough, and Hastings counties, by F. D. Adams. 1892-3.

627. On the French River sheet, by R. Bell. 1896. Map No. 570, scale 4 m. =1 in.

678. Seine river and Lake Shebandowan map-sheets, by W. McInnes. 1897. Maps Nos. 589 and 560, scale 4 m. =1 in.

723. Iron deposits along the Kingston and Pembroke railway, by E. D. Ingall. 1900. Map No. 626, scale 2 m. =1 in.; and plans of 13 mines.

*739. Carleton, Russell, and Prescott counties, by R. W. Ells. 1899. (*See* No. 739, Quebec.)

741. Ottawa and vicinity, by R. W. Ells. 1900.

790. Perth sheet, by R. W. Ells. 1900. Map No. 789, scale 4 m. =1 in.

961. Sudbury Nickel and Copper deposits, by A. E. Barlow. (Reprint.) Maps Nos. 775, 820, scale 1 m. =1 in.; Nos. 824, 825, 864, scale 400 ft. = 1 in.

962. Nipissing and Timiskaming map-sheets, by A. E. Barlow. (Reprint.) Maps Nos. 599, 606, scale 4 m. =1 in.; No. 944, scale 1 m. =1 in.

---

*Publications marked thus are out of print.

965. Sudbury Nickel and Copper deposits, by A. E. Barlow. (French.)
970. Report on Niagara Falls, by J. W. Spencer. Maps Nos. 926, 967.
977. Report on Pembroke sheet, by R. W. Ells. Map No. 660, scale 4 m. = 1 in.
980. Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in.
1081. On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in.
} Bound together.
992. Report on Northwestern Ontario, traversed by National Transcontinental railway, between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
998. Report on Pembroke sheet, by R. W. Ells. (French.) Map No. 660, scale 4 m. = 1 in.
999. French translation Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1038. French translation report on the Transcontinental Railway location between Lake Nipigon and Sturgeon lake, by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1059. Geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont., by W. H. Collins. Map No. 993, scale 4 m. = 1 in.
1075. Gowganda Mining Division, by W. H. Collins. Map No. 1076, scale 1 m. = 1 in.
1082. Memoir No. 6: Geology of the Haliburton and Bancroft areas, Ont., by Frank D. Adams and Alfred E. Barlow. Maps No. 708, scale 4 m. = 1 in.; No. 770, scale 2 m. = 1 in.
1091. Memoir No. 1: On the Geology of the Nipigon basin, Ont., by A. W. G. Wilson. Map No. 1090, scale 4 m. = 1 in.
1114. French translation: Geological reconnaissance of a portion of Algoma and Thunder Bay district, Ont., by W. J. Wilson. Map No. 964, scale 8 m. = 1 in.
1119. French translation: On the region lying north of Lake Superior, between the Pic and Nipigon rivers, Ont., by W. H. Collins. Map No. 964, scale 8 m. = 1 in.
} Bound together.

QUEBEC.

216. Mistassini expedition, by A. P. Low. 1884-5. Map No. 228, scale 8 m. = 1 in.
240. Compton, Stanstead, Beauce, Richmond, and Wolfe counties, by R. W. Ells. 1886. Map No. 251 (Sherbrooke sheet), scale 4 m. = 1 in.
268. Megantic, Beauce, Dorchester, Levis, Bellechasse, and Montmagny counties, by R. W. Ells. 1887-8. Map No. 287, scale 40 ch. = 1 in.
297. Mineral resources, by R. W. Ells. 1889.
328. Portneuf, Quebec, and Montmagny counties, by A. P. Low. 1890-1.
579. Eastern Townships, Montreal sheet, by R. W. Ells and F. D. Adams. 1894. Map No. 571, scale 4 m. = 1 in.
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. Map No. 590, scale 4 m. = 1 in.
670. Auriferous deposits, southeastern portion, by R. Chalmers. 1895. Map No. 667, scale 8 m. = 1 in.
707. Eastern Townships, Three Rivers sheet, by R. W. Ells. 1898.
*739. Argenteuil, Ottawa, and Pontiac counties, by R. W. Ells. 1899. (*See* No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. *Map No. 702, scale 10 m. = 1 in.
863. Wells on Island of Montreal, by F. D. Adams. 1901. Maps Nos. 874, 875, 876.
923. Chibougamau region, by A. P. Low. 1905.
962. Timiskaming map-sheet, by A. E. Barlow. (Reprint). Maps Nos. 599, 606, scale 4 m. = 1 in.; No. 944, scale 1 m. = 1 in.
974. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. Map No. 976, scale 8 m. = 1 in.
975. Report on Copper-bearing rocks of Eastern Townships, by J. A. Dresser. (French).
998. Report on the Pembroke sheet, by R. W. Ells. (French).
1028. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. Map No. 1029, scale 2 m. = 1 in.

*Publications marked thus are out of print.

1032. Report on a Recent Discovery of Gold near Lake Megantic, Que., by J. A. Dresser. (French). Map No. 1029, scale 2 m. = 1 in.
1052. French translation report on Artesian wells in the Island of Montreal, by Frank D. Adams and O. E. LeRoy. Maps Nos. 874, scale 4 m. = 1 in.; No. 375, scale 3,000 ft. = 1 in.; No. 876.
1144. Reprint of Summary Report on the Serpentine Belt of Southern Quebec, by J. A. Dresser.

NEW BRUNSWICK.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. Map No. 230, scale 4 m. = 1 in.
219. Carleton and Victoria counties, by L. W. Bailey. 1885. Map No. 231, scale 4 m. = 1 in.
242. Victoria, Restigouche, and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. Map No. 254, scale 4 m. = 1 in.
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887–8. Map No. 290, scale 4 m. = 1 in.
330. Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890–1. Map No. 350, scale 4 m. = 1 in.
661. Mineral resources, by L. W. Bailey. 1897. Map No. 675, scale 10 m. = 1 in. New Brunswick geology, by R. W. Ells. 1887.
799. Carboniferous system, by L. W. Bailey. 1900. } Bound together.
803. Coal prospects in, by H. S. Poole. 1900. } Bound together.
983. Mineral resources, by R. W. Ells. Map No. 969, scale 16 m. = 1 in.
1034. Mineral resources, by R. W. Ells. (French). Map No. 969, scale 16 m. = 1 in.

NOVA SCOTIA.

243. Guysborough, Antigonish, Pictou, Colchester, and Halifax counties, by Hugh Fletcher and E. R. Faribault. 1886.
331. Pictou and Colchester counties, by H. Fletcher. 1890–1.
358. Southwestern Nova Scotia (preliminary), by L. W. Bailey. 1892–3. Map No. 362, scale 8 m. = 1 in.
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. Map No. 641, scale 8 m. = 1 in.
685. Sydney coal-field, by H. Fletcher. Maps Nos. 652, 653, 654, scale 1 m. = 1 in.
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900
871. Pictou coal-field, by H. S. Poole. 1902. Map No. 833, scale 25 ch. = 1 in.

MAPS.

1042. Dominion of Canada. Minerals. Scale 100 m. = 1 in.

YUKON.

*805. Explorations on Macmillan, Upper Pelly, and Stewart rivers, scale 8 m. = 1 in.
891. Portion of Duncan Creek Mining district, scale 6 m. = 1 in.
894. Sketch Map Kluane Mining district, scale 6 m. = 1 in.
*916. Windy Arm Mining district, Sketch Geological Map, scale 2 m. = 1 in.
990. Conrad and Whitehorse Mining districts, scale 2 m. = 1 in.
991. Tantalus and Five Fingers coal mines, scale 1 m. = 1 in.
1011. Bonanza and Hunker creeks. Auriferous gravels. Scale 40 chains = 1 in.
1033. Lower Lake Laberge and vicinity, scale 1 m. = 1 in.
1041. Whitehorse Copper belt, scale 1 m. = 1 in.
1026. 1044–1049. Whitehorse Copper belt. Details.
1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.
1103. Tantalus Coal area, Yukon. Scale 2 m. = 1 in.
1104. Braeburn-Kynocks Coal area, Yukon. Scale 2 m. = 1 in.

*Publications marked thus are out of print.

BRITISH COLUMBIA.

278. Cariboo Mining district, scale 2 m. = 1 in.
604. Shuswap Geological sheet, scale 4 m. = 1 in.
*771. Preliminary Edition, East Kootenay, scale 4 m. = 1 in.
767. Geological Map of Crowsnest coal-fields, scale 2 m. = 1 in.
*791. West Kootenay Minerals and Striæ, scale 4 m. = 1 in.
*792. West Kootenay Geological sheet, scale 4 m. = 1 in.
828. Boundary Creek Mining district, scale 1 m. = 1 in.
890. Nicola coal basin, scale 1 m. = 1 in.
941. Preliminary Geological Map of Rossland and vicinity, scale 1,600 ft. = 1
987. Princeton coal basin and Copper Mountain Mining camp, scale 40 ch. = 1 in
989. Telkwa river and vicinity, scale 2 m. = 1 in.
997. Nanaimo and New Westminster Mining division, scale 4 m. = 1 in.
1001. Special Map of Rossland. Topographical sheet. Scale 400 ft. = 1 in.
1002. Special Map of Rossland. Geological sheet. Scale 400 ft. = 1 in.
1003. Rossland Mining camp. Topographical sheet. Scale 1,200 ft. = 1 in.
1004. Rossland Mining camp. Geological sheet. Scale 1,200 ft. = 1 in.
1068. Sheep Creek Mining camp. Geological sheet. Scale 1 m. = 1 in.
1074. Sheep Creek Mining camp. Topographical sheet. Scale 1 m. = 1 in.
1095. 1A.—Hedley Mining district. Topographical sheet. Scale 1,000 ft. = 1 in.
1096. 2A.—Hedley Mining district. Geological sheet. Scale 1,000 ft. = 1 in.
1105. 4A.—Golden Zone Mining camp. Scale 600 ft. = 1 in.
1106. 3A.—Mineral Claims on Henry creek. Scale 800 ft. = 1 in.
1125. Hedley Mining district: Structure Sections. Scale 1,000 ft. = 1 in.
Deadwood Mining camp. Scale 400 ft. = 1 in. (Advance sheet.)

ALBERTA.

594–596. Peace and Athabaska rivers, scale 10 m. = 1 in.
*808. Blairmore-Frank coal-fields, scale 180 ch. = 1 in.
892. Costigan coal basin, scale 40 ch. = 1 in.
929–936. Cascade coal basin. Scale 1 m. = 1 in.
963–966. Moose Mountain region. Coal Areas. Scale 2 m. = 1 in.
1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.
1117. 5A.—Edmonton. (Topography). Scale ½ m. = 1 in.
1118. 6A.—Edmonton. (Clover Bar Coal Seam). Scale ½ m. = 1 in.
1132. 7A.—Bighorn coal-field. Scale 2 m. = 1 in.

SASKATCHEWAN.

1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.

MANITOBA.

804. Part of Turtle mountain showing coal areas. Scale 1½ m. = 1 in.
1010. Alberta, Saskatchewan, and Manitoba. Coal Areas. Scale 35 m. = 1 in.

NORTH WEST TERRITORIES.

1089. Explored routes on Albany, Severn, and Winisk rivers. Scale 8 m. = 1 in.
1099. Pelly, Ross, and Gravel rivers, Yukon and North West Territories. Scale 8 m. = 1 in.

ONTARIO.

227. Lake of the Woods sheet, scale 2 m. = 1 in.
*283. Rainy Lake sheet, scale 4 m. = 1 in.
*342. Hunter Island sheet, scale 4 m. = 1 in.
343. Sudbury sheet, scale 4 m. = 1 in.
*373. Rainy River sheet, scale 2 m. = 1 in.
560. Seine River sheet, scale 4 m. = 1 in.
570. French River sheet, scale 4 m. = 1 in.

*Publications marked thus are out of print.

*589. Lake Shebandowan sheet, scale 4 m. =1 in.
599. Timiskaming sheet, scale 4 m. =1 in. (New Edition 1907).
605. Manitoulin Island sheet, scale 4 m. =1 in.
606. Nipissing sheet, scale 4 m. =1 in. (New Edition 1907).
660. Pembroke sheet, scale 4 m. =1 in.
663. Ignace sheet, scale 4 m. =1 in.
708. Haliburton sheet, scale 4 m. =1 in.
720. Manitou Lake sheet, scale 4 m. =1 in.
*750. Grenville sheet, scale 4 m. =1 in.
770. Bancroft sheet, scale 2 m. =1 in.
775. Sudbury district, Victoria mines, scale 1 m. = 1 in.
*789. Perth sheet, scale 4 m. =1 in.
820. Sudbury district, Sudbury, scale 1 m. =1 in.
824-825. Sudbury district, Copper Cliff mines, scale 400 ft. =1 in.
852. Northeast Arm of Vermilion Iron ranges, Timagami, scale 40 ch. =1 in.
864. Sudbury district, Elsie and Murray mines, scale 400 ft. =1 in.
903. Ottawa and Cornwall sheet, scale 4 m. =1 in.
944. Preliminary Map of Timagami and Rabbit lakes, scale 1 m. =1 in.
964. Geological Map of parts of Algoma and Thunder bay, scale 8 m. =1 in.
1023. Corundum Bearing Rocks. Central Ontario. Scale 17½ m. = 1 in.
1076. Gowganda Mining Division, scale 1 m. =1 in.
1090. Lake Nipigon, Thunder Bay district, Ont. Scale 4 m. =1 in.

QUEBEC.

*251. Sherbrooke sheet, Eastern Townships Map, scale 4 m. =1 in.
287. Thetford and Coleraine Asbestos district, scale 40 ch. =1 in.
375. Quebec sheet, Eastern Townships Map, scale 4 m. =1 in.
*571. Montreal sheet, Eastern Townships sheet, scale 4 m. =1 in.
*665. Three Rivers sheet, Eastern Townships Map, scale 4 m. =1 in.
667. Gold Areas in southeastern part, scale 8 m. =1 in.
*668. Graphite district in Labelle county, scale 40 ch. =1 in.
918. Chibougamau region, scale 4 m. =1 in.
976. The Older Copper-bearing Rocks of the Eastern Townships, scale 8 m. =1 in
1007. Lake Timiskaming region, scale 2 m. =1 in.
1029. Lake Megantic and vicinity, scale 2 m. =1 in.
1066. Lake Timiskaming region. Scale 1 m. =1 in.

NEW BRUNSWICK.

*675. Map of Principal Mineral Occurrences. Scale 10 m. =1 in.
969. Map of Principal Mineral Localities. Scale 16 m. =1 in.

NOVA SCOTIA.

*812. Preliminary Map of Springhill coal-field, scale 50 ch. =1 in.
833. Pictou coal-field, scale 25 ch. =1 in.
897. Preliminary Geological Plan of Nictaux and Torbrook Iron district, scale 25 ch. =1 in.
927. General Map of Province showing gold districts, scale 12 m. =1 in.
937. Leipsigate Gold district, scale 500 ft. =1 in.
945. Harrigan Gold district, scale 400 ft. =1 in.
995. Malaga Gold district, scale 250 ft. =1 in.
1012. Brookfield Gold district, scale 250 ft. =1 in.
1019. Halifax Geological sheet. No. 68. Scale 1 m. =1 in.
1025. Waverley Geological sheet. No. 67. Scale 1 m. =1 in.
1036. St. Margaret Bay Geological sheet. No. 71. Scale 1 m. =1 in.
1037. Windsor Geological sheet. No. 73. Scale 1 m. =1 in.
1043. Aspotogan Geological sheet. No. 70. Scale 1 m. =1 in.

NOTE.—Individual Maps or Reports will be furnished free to *bona fide* Canadian applicants.

Reports and Maps may be ordered by the numbers prefixed to titles.

Applications should be addressed to The Director, Geological Survey Department of Mines, Ottawa.

---

*Publications marked thus are out of print.

SUMMARY REPORT

OF THE

MINES BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR ENDING DECEMBER 31

1910

PRINTED BY ORDER OF PARLIAMENT

OTTAWA
PRINTED BY C. H. PARMELEE, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1911

To His Excellency the Right Honourable Sir Albert Henry George, Earl Grey, Viscount Howick, Baron Grey of Howick, a Baronet, G.C.M.G., &c., &c., &c., Governor General of Canada.

MAY IT PLEASE YOUR EXCELLENCY:

The undersigned has the honour to lay before Your Excellency, in compliance with 6-7 Edward VII, Chapter 29, section 18, the Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1910.

(Signed) W. TEMPLEMAN,
Minister of Mines.

Hon. Wm. Templeman,
Minister of Mines,
Ottawa.

Sir:—I have the honour to submit herewith, the Director's Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1910.

I am, sir, your obedient servant,

(Signed) A. P. LOW,
Deputy Minister.

CONTENTS.

Director's General Report—

Reports on Chemical Laboratories, Statistical Division, Assay Office, Fuel Testing Station, Metallurgical Laboratory, Etc.

ILLUSTRATIONS.

Photographs.

Drawings.

Maps.

SUMMARY REPORT

OF THE

MINES BRANCH OF THE DEPARTMENT OF MINES

FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1910

A. P. Low, Esq., LL.D.,
Deputy Minister,
Department of Mines.

Sir:—

I have the honour to submit, herewith, the Summary Report of the Mines Branch of the Department of Mines for the calendar year ending December 31, 1910.

CHANGES IN STAFF.

Theophile C. Denis, B.Sc., Mining Engineer, resigned March 31, 1910, to accept the position of Superintendent of Mines, Department of Colonization, Mines, and Fisheries, Province of Quebec.

During the year the following appointments have been made to fill positions on the staff of the Mines Branch:—

Geo. C. Mackenzie, B.Sc., M.E., appointed April 1, 1910, as ore dressing expert.

J. G. S. Hudson, M.E.—who had been employed by the Mines Branch since August, 1908, to prepare a report on "Coal Mining in Nova Scotia"—was appointed as mining engineer on April 1, 1910.

H. S. de Schmid, M.E., appointed in May, 1910, as mining engineer.

Edgar Stansfield, M.Sc., appointed July 1, 1910, as chemist.

L. H. S. Cole, B.Sc., appointed August 22, 1910, as assistant mining engineer.

C. T. Cartwright, M.E., appointed May 19, 1910, as assistant mining engineer.

A. Ellement, appointed as packer, Aug. 3, 1910.

INTRODUCTORY.

A glance at the various lines of economic work indicated in the following pages, and at the description of the new enterprises undertaken, will show that the work of the Mines Branch is becoming more *practical* every year. This is evidenced by the rapid exhaustion of the monographs on the chief mineral resources of the country: such as asbestos, mica, etc.; and the increasing demand for the bulletins on electric smelting of iron ores and on the manufacture of peat fuel.

Among the new lines of mineralogical investigation initiated during the year, was that of a study of the building and ornamental stones of Canada. This work is of considerable importance in view of the great demand for building materials needed in the construction of the immense number of homes, innumerable civic institutions, public works, and industrial establishments necessitated by our progressive civilization. But while the work done towards utilizing the metallic and non-metallic mineral resources of the country is of ever increasing importance, the immediate necessity of protecting the lives of the army of men engaged in the mining industries of the Dominion is of paramount importance. The annual loss of life in Canada, due to explosions in mines and factories, has been deplorable—as the comparative statistics on page 157 clearly show. Most of the accidents were due to lack of protective laws and regulations. Perceiving this, the Mines Branch set to work early in the year to remedy this state of affairs. Aided by the best expert assistance available, information and data regarding the conditions peculiar to Canada were gathered, and a comprehensive Explosives Bill prepared and duly submitted to Parliament by the Honourable the Minister of Mines on December 13, 1910. If anything could expedite the passing of such a Bill, it assuredly should be the reading of the reports on pages 137, 140 and 144, giving detailed accounts of the three terrible disasters which occurred during 1910—while the Explosives Bill was being prepared.

In connexion with this question of explosives, one of the most urgent requirements is the establishment of an explosives testing station at Ottawa—under direct governmental control. Preliminary steps have already been taken towards the planning of such a station. A suitable site is available, in close proximity to the government Fuel Testing Station and concentration laboratory on Dolly Varden and Division Streets, Ottawa.

In keeping with the government policy of taking the initial steps towards developing the material resources of the country—as in the case of electric smelting of refractory iron ores, and the manufacture of cheap peat fuel; so, this year, the Mines Branch has established a permanent magnetic separation and concentration plant at Ottawa. When it is remembered that over 80 per cent of the iron ores used in the blast furnaces of Canada are imported, any movement which promises to economically utilize our own resources, encourage the investment of capital, and employ Canadian labour, is manifestly a step in the right direction. This is precisely what the installation of a modern ore dressing and concentration laboratory at Ottawa means.

PROGRESS IN ELECTRO-METALLURGY.

During 1910 very little progress was made in Canada along the lines of electric smelting.

Three years ago, inactivity on the part of practical men was attributed to the lack of evidence as to the commercial advantages of the electro-thermic process. In August, 1909, however, the proof of the practicability of the electric shaft furnace for the smelting of refractory iron ores on a commercial scale was set forth in a Mines Branch report on the subject[1]; and all subsequent data have been confirmatory of the satisfactory results then given out.

The following extracts from foreign technical journals, and communications from reliable official sources, will show that the commercial advantages of the electric furnace for the smelting of iron ores are being fully recognized and utilized by other countries.

EXTRACT FROM *Page's Weekly*, LONDON, ENGLAND, SEPTEMBER, 1910.

Electric Smelting in Norway.

"Foremost among the new industrial projects in the Bergen district must be placed that of the electric smelting of iron and steel. As far as I can ascertain, writes Consul F. Drummond-Hay, two processes have been tried in western Norway. One of these is described as the method employed by the Noble Electric Steel Company at Heroult, in California, and is stated to have been tried at some smelting works at Trondhjem. The other method is the Grönvall process; and a company is being formed for the erection of electric iron and steel smelting works near the growing industrial centre of Odda, in Hardanger: the necessary electric power to be supplied by the Tysoe Falls Company, in that neighbourhood. It is stated that this undertaking will probably prove of great importance for the utilization of Norwegian low grade ores."

Teknisk Tidskrift, September 10, 1910.

The Electric Smelting of Iron Ore in Sweden.

The first experiments in electric smelting of iron ore in our country were made in 1906, and have since then continued with various types of furnaces and gradually added improvements. We have now advanced so far, that it may be stated that the results obtained indicate that, *the economical solution of the production of pig iron in the electric furnace has been made within known limits.*

The experimental furnace at Domnarfvet is now torn down, and work has commenced in the erection of new electric furnaces, thus pointing to the introduction of a permanent production of pig iron by the electro-thermic process. Power will be furnished by the new power station at Bullerforsen, which at high water delivers 24,000 H.P. Not less than ten such furnaces will be gradually erected by the Stora Kopparbergs Bergslags Aktiebolag at Domnarfvet, and for their operation a new power plant is being planned at Forshuford above the Kvarnsveden paper mill. The furnace now under construction is expected to be ready for operation in February of next year, and is designed for a production of 12,000 tons of pig iron per year from 4,000 H.P. The cost of the furnace is estimated at 40,000 kronor.

The experimental furnace now being built at Trollhättan will require 2,500 H.P. with a yearly production of 7,000 tons of iron.

The Hoganas works are also interested in the electric smelting method, and are at the present time constructing one furnace with yearly capacity of 10,000 tons of pig iron, and intend to gradually increase their plant to ten furnaces of 10,000 to 12,000 tons each.

These better known projects for the utilization by the electric process of the country's iron ore resources mean a yearly pig iron production of 250,000 tons, which is a significant revolution in the pig iron production, a development of our water powers, and increased mining of iron ore.

August 6, 1910.

Announcement made by *The Mining and Scientific Press* that 5 additional electric furnaces for the production of pig iron are being installed at Heroult-on-the-Pitt, Shasta county, California.

The plans drawn by Engineer Carl von Waldeck for Mr. Boholm of Trondhjem, Norway, for the erection of an electric smelting plant producing pig iron, contemplate the use of the Lyon's furnace, type of which is in operation at Heroult-on-the-Pitt, Shasta county, California.

[1]See report (No. 32) on the Investigation of an Electric Shaft Furnace, Domnarfvet, Sweden, (Second Edition), by Dr. Eugene Haanel, 1909.

Extracts from Swedish Journals.

Plate I.

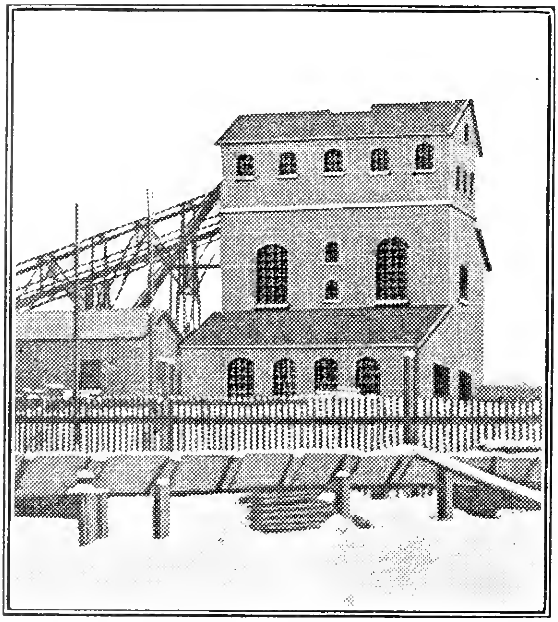


Foto. Wallén, Trollhattan *Kliché: Bengt Silfversparre*

Jarnkontorets Experimental Electric Furnace, Trollhättan.

(*a*)

The electric furnace at Trollhättan has been in continuous operation since Nov. 15 (1910) and the results of the experiments indicate the realization of the highest expectations. Any exact figure as to the production of pig iron, per H.P. year, is not obtainable; but, it has been stated authoritatively, that it is more than 3 tons. (From *Weekly Magazine*, Gothenburg—Hvar 8 Dag.)

(*b*)

With all preliminary work concluded at the Alfharleby waterfall, it has been decided to commence immediately the work of developing power, with an initial installation of machinery for 18,000 H. P. (to be increased to 42,000).

(*c*)

Since the commercial success of the electric smelting method of iron ore has been established by the most favourable results obtained by Jarnkontoret's electric smelting furnace at Trollhättan, a large part of this power is to be used for this purpose. (*Svenska Dagbladet*)

Communication From Swedish Consul.

Sweden.

The Royal Swedish Consulate in Montreal communicates the following information regarding the progress of electric smelting in Sweden and Norway, which data were obtained from the Royal Department of Foreign Affairs, Sweden:—

(1) The furnace at Trollhättan is constructed for 2,500 H.P. with a production of about 7,500 tons.

(2) At Domnarfvet one furnace of 4,000 H.P., with 12,000 tons capacity, is under construction and is expected to be in operation this summer.

(3) Another large iron works, the name of which at the present time we are not at liberty to give, will erect two furnaces of 2,500 H.P. each, with a combined output of 15,000 tons. These furnaces should be in operation this coming autumn.

Regarding the results obtained at Jarnkontorets furnace at Trollhättan, we are not at the present time in possession of an official report, but may communicate that the furnace has been running continuously since November 15, and up to the 18th of February produced 1,271 tons pig iron, with a power consumption of 2,150 kw. hours (corresponding to 3,000 kg. (3·3 tons) pig iron per H.P. year). Coal consumption is 24·40 hectolitres (of 70% C), and the electrode consumption of 11 kg. gross weight and 6 kg. net weight per ton of pig iron. These figures are averages for the whole period of the run.

It may also be stated that the durability of the furnace has proved to be very satisfactory. (The above figure, 2,150 kw., has been obtained according to a curve of correction, recently obtained when controlling the measuring instruments at Trollhättan)

These furnaces are all constructed according to the patents of A. B. Electrometall.

(4) The Hagfors furnaces will have a capacity of 18,000 tons per annum, each furnace using 3,000 H.P.

Norway.

A. S. Hardanger Elektriske Jern-og Staalverk was incorporated in 1910 with a capital of 1,200,000 kronor. They are now building one electric furnace of 3,500 H.P., producing about 9,000 tons of iron per year. This furnace will be ready to run by the end of the coming summer. Later, an electric steel furnace and rolling mill will be erected.

A. S. Fosse kompagni was incorporated this year with a capacity of stock of 2,200,000 kronor. The Company has floated a loan of two million kronor, of which the Royal Bank of Norway has taken up half. The iron works will consist of electric iron and steel furnaces, with a production of 14,250 tons of billets per year. This plant is expected to be ready by the beginning of 1913.

At last we beg to add that the Fosse Company, which is an old iron works and has been idle for a long time, has closed contract for erection of an electric pig iron furnace of 3,000 H.P.

Steel Making in the Electric Furnace.

Hitherto, public references to the manufacture of steel by means of the electric furnace have consisted mainly of statements of results, and graphic descriptions of the apparatus and mechanical appliances used. Very little has been given out explanatory of the chemical reactions involved in the electrothermic process itself. A few notes, therefore, on the more technical and physical aspect of the subject may, at this stage, be deemed opportune. In October, 1910, Professor Joseph W. Richards—in an article in *The Metallurgical and Chemical Engineering Journal*, entitled, "The Passing of Crucible Steel"—reviews the work being done in Germany in the refining of iron into steel; and describes, particularly, the processes used in the works of the Stahlwerke Rich, Lindenber, Aktien Gesellschaft, at Remscheid-Hasten. Professor Richards says:—

As to the reactions in the process, phosphorus and other oxidizable elements are completely eliminated by the first slag; copper and arsenic are not, and should, therefore, not be in the molten metal charged in any harmful quantity. Sulphur is eliminated by the action of calcium carbide formed in the second slag:—

$$CaC_2 + FeS = CaS + FeC_2.$$

In this second stage, silicon, manganese, chromium, nickel, vanadium, molybdenum, boron, or tungsten are added to the steel with quantitative accuracy, scarcely a trace of any of these additions passing into the slag, and the steel having the exact calculated composition.

Comparing the electric process as here developed with the crucible process thus displaced, the management, after five years' experience, affirms with the greatest positiveness that the electric steel is more nearly of the desired composition; more uniform in composition; can be made from far cheaper raw materials; costs far less for the smelting operation; far less for labour; the labour required is much easier and safer; the output per given sized plant is greater; the steel is more free from blow-holes; develops less edge-cracks or surface faults; and for a given ductility will carry more carbon and, therefore, show higher strength.

Commercial Aspect of Electric Steel Making.

The following statement of the intrinsic properties of the steel demanded for the purposes of modern constructional engineering, shows that steel manufactured in the electric furnace is ideally adapted for all commercial purposes. In a paper read before the Chicago section of the American Electrochemical Society[1] Mr. James Lyman says:—

The demand for strictly high-grade steel, absolutely homogeneous, with fine grain, is to-day coming from the railways for steel rails and structural bridge steel, from the government for armament, from the automobile industry, from every manufacturer of tools and machinery, engines, steam turbines, electrical manufacturers, and, indeed, every manufacturer using iron or steel. The treatment of Bessemer and open-hearth steel in the electric furnace at an increased cost entirely within the limits of the purchaser will make this steel comparable in its fineness with crucible steel, and have the physical characteristics best adapted to the particular application desired. Since the railways have investigated the causes of rail breakages, it has been proved that many of them were due to the presence of foreign injurious bodies, such as slag, manganese sulphides, etc. The possible presence of these impurities, as well as the products of oxidation and nitrogen, is inherent in the Bessemer and open-hearth furnace product, but can be almost entirely eliminated by a treatment of an hour or two in the electric furnace.

Rails from electric furnace steel are now being tried out on curves, railway crossings; and points where the service is most severe by a number of the large railway systems. These rails combine unusual tensile strength, toughness, and hardness. Their life alone, aside from their increased reliability, will probably justify the increased cost.

To bring the enormous output of steel rails, structural, merchant, and plate steel up to the high grade of crucible steel will mean a new era for the steel business and rapid advances in all lines of manufacture employing iron and steel.

The manufacture of modern and light-weight steel castings has always been a difficult and unsatisfactory problem. There is a large wastage, particularly in castings of odd shapes. This is principally due to impurities and sluggishness of the flow of metal in castings. With less than one-third the electric power necessary for purification, the liquid metal can be held indefinitely in an electric furnace without any loss in its composition or danger of burning, and a highly liquid metal can be cast uniformly free from impurities and gases. Such steel castings can in a large measure replace the steel forgings at present used, at a much reduced price. While the large steel companies will, no doubt, introduce electric furnaces as a refining means for their principal output, the electric furnace can probably be used to advantage by manufacturers of all kinds of iron and steel products in making special high-grade steels from their waste scrap iron and steel, including borings and turnings, as it accumulates in process of manufacture. These furnaces will either be entirely electric or the metal may be brought to the melting point by gas or coke fuel, and then treated by electric heat.

The advantages of the electric furnace for commercial work have been admirably summarized as follows[2]:—

(1) That the electric furnace itself has passed from the field of experiment to that of engineering, but that the fields of manufacture using the electric furnace products are still experimental.

---

[1] The Electric Furnace for the Manufacture of Iron and Steel, by James Lyman.

[2] "The Reliability of Electric Furnaces for Commercial Work," by Fred. T. Snyder, a paper read before the American Electro-chemical Society, 1910.

(2) That the electric furnace is technically reliable and will operate continuously with the men and supplies that are available in this country. That the details are simple and rugged, and that the inherent regulating powers can be made such as to bring it well within the ability of usual plant labour.

(3) That the electric furnace is commercially reliable. That when installed with the same business care and adaptation to conditions that should be used with other furnaces, it will earn a profit on the investment, and a profit that is larger than the normal manufacturing profit in proportion as the field is newer and more open.

Comment.

The foregoing notes show (1) that the claims made by the Mines Branch since 1905-6, as to the suitability of the electric furnace for meeting the metallurgical conditions peculiar to Canada, have been fully substantiated, and (2) that European countries like Sweden and Norway, as well as the United States, are eagerly availing themselves of the pioneer work done by Canada in the development of the electro-thermic process for the smelting of refractory iron ores. The progressive spirit evinced by the ironmasters and captains of industry in the above-mentioned countries is in marked contrast to the condition of *inertia* prevailing in Canada. Since the winter of 1905-6 the Dominion Government have spent a considerable amount of money on experiments, and utilized the services of their technical experts in an effort to solve—theoretically and practically—the problem of economically smelting the refractory iron ores of the country, and have succeeded even beyond expectation. It is hoped, therefore, that the evidence of activity in other countries, given in the above extracts, may be an incentive to Canadian manufacturers to utilize the electric furnace—wherever iron ore deposits, suitable fluxes, and metallurgical fuel, are in strategic proximity to cheap water power—and thus bring about the establishment of an iron and steel industry, commensurate with the growing commercial importance of the country.

PEAT FUEL INDUSTRY

The forward movement begun by the Mines Branch in June, 1906, to solve the problem of providing a cheap domestic fuel for the middle provinces: Quebec, Ontario, and Manitoba—where there is no coal, but very extensive peat bogs—attracted, on account of its commercial importance, wide attention. Indeed so much so, that the American Peat Society, recognizing the essentially practical work being done by the Canadian Government, held its annual meeting at Ottawa on July 25, 26, and 27, 1910. The government peat plant at Alfred, Ont., was visited by the members of this national organization, as also was the Fuel Testing Station at Ottawa, and the impressions made were crystallized into the following resolution, adopted unanimously at the last session held July 27, 1910:—

Resolved: that the American Peat Society hereby expresses its thanks to the Hon. Wm. Templeman, Minister of Mines, for his cordial welcoming telegram, and for the opportunity of visiting the most interesting and satisfactory demonstration peat-fuel plant at Alfred, and the peat gas producer and power plant in Ottawa.

That congratulations are extended to the Minister and to the Director and experts in charge of these plants for the success that has crowned their efforts, and the very important demonstration which they have made of the practicability of making peat-fuel in quantities, and of using it for the production of power.

This authoritative testimony to the success of the attempt made by the Mines Branch to solve the problem of economically manufacturing peat fuel needs no extended comment; except to state that the aforesaid convention resulted in the establishment of a Canadian Peat Society: an organization which has already done effective practical work. During the autumn, some 500 tons of peat fuel, manufactured at the Alfred plant, were sold at $3.25 to $3.50 per ton to private individuals in Ottawa, for domestic use. The reports coming in from the consumers—showing that the peat has given great satisfaction as a fuel for open fire grates, cooking stoves, and even in furnaces for heating the house; and the numerous inquiries from business men and capitalists are so encouraging, that, with the advent of spring it is confidently anticipated there will be a marked revival of interest in the peat industry throughout the provinces where there is no coal.

Since 1907, ten peat bogs have been investigated, delimited, and plans made thereof. In 1910, only one was investigated, viz., the Holland peat bog, situated in Simcoe county, Province of Ontario. This is the largest peat bog so far examined and delimited by the Mines Branch. It covers over 16,000 acres, and should produce over 9,000,000 tons of peat fuel. The report of Mr. Anrep shows that the surface of this immense bed of peat is free from trees, hence can be worked economically by labour-saving machinery; while the quality as regards ash, and calorific value is satisfactory. A bulletin and map of the bog will be published at an early date.

GOVERNMENT PEAT PLANT AT ALFRED.

The report of Mr. A. Anrep, Jr., on page 115 shows that during a period of 50 days, 1,600 tons of air-dried peat fuel were manufactured—an average of 33 tons per day—the cost being as follows:—

Cost of 1 ton of peat on field	$1.59
" " 1 " " " turned, at 6c. per ton	1.65
" " 1 " " " open piled, at 10c. per ton	1.75
" " 1 " " " stored in shed, at 25c. per ton	2.00

Analyses of Peat Fuel.

The following analyses were made in the laboratory of the Central Experimental Farm, Ottawa:—

Copy.

Dominion Experimental Farms,
Wm. Saunders, C.M.G., Director.
Central Experimental Farm,
Ottawa.

Dr. E. Haanel,
Director of Mines,
Ottawa.

Dear Sir:—

You will doubtless be interested in the following analyses recently made in the Farm laboratory of samples of peat from the Government bog at Alfred.

No. 1 is the sample supplied by yourself

No. 2 is a sample submitted by an Ottawa purchaser.

Peat as Received.

	No. 1	No. 2
Moisture	24·07	27·78
Organic matter	71·23	67·81
Mineral matter or ash	4·70	4·41
	100·00	100·00

Composition of Ash.

	No. 1	No. 2
Mineral matter insoluble in acid	19·30	17·46
Oxide of iron and alumina	23·30	20·20
Carbonate of lime	42·50	44·64
Phosphoric acid	0·797	0·604
Potash	0·65	0·48

Some few weeks previous to making the above analyses a correspondent who was burning this peat in an open grate submitted a sample of the ash so obtained, the object being to ascertain the fertilizing value of the ash for garden purposes. This ash afforded the following data:—

	Per cent.
Lime*	26·55
Phosphoric acid	0·80
Potash	0·695

*Equivalent to carbonate of lime, 47·41%.

Yours faithfully,

(Signed) **Frank T. Shutt,**
Dominion Agricultural Chemist.

In addition to the above analyses, another was made of peat ash in the Mines Branch laboratory—October 12, 1910, by Harold A. Leverin, Ch.E., as follows:—

Analysis of Ash.

(From Peat Fuel Manufactured at Alfred Peat Bog.)

SiO_2	19·30
Al_2O_3	7·78
Fe_2O_3	6·22
CaO	31·39
MgO	14·33
K_2O	1·51
P_2O_5	1·03
CO_2 (by diff.)	18·44
	100·00

PROGRESS OF PEAT INDUSTRY IN SWEDEN

De Laval Wet-Carbonizing Process.

The Swedish government have decided to grant to Dr. G. de Laval—the distinguished inventor—the sum of 19,000 kronor ($5,130) for further experimentation on his new process of wet-carbonizing peat. The Government peat engineer, Ernest Wallgren, reports that de Laval's new process may solve the problem of continuous manufacture of a fuel, independent of air-drying, which will be able to successfully compete with coal.

Peat Powder—As a Substitute for Charcoal—Used in the Electric Furnace for the Manufacture of Pig Iron from Iron Ore.

Teknisk Tidskrift. August 24, 1910.

By Prof. E. Von Odelstierna,

Stockholm, Sweden.

At Arvika, Sweden, experiments have been conducted using peat powder in the reduction of iron ore in the electric furnace.

The bottom electrode was found to cause damage to the hearth, hence was replaced with an iron electrode situated between the two carbon electrodes. Very good results were obtained.

Recently, we have succeeded in getting 2·65 tons of iron per H.P. year; 445 kilograms (981 pounds) of peat powder being required for the reduction.

The loss in weight of the iron electrode was found to be only a few kilograms per charge. The loss of the carbon electrodes was not determined, but was rather considerable.

The furnace is now being rebuilt with a view to utilizing the furnace gases for preheating the charge, and roasting the ore.

Svenska Dagbladet, December 2, 1910.

JONKOPING.

Following Captain Wallgren's very favourable address on "The Investigation of the Ekelund Peat Powder Process" before the Swedish Peat Society, Lieutenant Ekelund was interviewed, and stated that by using his process even lower grades of peat can be worked, by which a production on a large scale through the country has been made possible. New furnaces are being built at Báck, increasing the output to 20,000 tons per annum.

Three new peat powder plants are under consideration, to be erected during the coming spring.

FUEL TESTING STATION AT OTTAWA.

Peat Gas Producer and Gas Engine Plant, and Gas Testing Laboratory.

A description of the gas producer and gas engine plant erected at the Government Fuel Testing Station, Ottawa, was given in detail, in the Summary Report for 1909 (p. 12), hence it is only necessary to state that, the installation of the plant was completed about April 1, 1910. The gas analytical laboratory, however, was not ready for operations until November 1910, so that no complete chemical tests could be carried out until after that date.

Notes on peat gas producer tests, and tests of the Körting gas engine operated with gas generated from peat fuel manufactured at the government plant, Alfred, are recorded, in some detail, in the preliminary report of Mr. B. F. Haanel, chief of Fuel Testing Division, page 44; while the chemical tests will be found in the summary report of Mr. Edgar Stansfield—who is in charge of the gas analytical laboratory.

ESTABLISHMENT OF GOVERNMENT ORE-DRESSING AND CONCENTRATION LABORATORY AT OTTAWA.

The fact that Canadian blast furnaces are dependent upon foreign mines for over 80 per cent of their supply of iron ores, indicates that, our resources of ore suitable for reduction by existing methods of smelting, are, as far as known, limited. At the same time, extensive deposits of low-grade ores—which the ironmaster can not use in their natural condition—are known to exist in large quantities, at accessible points, in many parts of the Dominion; and if these hitherto negligible deposits of iron ore could be utilized economically, it would encourage the growth of our iron and steel industry. Recognizing this situation, the Mines Branch has undertaken the work of demonstrating that the low-grade iron ores of Canada may be rendered acceptable for smelting, by the adoption of modern methods of ore-dressing.

With this object in view, the mining laboratory of Queen's University, Kingston, Ont., was temporarily secured for experimentation and testing during the autumn and winter of 1909-10. Tests were completed on the high sulphur iron ores of the Bristol mine, Pontiac county, Que., and the siliceous ores of the Bathurst range, N.B. Experiments were also conducted with a copper-nickel ore from the Worthington mine, Ontario, with a view to ascertaining the practicability of producing therefrom, iron-nickel concentrates free from copper; for the subsequent manufacture of ferro-nickel pig. The results of these experiments were, from the standpoint of concentration, entirely satisfactory. A detailed report of these experiments was published in 1910.[1] Immediately after the completion of these tests at Kingston, a government owned plant was installed at the Fuel Testing Station, Ottawa; for the experimental concentration of low-grade magnetic iron ores. This plant consists of a complete working unit of the Swedish Gröndal separating system: consisting of an ore crusher, ball mill, and two magnetic separators. The machines are of standard, commercial size, the capacity of the unit being from 50 to 100 tons of crude ore per 24 hours. The motive power is derived from the gas producer plant of the Fuel Testing Station, which is operated with peat fuel from the Government bog at Alfred.

That the establishment of this ore-dressing laboratory is meeting with approval from the mining public is evidenced by the fact that some 80 odd tons of various ores from Ontario, New Brunswick, and Nova Scotia have been received for testing purposes. These samples, ranging in size from 2 to 5 tons, are now undergoing treatment.

The summary report of the ore-dressing laboratory, page 48, contains the details of the experiments with Wilbur waste ore, and it is encouraging to note that low-grade material of this character, containing 38 per cent of iron, will yield a 65 per cent concentrate, with a recovery of nearly 95 per cent of the original iron.

A full report of the operation of the ore-dressing laboratory for the year will be issued later in bulletin form. This report will contain complete data of all experimental testing, accompanied by descriptive drawings of the various machines and apparatus.

INVESTIGATION OF PROCESSES FOR THE REDUCTION OF REFRACTORY ZINC ORES.

The following petition—signed by the zinc producers of East and West Kootenay, British Columbia—asking for an investigation of modern processes for the extraction of zinc from refractory ores, and dated April 7, 1910—was addressed to the Honourable the Minister of Mines:—

Petition

Hon. William Templeman,
Minister of Mines,
Ottawa.

Sir,—

I have the honour to submit on behalf of those engaged in zinc mining in British Columbia, certain facts in regard to the present condition of the industry.

In the report of the Commission appointed to investigate the zinc resources of British Columbia, it was estimated that the productive capacity of the mines for zinc ore might be expected to reach 30,000 tons of ore per year, crediting 15,000 tons each to the Slocan and Ainsworth districts. The actual shipments during the year 1908 were 7,000 tons. The unsatisfactory condition of the industry is largely due to adverse transportation conditions. These ores must be shipped to smelting works in Europe to meet hostile tariff duties and the long haul to Kansas, if shipments be attempted to the United States. This disability is accentuated by the unusual character of the British Columbia zinc ores, in that a large part of their value is in the silver contained in the zinc. Under the technical conditions of smelting zinc ores in the usual retort process, the ore has to be smelted twice; first to recover the zinc,

---

[1] Bulletin No. 5. Magnetic Concentration Experiments with Iron Ores of the Bristol Mines, Que., Iron Ores of the Bathurst Mines, New Brunswick, a Copper Nickel Ore from Nairn, Ontario, by Geo. C. Mackenzie.

and second to recover the silver. The cost of the double treatment and the double losses in treatment prevent the smelters from paying more than one-half of the value of the silver. A complete modern retort plant was constructed and placed in operation at Frank, Alberta, at a cost of some $300,000, for the exclusive purpose of smelting these British Columbia zinc ores. Under the technical conditions as to character of ore and economic conditions as to transportation and supply, it was found impossible to continue operations, and this plant was shut down and is being dismantled. Deprived of this market for their ores, and facing the probability of entirely losing the market of the United States zinc smelters through still higher customs duties, the miners of the west have been diligently casting about for some other way to avoid having to shut down.

The history of most of the mines is the same. Starting at the surface as lead mines carrying silver, it is found that as depth is reached, the lead is replaced by zinc to a larger and larger extent, until finally the zinc ore and its silver content is one of the principal resources. These ores of British Columbia, fairly high in zinc, unusually high in silver, and with some lead have been extremely difficult to market at any price, notwithstanding the high natural value of the contained metals. As there is no distinction in the mining of these ores in the production of lead and zinc, the utilization of both is each essential in the production of the other.

Thorough and repeated examinations were made of all known and available processes which indicated any prospect of handling these zinc-silver ores. Of these the only plan which offers hope of economic success in British Columbia was the smelting of these ores with electricity. If such an ore be put into a lead-silver blast furnace, the blast burns the zinc to oxide as fast as smelted and this oxide accumulating on the ore clogs up the furnace and soon stops its operation. A certain small amount of such oxide (15%) can, with skilful smelting, be dissolved in the slag and so gotten out of the way. Zinc so put into the slag is economically lost as there is no known way of profitably recovering it. Where electricity is used for heat the zinc is not burned as reduced and may be removed and recovered as a saleable product. While this process was known to be scientifically sound, there was no actual electric zinc smelting plant in successful operation adapted to British Columbia conditions which could be copied. It was necessary to have a process by which the zinc would be saved as well as the silver and lead. In this extremity a number of the prominent mine owners and operators interested themselves in the experiments that had been carried on for some time at Vancouver in the electric smelting of zinc-silver ores. Numerous tests were made on samples of ores shipped from the different mines. So encouraging were the results obtained that a company was organized, "The Canada Zinc Company," to carry the work further on a larger scale. A site was secured at Nelson, British Columbia, lying between the track of the Canadian Pacific railway and the west arm of Kootenay lake. At this point an abundant supply of low cost electricity is available from the Bonnington falls of the Kootenay river. Low freight rates exist from all points of the mining districts of East and West Kootenay. A small but thoroughly built smelting plant with a capacity of 10 tons of ore per day was erected at a cost of about $70,000. The experiments begun at Vancouver have been carried forward at a cost of some $50,000. These experiments proved what a difficult matter it was to handle these ores in any practical way. Gradually progress was made. One mechanical and electrical difficulty after another was successfully overcome. During this time the object was to produce from these ores three saleable products: (1), lead-silver bullion; (2), zinc in spelter form, practically free from lead and silver, and (3), a matter containing the proper contents of the ore. Operating with this object, the experiments with the plant were continued to the first of January in this year. At that time the difficulties incident to the experimental operation of the plant, had exhausted the funds of the Company. Up to the time of closing down, it has been demonstrated that the silver and lead could be effectively separated from the zinc. Some spelter was made, but further experimental work will be necessary and changes will be required in the apparatus to secure commercial results. The financial conditions of the Company have made it impossible to carry out these changes and continue the experiment. The changes necessary include rearranging the electrical equipment of the plant to operate at a pressure of 50 volts in place of 100 volts, including provision for graphite electrodes in place of amorphous carbon; making certain alterations and improvements to the present 800 H. P. furnace which suggested themselves during its operation, and installing chambers for burning, settling, and collecting the zinc in the form of zinc-oxide. These proposed changes and the operation of the plant to demonstrate their commercial practicability will cost approximately from $20,000 to $25,000.

In view of the pending changes in the United States tariff, which, as soon as put into force, will absolutely prohibit the exportation of zinc ore from Canada to the United States, it is necessary if the industry is to continue that Canada should be provided with domestic zinc smelting facilities for treating its own ore. In the absence of a successful process for this purpose it has been impossible to enlist capital for this undertaking.

I, therefore, respectfully urge your Government to make provision for completing the experimental work begun by the Canada Zinc Company. On making an appropriation for this purpose, the Company are willing to place their entire plant at the disposal of the officers of your Department and to render them every assistance in their power to complete the experiments and demonstrate the commercial practicability of smelting the zinc-ores with electricity.

With this advantage, the zinc industry can be developed into one of great importance to Canada and your Department; by granting the assistance at the present time you will do for this industry what you have so successfully done for the iron and steel industries by the experiments in electric smelting carried to so successful a conclusion by your Department.

With unlimited water power in all parts of the Dominion and with its inexhaustible and diversified mineral resources, no country has more to gain from electric smelting than Canada.

I am fully convinced that a small amount of money expended by your Department as indicated above, will prove the greatest possible boon to the zinc industry.

I remain,
Yours respectfully,
(Signed) **Louis Pratt,**
Representing the Zinc Producers of East and West Kootenay.

Recommendations of Director.

In response to the request of the Honourable the Minister of Mines, the following Memorandum was prepared by the Director of Mines; dealing with the foregoing petition, and making certain recommendations:—

Copy

Ottawa, January 3, 1910.

Memorandum:
Honourable William Templeman, M.P.,
Minister of Mines.

I have the honour to submit the following statement regarding the petition to divert $50,000 of the unearned portion of the lead bounty fund to be used to complete the experiments in smelting zinc ores by the electro-thermic process, which have been carried on by the Canada Zinc Company at Nelson, B.C.

Recognizing the pressing need of the zinc miners of British Columbia, as set forth in their petition, of finding some method which will enable them to market the output of their mines in the form of some manufactured product, and the propriety of the Government to come to their assistance, I am of the opinion that, *instead of making an appropriation for the continuance of the smelting experiments made at Nelson, B.C., so far without success*, information should *first* be obtained of the different processes which have been invented in Europe, and one of which has been in actual operation for some years.

There are at present four processes which promise commercial results:—

1st: The De Laval process, *in operation* at Trollhätten, Sweden; the final product of which is spelter.

2nd: The improved process of De Laval, plant for the demonstration of which is under way of erection by Mr. Ferguson, in London, England. Final product spelter. This process claims to save all the valuable contents of the ore and the sulphur in a solid state.

3rd: The Coté-Pierron process, recently invented in France. Final product spelter, or zinc oxide.

These three processes are electric smelting processes.

4th: The bisulphite process—final product zinc oxide. Plant for demonstration on a commercial scale, which is being erected in Wales, approaches completion. This is a chemical process. The mineral is brought into solution and precipitated as bisulphite, which is then converted into zinc oxide.

In view of these facts, I would recommend that the petition of the zinc miners of British Columbia to divert $50,000 of the unearned lead bounty fund for the purpose of aiding the zinc miners of British Columbia in an endeavour to bring the treatment of the zinc ores in Canada to a successful issue be granted, and that that amount be placed at the disposal of the Mines Branch of the Department of Mines, to be employed:—

1st: for the investigation on a commercial scale of the processes above enumerated, or of any other process, and that detailed reports of such investigations be made to the Minister of Mines from time to time.

2nd: for the setting up and operating of an experimental plant at Nelson, B.C., to test that one of the processes reported upon, which promises commercial success in treating the zinc ores of British Columbia.

Respectfully submitted.
(Signed) **Eugene Haanel,**
Director of Mines.

Resolution Before House of Commons.

After a thorough consideration of all the facts and conditions a resolution was submitted to Parliament by the Honourable the Minister of Mines, March 21, 1910, as follows:—

"Resolved that it is expedient to enable the Governor in Council to authorize the expenditure of a sum not exceeding fifty thousand dollars for investigating the processes used in the production of zinc; for making experiments, and for any other purpose that may be deemed advisable for the promotion of the production and manufacture in Canada of zinc and zinc products from Canadian ores."

The resolution was adopted (March 21, 1910) and resulted in the subsequent enactment of a Bill authorizing the proposed investigation:—

Bill as Passed April 8, 1910

Copy

THE HOUSE OF COMMONS OF CANADA.

BILL 182.

An Act respecting the payment of bounties on lead contained in lead-bearing ores mined in Canada, and to promote the production in Canada of zinc.—

His Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1908, C.43 S.1 amended. Amount of lead bounties.

1. Subsection 2 of section 1 of chapter 43 of the statutes of 1908 is amended by striking out the words "five hundred" in the last line thereof and substituting therefor the words "four hundred and fifty."

Grant in aid of the production of zinc

2. The Governor in Council may authorize the expenditure of a sum not exceeding fifty thousand dollars for investigating the processes used in the production of zinc, for making experiments, and for any other purpose that may be deemed advisable for the promotion of the production and manufacture in Canada of zinc and zinc products from Canadian ores.

Instructions to Mr. W. R. Ingalls, of New York.

Thereupon, the following instructions—in part—were issued:—

Copy

Mines Branch,
Department of Mines,
Ottawa,
June 7, 1910.

To
Walter Renton Ingalls, Esq.,
595 Pearl Street,
New York, N.Y.

Dear Sir,—

You are hereby authorized to inaugurate and carry through an investigation for the discovery or development of a method for the economic treatment of the mixed zinc sulphide ores of Canada in the production of metallic zinc of a marketable zinc product.

The following recommendations made by you regarding the conduct of the investigation are approved, and are to be adhered to:—

1st. That you devote personal attention to all schemes that may be presented to this office in the interest of the problem to be solved.

2nd. That it is specially agreed, that no invention that may result from this investigation be patented in the Dominion of Canada, but that rights may be reserved as to other countries.

3rd. That all possible work in connexion with this investigation be done in Canada.

4th. That such small scale experiments as would be most conveniently done by you outside of Canada be permitted to be done in such place as you may direct.

5th. To enable the Department to make statements regarding the progress of the inquiry, when required, it will be necessary that all plans for the investigation which may be recommended by you from time to time be forwarded to this Branch for approval, and that monthly statements of expenditure, covered by vouchers in duplicate, be made to this Branch to meet the requirements of the Auditor General.

I am Sir,
Yours very truly,
(Signed) **Eugene Haanel,**
Director of Mines.

Accepted, June 10, 1910.
(Signed) **Walter Renton Ingalls.**

Pending Processes for Treating Zinc Ores.

The undeveloped processes mentioned in the Summary Report for 1909 (pp. 4 and 5), for the reduction or treatment of zinc-lead and zinc-lead-silver ores, are still in *status quo*. A letter dated July 4, 1910, from Mr. F. W. Harbord, the eminent metallurgist of London, England—who had been commissioned by the Department of Mines to investigate and report on the De Laval, Côte and Pierron, Sulman-Picard-Hommel, Kermode, and Ferguson processes—indicates that none of the zinc processes he had been engaged to study are, as yet, ready for investigation. And from the fact that since the date mentioned no further communication has been received, it is safe to conclude that, no further progress has been made.

EXPLOSIVES.

On page 7 of the Mines Branch Summary Report for 1909, appears a general statement under the title "Accidents in Mines, Caused by Explosives"; and this was supplemented by a detailed report by Mr. J. G. S. Hudson, on page 124. From the information set forth in that report, it was evident that Canada was greatly in need of an Explosives Act, to regulate the manufacture, storage, importation, and testing of explosives; and the necessity for immediate legislation was intensified during 1910, by three very serious explosions—attended by deplorable loss of life. The first disaster was the explosion of "Virite," which occurred March 8, 1910, at the works of the General Explosives Company of Montreal, Ltd., situated in Hull, Que.; the second was the explosion, July 11, 1910, of so-called "Blasters' Friend," at Sand Point, Renfrew county, Ont., and the third was the coal mine accident at Bellevue mine, near Frank, Alberta, on December 8, 1910. It is a lamentable fact, that in Canada during 1910, no less than 14 men were killed by explosions in explosives factories, while 10 were killed and 20 injured by explosions of magazines; whereas in England during 1909, where 40,000 tons of high explosives were manufactured—an amount far in excess of that made in this country—only 6 were killed and 12 injured in explosives factories; and 1 killed and 4 injured by the explosion of magazines. It may also be pointed out that, in Ontario during 1909, 49 per cent of the total number of fatalities in mines was caused by explosives.

In view, therefore, of the demand for legislative action, work was commenced on the preparation of data for drafting an Explosives Bill, adapted to the conditions existing in Canada.

In the framing of this Bill, the following salient points were maintained:—

(1) That as no Act was in force, the proposed Bill should be wide in its scope, as regards powers and conditions.

(2) That on account of the peculiar conditions existing in Canada, viz.: the great diversity of climatic conditions; the magnitude of the territory to be covered; and great diversity of operations to which explosives are applied, the Act would best accomplish its purpose, if operations under its general provisions were permitted only by sanctions issued under special Orders-in-Council; so that each case might be dealt with equitably, in accordance with existing conditions. For these reasons, the proposed Bill was made short and precise, so that it could be easily administered.

(3) Advisedly, the word "use" of explosives has been eliminated as far as possible from the Bill; with a view to preventing conflict of authority where provision has already been made under Provincial Mines Acts regulating the use of explosives. On railway, canals, or other construction works—not so governed—Federal Orders-in-Council will be issued for the proper use of explosives, so that adequate protection will be given to the men employed, and also to the general public.

(4) Provision has been made for the classification, authorization, storage, and transportation of explosives, and the issuance of licences to explosives factories, and storage magazines; also for the establishment of a technical explosives division: comprising inspectors, and staff of expert chemical examiners.

(5) Plans have already been submitted to the Public Works Department for the necessary buildings required for the proposed Explosives Testing Station; and estimates have been made for the proper equipment of the chemical and physical laboratories, and galleries for the Testing Station.

The most important section of the Bill is No. 18: under which are formulated the regulations governing the administration of the proposed Act. They are as follows:—

REGULATIONS.

19. The Governor-in-Council may make regulations—

(*a*) for classifying explosives, and for prescribing the composition, quality, and character of explosives;

(*b*) prescribing the form and duration of licenses, permits, and certificates issued under this Act, the terms and conditions upon which such licenses, permits, and certificates shall be issued, and the fees to be paid therefor;

(*c*) for regulating the importation, packing, and handling of explosives, and the transportation of explosives otherwise than by railway;

(*d*) for inquiries into the accidental explosion of explosives, and any accident caused by explosives;

(*e*) for the taking of samples of explosives required for examination and testing, and for the establishing of testing stations, and of the tests and other examinations to which explosives shall be subjected;

(*f*) prescribing the manner in which an explosive shall be tested and examined before it is declared to be an authorized explosive, and for determining to what examinations and tests authorized explosives shall be subject;

(*g*) to be observed by inspectors and other officers and employes charged with any duty under this Act, or under any regulations made thereunder;

(*h*) relating to the construction and management of factories and magazines;

(*i*) for the safety of the public and of the employes at any factory or magazine, or any person engaged in the handling, or packing of explosives, or the transportation of explosives otherwise than by railway;

(*j*) governing the establishment, location, and maintenance of factories and magazines, and the manufacture and storage of explosives;

(*k*) for the more effective carrying out of this Act.

2. All regulations made under this Act shall be published in *The Canada Gazette*, and upon being so published they shall have the same force as if they formed part of this Act.

The Explosives Bill was prepared by the Mines Branch, in consultation with Captain Arthur Desborough, H.M. Inspector of Mines, and in accordance with the advice of the Department of Justice. The provisions have, necessarily, been made broad and comprehensive, so that they will cover the wide range of conditions peculiar to Canada; and at the same time, harmonize with existing Provincial laws and regulations. The laws on the British Statute book, with regard to explosives—based as they are upon long and wide experience—have acquired international celebrity for their wisdom and equity, hence the best features applicable to Canadian conditions have been unhesitatingly embodied in the proposed Explosives Bill. A copy of Bill 79—"An act to regulate the manufacture, testing, storage, and importation of Explosives"—has been incorporated, as appendix III, on page 225.

MAGNETOMETRIC SURVEYING.

The investigation of magnetic iron ore deposits, which has been carried on since the formation of the Mines Branch, was continued during 1910. Two parties were employed in Ontario, New Brunswick, and Nova Scotia, examining magnetite deposits by the magnetometric method. Mr. Einar Lindeman extended the surveys already made near Bathurst, N.B., and at Bessemer, Ontario. He also made topographic surveys of these localities. Mr. Howells Fréchette made a magnetometric and topographic survey of a part of the Torbrook Iron Range, Annapolis county, Nova Scotia. In April, Mr. Lindeman delivered a short course of lectures on the Swedish methods of magnetometric surveying at the School of Mines at Kingston, Ontario; where they have recently installed an experimental table, and the regulation equipment for demonstrating the uses of the magnetometer.

CHEMICAL LABORATORY

The summary report of Mr. F. G. Wait indicates that, although the actual number of specimens examined and reported upon during 1910 was not quite so large as in 1909; yet, the staff in both the Sussex Street and Wellington Street branches has been fully employed. This diminution in the number of specimens sent in is doubtless due to the issuance of the schedule of compulsory charges. The announcement that examinations and analyses were no longer *free* has evidently had a deterrent effect.

The plea, urged by the Chief Chemist, that the division of the laboratory system into two sections, with two buildings in different parts of the city of Ottawa, is neither conducive to efficiency nor the most economic work, is obvious: another powerful reason why the Mines Branch should be housed under one roof; with ample space not only for present work, but with adequate provision for future development.

An important event in connexion with the work of the Chemical Laboratory was the publication in August, 1910, of a report by Mr. Wait, giving an account of the detailed chemical analyses made in the Mines Branch laboratories during the years 1906, 1907, and 1908; incorporated with which is a description of the commercial methods and new apparatus used in the analysis of oil-shales—by Mr. H. A. Leverin.

DIVISION OF MINERAL RESOURCES AND STATISTICS.

The work of this Division comprises the collection of statistics of mining and metallurgical production throughout Canada, and the collection and recording of information respecting the country's mineral resources. The following statistical bulletins and reports have been issued from this Division during the year:—

No. 62. Preliminary Report on the Mineral Production of Canada during the calendar year 1909.

No. 58. Annual Report on the Mineral Production of Canada during the calendar years 1907 and 1908.

No. 79. The Production of Iron and Steel in Canada during the calendar year 1909.

No. 80. The Production of Coal and Coke in Canada during the calendar year 1909.

No. 85. The Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada during the calendar year 1909.

In order to cope with the growing work of the Division and to facilitate the more prompt publication of the revised annual reports of mineral production, the staff was increased during the year by the appointment of Mr. C. T. Cartwright, B.Sc., who spent some months during the summer collecting statistics of the production of brick, stone, and lime in Ontario.

The usual annual report of the mineral production during 1910 will, of course, be issued as soon as possible during the current year; but the preliminary report already published, and which is included as an appendix to this report, indicates very plainly the rapid development of Canada's mineral production.

The total output during 1910 is valued at upwards of $105,000,000, and shows an increase over the production of the previous year of more than $13,000,000. The increase is shown to have been well distributed amongst the more important ores and minerals produced in Canada.

The officer in charge of the Division refers in his report to the desirability of a special investigation as to the market in Canada, among manufacturers and others, for numerous mineral products, in various stages of refinement. Considerable quantities of mineral products which have undergone some process of treatment are being imported; while the crude mineral ores are being exported. A knowledge of the requirements of the Canadian consumer in this respect might be of great assistance in the development of numerous branches of our mineral industries. The value of such an investigation is fully recognized, and it will be undertaken during the current year.

DOMINION OF CANADA ASSAY OFFICE

In accordance with the plans outlined in my Summary Report for 1909, the Dominion of Canada Assay Office was transferred on July 26, 1910, to the commodious new quarters, prepared by the Public Works Department, at the corner of Granville and Pender Streets, Vancouver, B.C. And pursuant to instructions by the Honourable the Minister of Mines, I visited and inspected the establishment in November. The following is a copy of my report:—

Memorandum

Copy

Ottawa, November 21, 1910.

Hon. William Templeman, M.P.,
Minister of Mines.

In accordance with your instructions of the 15th ultimo, I visited and inspected the Dominion of Canada Assay Office at Vancouver, B.C., and beg to submit the following report thereon.

The reason for the establishment of the Assay Office at Vancouver was to furnish the mining communities of the Yukon and British Columbia with a convenient market for their gold, and to keep the trade accompanying the marketing of same in this country. To meet the purpose for which this office was established, it would, of course, be necessary to offer the same price for the gold deposited as that which the producer can obtain elsewhere, without extra expense or inconvenience. This at present is not the case.

A great change has taken place in the mining conditions in the Yukon since the Assay Office was established; and especially in regard to the transportation of the gold output, since it can now be shipped by registered mail from Dawson to Ottawa or to San Francisco at the same expense as to Vancouver, viz., $1.25 per thousand dollars value.

The express rate, which formerly was the only means of transportation, is $9 per thousand dollars value from Dawson to Vancouver, $3.50 from Vancouver to San Francisco, and $3.75 from Vancouver to Ottawa.

The charges imposed at the Ottawa Mint and the different institutions in San Francisco purchasing gold are the same, namely, one-eighth of one per cent less on gross value of gold deposited than at our office, which places our assay office in an unfavourable position regarding amounts of bullion likely to be deposited, as evidently producers will bring their bullion to markets paying highest prices.

It is generally recognized that Vancouver should be the point to successfully intercept the gold output of the Yukon, preventing it from being marketed in a foreign country. As it takes at least a fortnight longer to get returns from Ottawa to Dawson than if marketed in Vancouver, the only gold, therefore, likely to be shipped from the Yukon or British Columbia direct to Ottawa would be that for which the proceeds were required in eastern Canada.

One of the chief arguments made for the establishment and continuance of the Assay Office at Vancouver is that the marketing of the gold is accompanied by increase of trade. The following facts, personally verified by me during the three days of my stay, confirm the reasonableness of the view:—

HAZELTON, B.C.,
October 19, 1910.

THE MANAGER,
Dominion Assay Office, Vancouver.

DEAR SIR,—

By this mail I am forwarding you under separate registered covers two parcels containing gold dust and gold amalgam.

The dust I value at about $1,025, the amalgam at about $450. Kindly have same realized, forwarding proceeds to Messrs. Wilson Bros., Wholesale Grocers, Victoria, B.C., and the certificate to me.

Trusting same will reach you safely,

I remain,

Yours truly,

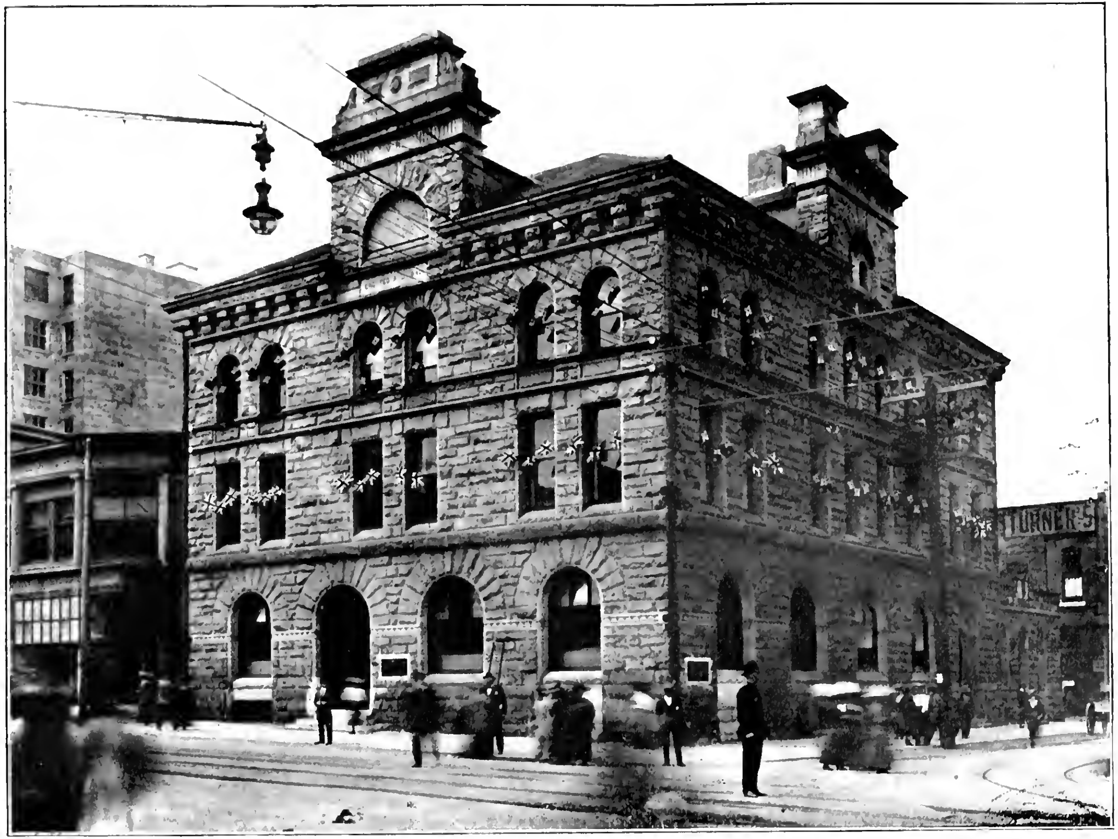
(Signed) R. S. Sargent.

Cheques in different banks were deposited by the Manager for the total sum of $40,000, against which cheques would be issued in payment of supplies purchased in the city. Two miners deposited about $17,000 worth of bullion and stated that they intended to spend the winter in Vancouver and invest their money there as opportunity offered. Had this money been deposited either in Seattle or San Francisco, it would have been lost to this country.

The amount of business, however, transacted is only a fraction of the business which this office ought to be transacting at this season of the year, with the result that a large amount of the trade and financial prestige which accompanies the marketing of the output of our gold mines is being reaped by a foreign country. This might to a certain extent be remedied by placing this office to a limited extent on the same footing in regard to charges as the Ottawa Mint and the different institutions in San Francisco, viz., that the charges remain the same as they are at present on all bullion received from British Columbia, Alberta, and Alaska, but that the charge of one-eighth of one per cent on the gross value of the bullion be not imposed on gold bullion from the Yukon on which the royalty or export tax has been paid.

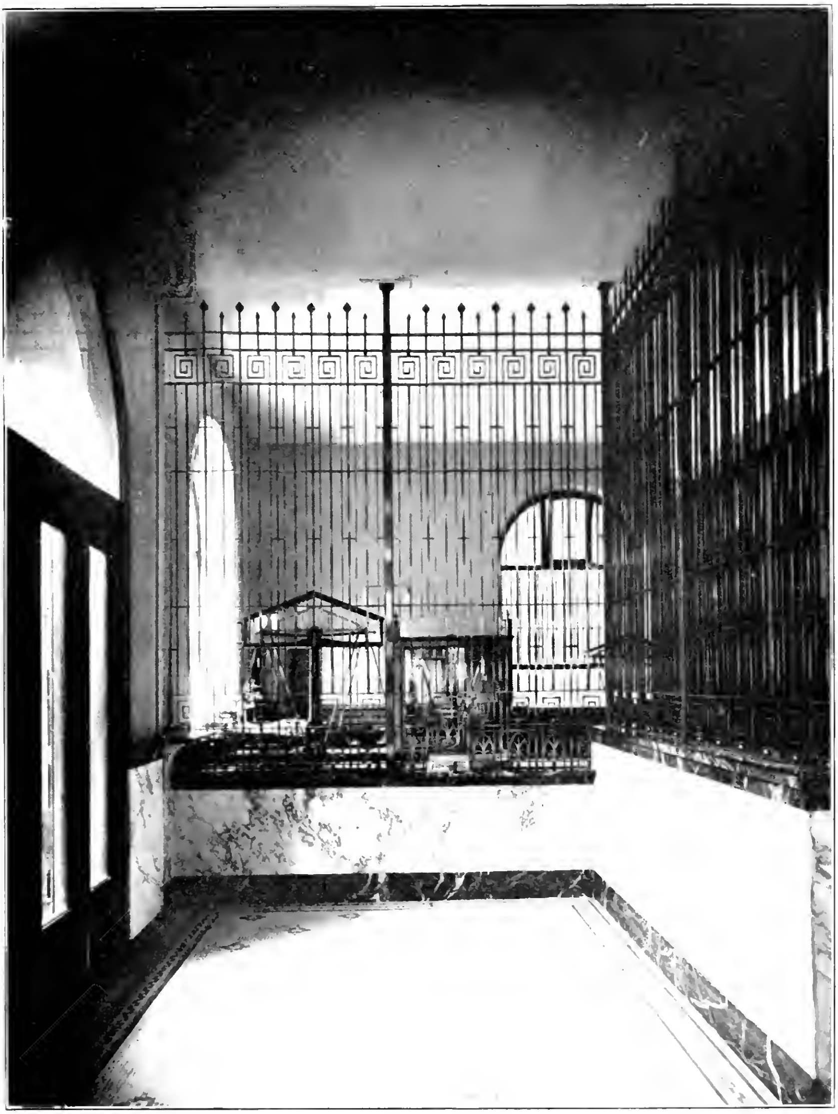
The Assay Office was transferred on July 26, 1910, from rented premises on Hastings Street (where the rent had been gradually increased from $100 to $400 per month) to quarters which had been prepared by the Public Works Department in the Government building at the corner of Granville and Pender streets, according

Plate II.



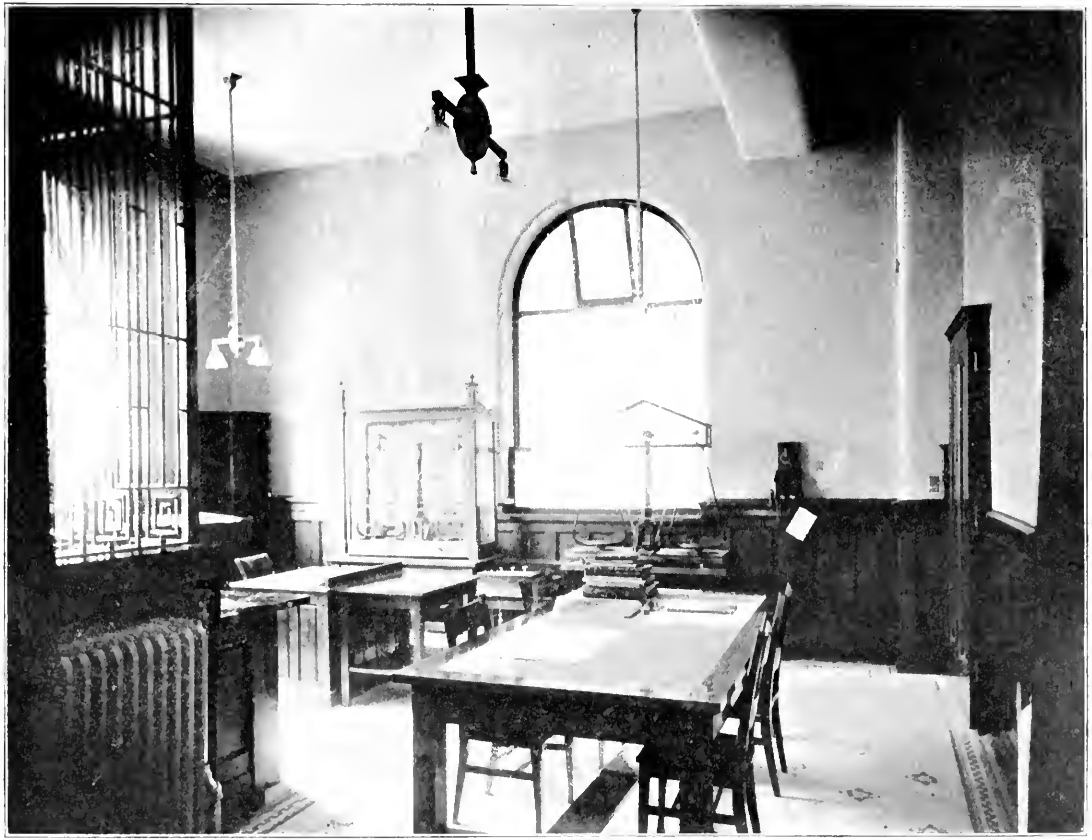
Dominion of Canada Assay Office: Corner Granville and Pender Streets, Vancouver, B.C.

Plate III.



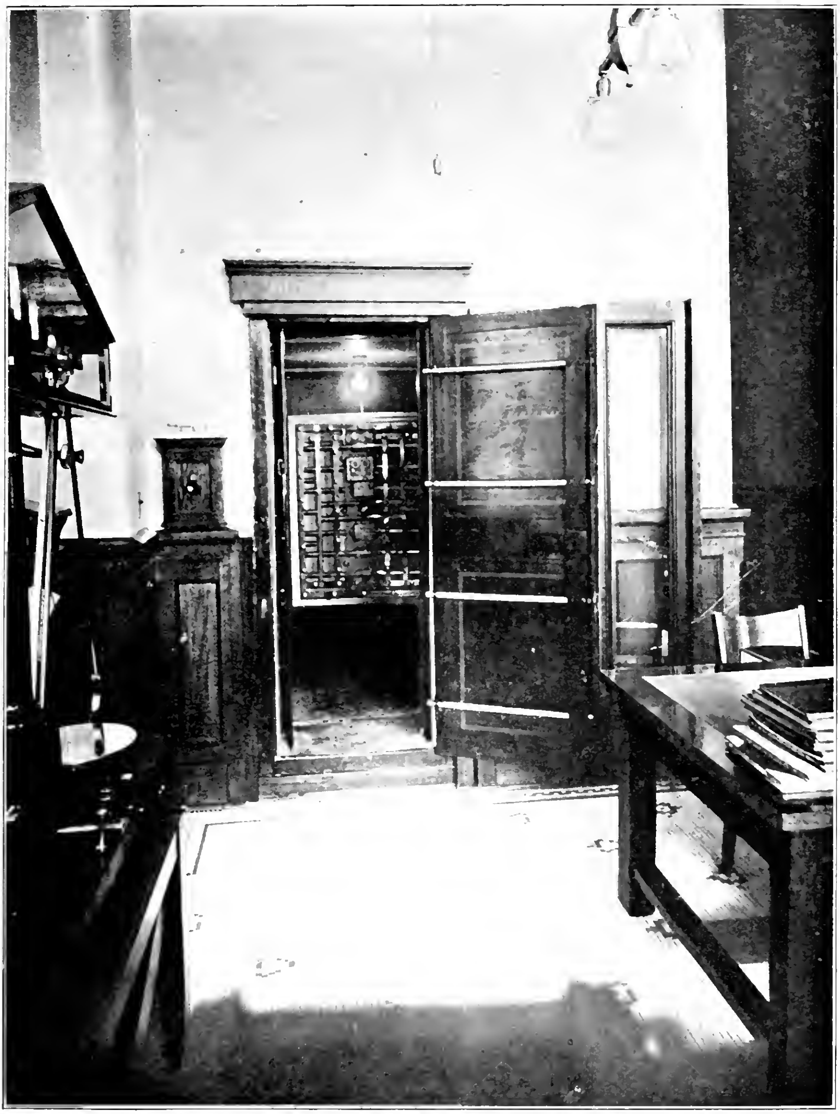
Vestibule.

Plate IV.



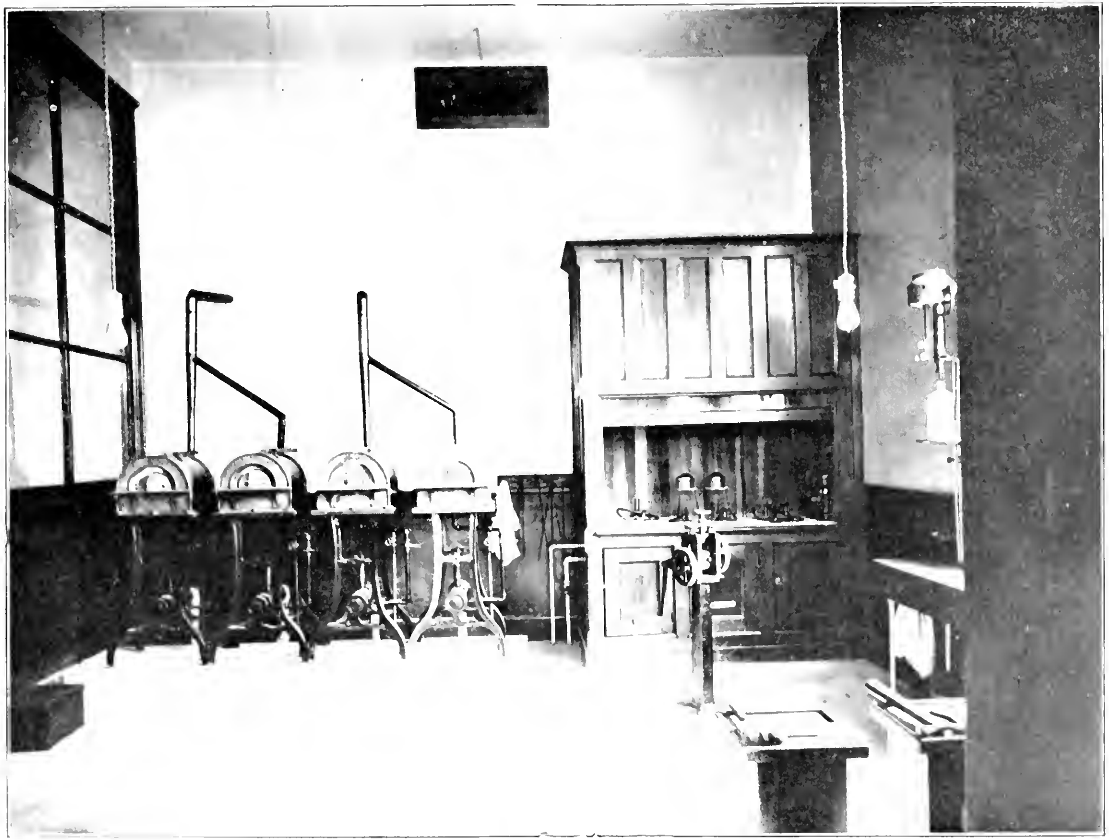
Receiving Office.

Plate V.



Safe Vault.

Melting Room.



Muffle Room.

to plans showing the division of space and position of balances and apparatus, which were forwarded to me and received my approval before the alterations necessary for permanent quarters of the Assay Office were proceeded with.

The building is located on one of the most central and prominent corners in the business section of the city, adjacent to all the banks, express offices, post-office, railway station, and docks, and the Assay Office has accordingly been fitted up in keeping with its surroundings and the class of business being transacted, viz., the purchase of gold bullion. The building was in very bad condition prior to the alterations, it having been necessary to renew the floors, which was done with re-inforced concrete, instead of wood joists and boards as formerly. In fact, all the wood work had to be replaced, as it was completely decayed. The overhead beams carrying the top floors were also rotten and were replaced with steel girders, which permitted a great improvement being made, viz., the removal of a number of columns. In the old windows there was about as much wood as glass and artificial light had to be used during the day, but with the new windows there is not a better-lighted building now in the city. The sanitary arrangements were also in bad condition and had to be entirely renewed and the electric wiring had all to be renewed and placed in conduits. A great improvement has also been made in connexion with the entrance. Formerly there were a couple of steps inside of the door which wasted considerable floor space; but by building the steps out to the lot line the top step is now on the floor level outside the door. Considerable space was also gained by making the two corner doors into windows and by making one window on Granville street into an entrance.

The largest item of expense, however, was the building of the heavy wall (in which there are 132,000 bricks laid in cement) between that section in the building allotted to the Assay Office and that of the other departments, so that the Assay Office would be absolutely self-contained: the foundation of the wall is on hard pan beneath the level of the basement floor, and extends to the roof of the building and part of it above the roof, as it contains the two ventilating shafts and the six flues with which the furnaces are connected.

The entrance to the Assay Office has an outer gate or steel grille and an inner heavy oak door with glass panels. The main corridor is finished with a marble dado 4′-6″ high, and access to the work rooms and bullion vault is shut off by a heavy trellis-like steel screen, which extends from the top of the dado to the ceiling. There are six rooms, viz., the general office, melting, muffle furnace, balance and manager's rooms and a room for the depositors from where they can look through the steel screen into the melting room and see their bullion melted. The floors of the corridor, depositors' room, and general office are laid with tile and the floors of the melting and muffle furnace rooms with concrete, and those of the balance room and manager's room with hardwood.

The furnace rooms are kept cool by an electric suction fan connected with a flue, the outlet of which is above the roof of the building, the capacity of the fan being sufficient to change the air in the rooms every four minutes.

The table in the balance room on which the scales are placed stands on concrete points projecting from a concrete pillar, the foundation for which is on hard-pan beneath the level of the basement floor.

The manager's office is situated directly opposite the receiving counter, with an uninterrupted view of everything passing to and from the vault.

The vault is electrically protected, it being lined with two sheets of steel riveted together with a wood liner between, grooved lengthwise at intervals of three-fourths of an inch, into which the electric wires are placed. There are also grooves running crosswise at each end of the wood liners for the connecting wires, which in turn connect with a switch situated just outside of the vault door. The latter is also electrically protected, glass doors into which wires are moulded closing over the vault door and connected up on the same principle. Any interference with the vault would ring a gong at the institution with which the electric protection is connected.

The motor and high pressure blower for supplying the blast for the furnaces are located in the basement and the crusher and pulverizer in the melting room, both being driven by belts leading through the floor from a shaft in the basement.

The staff of this office is made up of a manager, two assayers, one melter, one computer-bookkeeper, and one assistant melter-janitor, who perform their work in an exceedingly satisfactory manner. The capacity of the office with the above-mentioned staff would be about one and a half million dollars per annum. By omitting the charge of $\frac{1}{8}$ of one per cent on the gross value of gold bullion deposited from the Yukon, which has paid export duty, it is likely that the total amount deposited per annum in our office would reach this amount. The amount of deposits for 9 months for the year 1908 was $1,478,893.74—the last year of express transportation. The decrease since then is due to transmission of bullion by registered mail, as explained. With this amount of deposits the permanent staff would have ample work to keep them fully employed during the balance of the year making proof gold, grinding up, amalgamating, and cyaniding slag, treating silver, making cupels, silver discs, etc.

I may here mention that there is a staff of nine in the United States Assay Office at Boise, Idaho, and they treated during the year deposits amounting to $837,031.05. At the United States Assay Office at Carson, Nevada, there is a staff of seven and the deposits for the year at that institution aggregated in value $739,570.01, showing that the policy of the United States Government is to maintain institutions so as to give the business community in the region where the gold is obtained the benefit of the trade accompanying the marketing of same, and at the same time provide a convenient market for the output of the mines.

The following shows the business done at this office since the commencement of the current fiscal year, viz:—

Number of Deposits.	Weight.		Net value.
	Before melting Troy ozs.	After melting Troy ozs.	
327	33,287·50	32,660·35	$539,446.89

I have enclosed a specimen of each of the forms and books kept in this office and of the report and statement forms sent to me at Ottawa, to which the following is an index, viz:—

Books and Records kept in Office.

(1.) Interim receipt form, handed to depositor, to be returned endorsed when he obtains settlement.

(2.) Letter of Credit cheque, drawn on Bank of Montreal, Ottawa, issued in settlement of bullion deposits.

(3.) "Melt book," giving weights of deposits before and after melting and after clip, etc.

(4.) "Register of clippings," giving weight of clip before and after assay, etc., etc.

(5.) "Disbursements and credits for the purchase of gold bullion," from which can be seen at a glance the balance of credit.

(6.) "Assay record," details of fineness, etc., relating to each assay.

(7.) "Source, weights, and value of gold bullion deposits," in which the deposits are classified under the different districts, and showing weights before and after melting and net value.

(8.) "Gold bullion deposits"—a complete record of all transactions.

(9.) Ord r form issued when supplies are purchased locally under "Contingent Account."

(10.) Memorandum of gold bullion—certificate of assay.

Reports, Statements, etc., forwarded to me at Ottawa.

A. Manager's Report—"Deposits of gold bullion"—a complete record of all transactions (sent weekly).

B. Assayers' Report—"Assay record"—details of fineness relating to each assay (sent weekly).

C. Melter's Report—in which deposits are classified under the different districts, showing the description of bullion, weights before and after melting, and loss per cent (sent weekly).

D. Form No. 13—"Attendance register" (sent monthly).

E. Statement of Disbursements—Contingent account (sent monthly).

F. Abstract of Cash Statement, showing total receipts and expenditure and balance at credit under Contingent Account (sent monthly).

G. Estimate of contingent expenditure (sent monthly).

I have carefully investigated the feasibility of adding to the functions of the Assay Office, by requiring the staff during slack times to do general analytical and assay work, and have come to the conclusion that this is impracticable for the following reasons:—

1st. There is no space in the Assay Office which could be allotted to this work.

2nd. On consultation with a number of mining engineers in Vancouver and Nelson, I find that there is a feeling against converting the Assay Office into a general chemical laboratory. It has, moreover, been stated, notably by Mr. Fowler, that the miners would not avail themselves of the services of the assayers of our office, but would prefer to have their assays made by the professional assayers, who have given thorough satisfaction, and that the attempt to do general assay work would militate against the usefulness of our Assay Office by the enemies it would create in the regular profession.

3rd. Outside work which might come to our Assay Office would come during the busy season, when our assayers could not possibly attend to it.

4th. If, by cancelling the ⅛ of one per cent now charged on the gross value of gold deposited from the Yukon, the amount of deposits is increased to one and one-half million dollars per annum, the staff will be fully occupied throughout the year.

Respectfully submitted,

(Signed) **Eugene Haanel,**

Director of Mines.

DESCRIPTION OF ASSAY OFFICE ROUTINE.

The following is a descriptive sketch of the regular routine and operations in the Assay Office prepared by the Manager (Mr. G. Middleton):—

The manager receives and weighs in the bullion, the weighing being checked by the computer-bookkeeper, a specimen of the depositor's signature is taken and he is handed an interim receipt, to be returned endorsed when he receives cheque in settlement and certificate of assay. The bullion is placed in a box on which there is a frame for a number card, the box is then locked and a card placed in the frame on which has been written the number assigned to the deposit and by which it is identified during the different operations through which it passes and appears in all records connected with the same. The bullion box is handed to the melter, opened in the melting room, and the bullion transferred to crucible in the presence of the manager or whom he may appoint, the necessary flux added, then melted and thoroughly stirred so that the bullion will be homogeneous, then poured into mould, the resulting bar cleaned, dried, and stamped with melt number. The slag from the melting of deposit is crushed, then pulverized and washed, and the granules recovered are cupelled, weighed, and included in the weight of deposit after melting.

Clippings for assaying purposes are taken from a top and a bottom corner of the bar at diagonal points, after which the bar is weighed on a balance for that purpose and the weight stamped on bar. The clippings are weighed and charged by manager to assayers while assay is being made, then returned to manager, weighed and included in the weight of deposit after melting, the loss in weight by assaying being seldom more than the one hundredth part of an ounce; two assays are made by each assayer (two), making four checks, and these checks must all agree to within 0·16 of a part per 1000 parts, otherwise the bar has to be remelted and re-assayed. A proof to check results accompanies each assay made. A report to the manager on form provided for the purpose is then made by each assayer of the proportion contained per thousand parts of fine gold, of fine silver, and of base metal, gold being reported to the next quarter-thousandth part below and silver to the next half-thousandth part below.

The computation of the values are then made by the manager and computer-bookkeeper, each using a different formula; $20·6718 per ounce is paid for the fine gold contained in the deposit and the rate for the silver is regulated by market value.

The certificate handed to depositor contains particulars of the weight before and after melting, proportion of gold, or fineness, and value, proportion of silver, or fineness, and value, deductions, net value and value per ounce after melting. The Letter of Credit cheques issued in settlement are negotiable without charge at any bank in Canada.

Necessary proof gold, silver, and cupels are made during the winter months.

Abstract of Assay Office Returns.

During the calendar year ending December 31, 1910, 46,064·31 ounces of gold bullion, valued at $746,101.92, were received and assayed. These deposits were derived from the following sources:—

Source.	Number of deposits.	Weight. Before melting.	After melting.	Net value.
		Ozs.	Ozs.	$ cts.
Yukon Territory	57	3,688·06	3,594·87	62,094.09
British Columbia	401	35,189·99	34,482·73	571,670.52
Alberta	1	34·03	32·59	595.51
Alaska	29	6,961·43	6,938·11	108,348.01
California	2	190·80	180·62	3,393.79
	490	46,064·31	45,228·92	746,101.92

Weight before melting	46,064·31	ounces.
Weight after melting	45,228·92	"
Loss by melting	835·39	"
Loss percentage by melting		1·8135

The earnings of the Assay Office, as shown by the accountant's statement on page 42, were $1,017.35 for the year.

FIELD WORK.

Iron—

Mr. E. Lindeman, in the early part of the year, concentrated his attention on the completion of his investigation of the iron-bearing district in the vicinity of Austin brook, New Brunswick: making magnetometric and topographical surveys.

Mr. Howells Fréchette was occupied during the summer, investigating the northwestern portion of the Torbrook iron ore deposits, in Annapolis county, Nova Scotia, for the purpose of determining the position of the ore beds, and, if possible, to ascertain whether the ore—due to multiple folding—approaches the surface within workable distance at other points than the present known lines of outcrop. Later in the season, he visited the magnesite deposits in Argenteuil county, Quebec.

In addition to his field work, Mr. Fréchette devoted considerable time to the revision of reports, and the preparation of notes and memoranda in answer to inquiries received by this office.

Copper—

Dr. Alfred W. G. Wilson spent the early part of the year visiting the localities and mines in the United States, where copper ores similar to those found in Quebec and other parts of eastern Canada are mined and smelted. It was considered that direct knowledge of mining methods and processes employed by the successful American companies would be an advantage in the preparation of that portion of the proposed monograph on the Copper Industry of Canada, which relates to the mines and prospects of Quebec and the Maritime Provinces. After an interval of office routine work at Ottawa, Dr. Wilson visited western Ontario, and in the autumn, the Provinces of New Brunswick and Nova Scotia, where all available information was gathered respecting the past work and present condition of the copper ore fields in these districts. Before returning to Ottawa, Dr. Wilson paid a visit to the copper and sulphur ores and pyrites fields of Newfoundland; from whence cupriferous ores have been shipped to Wales, Great Britain, and the United States for more than twenty years. The geological conditions under which the ore bodies occur are similar to those in Nova Scotia; but development work and exploration are much further advanced, hence the advantage of a comparative study of those two fields.

Molybdenum—

Professor T. L. Walker, Ph.D., of the University of Toronto, continued his study of the Canadian deposits of molybdenite, confining his researches in the early part of the season to Ontario and British Columbia, concluding with the examination of some deposits in New Brunswick and Quebec. In one locality in New Brunswick, he discovered a hitherto unknown occurrence of wolframite. This mineral, when pure, contains about 60 per cent of tungsten, a metal for which there is at present a great demand. It is extensively used in the manufacture of filaments for incandescent electric lights, also in the alloying of steels for high speed, cutting tools.

Tin and Silver-Cobalt—

Mr. L. S. H. Cole, immediately after his appointment on the staff—August, 1910—was sent to Arnprior to investigate a reported tin deposit. The property on which the tin ore was reported to have been found showed no indications of the presence of this metal, but carried only a little zinc blende in calcite. He spent the latter part of the year obtaining information regarding mining operations in the Cobalt and Porcupine districts of Ontario; having special regard to methods of concentration of the silver-cobalt ores now in use in the Cobalt camp; and subsequently prepared a map (No. 94) showing the Cobalt, Gowganda, Shiningtree, and Porcupine districts: a copy of which is incorporated at the end of this report.

Mica—

Mr. Hugh S. de Schmid was engaged during the summer of 1910, gathering data for a revised, enlarged, second edition of the Mines Branch monograph on mica, published in 1905. He visited over 200 mica properties in Ontario and Quebec, and obtained much information on this important subject. A large proportion of the mines visited closed down some years ago at the time of the depression in the mica market and have not since been reopened.

Operations in Quebec were found to be comparatively at a standstill.

In Ontario, on the other hand, more activity was being displayed, and many old mines were in process of re-development.

A special feature of this investigation is the compilation of a new key map, showing the geographical location of the various mica deposits, and the extent of the mica industry throughout the Dominion.

Building Stones—

Professor W. A. Parks, Ph.D., of the University of Toronto, was engaged to investigate "The Building and Ornamental Stones of Canada."

The field work in Ontario for the preliminary report on the subject has been completed, and will be published in 1911. In addition to a study of the quarries in Ontario, Dr. Parks spent some time in the granite and marble areas of Vermont, and the slate region of western New York; also the quarries of the Missisquoi Marble Co., Philipsburg, Que. During this field work, numerous samples—representative of the various stones—were collected, and tests are being made with a view to determining the physical characteristics, in order to ascertain the commercial uses to which the stones can be most economically applied. These tests include crushing strength, porosity, ability to resist heat and frost, and manner in which the various stones chip and cut, etc.

Peat—

Mr. A. Anrep, Jr., the Swedish expert in charge of the Government peat plant at Alfred, Ont., started out-door operations there in May, and during a period of 50 days manufactured 1,600 tons of peat-fuel. Subsequent to this, he surveyed the Holland peat bog near Bradford, Ont., probably the largest in the Province: covering 14,641 acres.

Explosives—

Captain Arthur Desborough, H.M. Inspector of Explosives, London, England, visited the explosives factories of the Dominion: making an exhaustive study of the conditions peculiar to Canada. A report, setting forth his views, and accompanied by recommendations for legislatively regulating the manufacture and use of explosives, was published June 14, 1910. A reprint will be found on page 120.

Mining Data—

Mr. J. G. S. Hudson, in the early part of the year, was engaged in the gathering and compilation of statistics on explosives, and on accidents in mines. During part of the summer season, he accompanied Captain Desborough on a tour of inspection and investigation of the explosives factories in the Dominion. In addition to this work, he investigated the explosion of "Virite" which occurred on May 8, 1910, at the works of the General Explosives Company, Montreal, Ltd., situated in Hull, Que.; the disaster (July 11, 1910) with "Blasters' Friend," at Sand Point, Renfrew county, Ont., and the serious coal mine accident on December 8, 1910, at Bellevue mine, near Frank, Alta.

GENERAL CONSIDERATIONS.

A recapitulation of the main aspects of the work done by the Mines Branch during 1910 would show that, considerable work of an essentially practical character has been accomplished: in the investigation of the mineral and metal resources of the country and in the demonstration of economic methods of utilizing them commercially. This work would have been greatly accelerated had it not been for the very serious disadvantage under which the Executive of the Mines Branch has laboured, owing to the operations of the various subdivisions being necessarily conducted in five different parts of the city of Ottawa, instead of all being—as far as possible—under one roof. The headquarters were large enough in 1901—when the Mines Branch was established—but in 1910 are altogether inadequate to accommodate the greatly increased technical staff. The present divisional locations are as follows:—

(1) Headquarters—Director's offices; Statistical Division; Explosives Division, and general laboratory—Wellington Street.

(2) Chief Chemical Laboratory—Sussex Street.

(3) Fuel Testing Station, and Concentrating Laboratory—Division Street.

(4) Divisions of metalliferous and non-metalliferous ore deposits; mapping and drafting division; storage and distribution of reports—Sparks Street.

(5) Editor's and Accountant's Offices—Victoria Memorial Museum.

This enforced decentralization is a heavy handicap on the work of the Department, involving, as it does, great loss of time, waste of energy, and costly, unnecessary routine.

Inasmuch, therefore, as the development of the mineral and metal resources is of vital importance at the present stage in the industrial progress of the Dominion, it is imperative—in the interests of projected efficiency—that new, permanent quarters, capable (as far as possible) of housing the entire technical staff of the Mines Branch under one roof, should be provided without delay.

As mentioned in the introductory, there has been an unusual demand for the various technical publications of the Mines Branch: the total number of monographs, reports, bulletins, etc., distributed through the Post Office during the year being 38,650—an increase of 3,650 over 1909.

The progressive development of the mineral industry in Canada is shown by the fact that the total value of mineral products for the year 1910 was $105,040,958—an advance of $14,625,195 over the year 1909. The correspondence of the Statistical Division amounted to 7,727 communications received and sent; while the direct correspondence of my own office amounted to 4,750 letters received and 3,914 sent.

I have the honour to be, Sir,

Your obedient servant,

(Signed) **Eugene Haanel,**
Director of Mines.

REPORTS

ON

CHEMICAL LABORATORIES, STATISTICAL DIVISION, ASSAY OFFICE, FUEL TESTING STATION, METALLURGICAL LABORATORY, ETC.

CHEMICAL LABORATORY.

(a) Sussex St.
(b) Wellington St.

F. G. Wait, M.A., F.C.S.

Chief Chemist.

Both branches of the laboratory have been in constant operation during the year, and the time of the three members of the chemical staff has been fully occupied.

During the year, 750 specimens have been reported upon. This is a slight falling off from the number reported last year, and may be attributed to the enforcement of the schedule of charges to which reference was made in last year's report.

The laboratory is divided into two sections, established in separate buildings. Such a condition is not only not conducive to the most efficient service, but at the same time, makes it impossible to avoid duplication of the equipment, and some overlapping of work. It is confidently expected that such changes will be undertaken, if not completed, during the present year, as will bring the two sections, at present divided, into one, and that, fully equipped on modern lines.

It is not the place in a summary report to enter into lengthy details regarding the work done; but for the purpose of easy reference, the various materials operated upon may be classified under convenient headings, as follows:—

FUELS, comprising:—

I. *Peat*, 10 samples from:—

(a) Ontario—

(1) Alfred peat bog, in Alfred township, Prescott county.

(2) Brockville bog, in Leeds county.

(3) Brunner bog, in Ellice township, Perth county.

(4) Komoka bog, in Lobo and Caradoc townships, Middlesex county.

(5) Rondeau bog, in Harwich township, Kent county.

II. *Lignites*, 3 samples, from:—

(a) Saskatchewan—

(1) S.E. ¼ section 12, township 9, R. 28, west of 3rd.

(b) Alberta—

(1) Ferry Point, in section (?), township 43, R. 18, west of 4th.

(2) Tofield—

III. *Lignitic Coal*, from:—

(1) Driftwood creek, some 50 miles south of Hazelton, B.C.

IV. *Coals*, 16 samples, from:—

(a) Alberta—

(1) Leitch's collieries, at Passburg, township 7, R. 3, west of 5th—3 samples.

(2) Jasper Park collieries—along or near the proposed line of the G. T. P. Ry.—in the Rocky mountains—8 samples.

(3) Brule lake, Athabaska river.

(b) British Columbia—

(1) Bulkley River valley, Omineca Mining Division, "Sander's coal."

(2) From a point some 20 miles south of Hazelton—3 samples.

V. *Anthracite:*—

In addition to the analyses, outlined above, made upon Canadian material, some 63 samples of Pennsylvania anthracite were collected from the bins and stock piles of 14 Ottawa coal dealers, and the ash content of each sample determined. The object in view was to ascertain whether or not the Pennsylvania anthracite supplied to the public buildings in eastern Canada, fulfilled the requirements of the specifications on which tenders were based.

It was assumed that the coal sold in Ottawa was equal in all respects to that sent to other cities in Canada, from the same mines; and that the samples taken—all on one day, and from the dealers—would give a fair representation of the output of those mines.

The 63 samples comprised:—

(A) "Red" ash, 3 sizes—9 samples—average ash content 7·87 per cent.

(B) "White" ash, 5 sizes—54 samples—average content 9·06 per cent.

Average of 63 samples—"Red" and "White"—8·89 per cent.

IRON ORES, 28 samples, comprising:—

I. *Magnetite*, from:—

(a) Nova Scotia—

(1) Annapolis county—Torbrook mines—5 samples.

(b) Quebec—

(1) Chicoutimi county—20 miles from Chicoutimi village, in the Lake St. John district.

(c) Ontario—

(1) Lanark county—Lavant township—from the Wilbur mine—4 samples.

Iron Hill mine—1 sample.

Clyde River mine—1 sample.

II. *Hematite*, from:—

(a) Nova Scotia—

(1) Antigonish county—north of Brierly brook.

(b) New Brunswick—

(1) Northumberland county—from Allison farm, near Wayerton.

COPPER ORES:—

(a) Quebec—

Twenty-seven samples of cupriferous ores from the Eustis mine in the township of Ascot, Sherbrooke county, Quebec—collected by Dr. A. W. G. Wilson—have been assayed during the year. It is expected that other samples from this, and other districts, will be examined in the near future, and it has been thought advisable to defer extended reference to them until a later report.

(b) Ontario—

District of Nipissing—James township—Ottawa Belle claim, No. 7, R. 414—1 sample.

(c) British Columbia—7 samples, from the Gold Drop, Granby, and War Eagle mines, at Phoenix; and from the North Arm of Burrard inlet.

LIMESTONES:—

During the year, 3 samples of limestones, all from British Columbia—collected by Mr. O. E. LeRoy of the Geological Survey—have been examined by Mr. Leverin.

ORES OF MOLYBDENUM:—

Fifteen samples, all collected by Dr. T. L. Walker, from the undermentioned localities:—

(a) Ontario—

(1) Addington county—lot 2, con. xiv, of Sheffield township.

(2) Haliburton county—Cardiff and Lutterworth townships.

(3) Renfrew county—lot 8, con. vii—of Brougham township.
" " —Jamiesons mine—Lynedoch township.
" " —lot 22, con. ii—of Ross township.
" " —Hunt's claim—Mount St. Patrick.

(4) Vicinity of Lake Timagami.

(*b*) British Columbia—

(1) Highland valley, Ashcroft.

(2) Grande Prairie.

(3) Rossland, Giant mine.

(4) Texada island, Marble Bay mine.

ORES OF TUNGSTEN:—

Two samples of scheelite—calcium tungstate—from the town of Scheelite, situated 2 miles west of the workings of the Moose River Gold Mining Co., in Halifax county, N.S.

BRICK AND POTTERY CLAYS:—

Partial analyses of thirteen samples have been made during the year. Of this number, two samples were taken from William's clay bed at Petrolia, Ont.; two from Edrans, Man.; one from Asquith, Sask.; and one from Strathcona, Alta.

They were examined as to their suitability for brick and pottery ware, and also for cement making. None are worthy of special mention.

GYPSUM.

Thirty-two samples, collected by Mr. W. F. Jennison, from:—

(*a*) New Brunswick:—

(1) Albert county—8 samples.

(b) Nova Scotia:—

(1) Hants county—24 samples.

Quantitative analyses of these several samples were made.

OIL-SHALES:—

Thirty samples.

These were examined, and their yield of oil and of sulphate of ammonia determined.

They were taken at the undermentioned localities:—

(a) Nova Scotia—

(1) Antigonish county, Big Marsh—9 samples.

(b) New Brunswick—

(1) Albert county—6 samples.

(c) Ontario—

(1) From the vicinity of Collingwood.

(2) From the vicinity of Petrolia.

ROCKS AND MINERALS:—

The analyses of 21 samples of minerals and rocks have been completed and reported during the year—all by Mr. Connor.

These comprise:—

Asbestos, serpentine, diabase, and peridotite, from the Eastern Townships of the Province of Quebec;

Serpentine, augite-syenite, and pyroxenite from Olivene mountain, near Tulameen river, Yale district, British Columbia;

Chert, sericite-schist, and four specimens of contact metamorphic rocks, from Wheaton River district, Yukon Territory.

NATURAL WATERS:—

Six samples of natural water have been examined during the past twelve months. Two samples were taken from springs in Kamouraska county, Quebec; one from a well at Whitewood, Sask.; and three from springs situated on the west bank of Bulkley river, 20 miles above Hazelton, in the Omineca Mining Division, British Columbia.

GLASS SAND:—

Sand, thought to be suitable for use in glass-making, has been discovered at three different localities in Manitoba: shore of a small lake near Dauphin; from a 200 ft. boring at Ste. Anne des Chenes, Provencher county; and an undefined point on the shore of Lake Winnipeg.

Analyses of these samples have been made, and all were found to be remarkably free from oxides of iron, manganese, and other deleterious constituents.

FURNACE ASSAYS:—

One hundred and forty furnace assays for gold, silver, and platinum, have been made. Of this number, only 40 were accompanied by definite information indicating the locality of occurrence. The remaining 100 were sent in to the office and paid for, as commercial propositions.

The 40 specimens above referred to were distributed as follows:—

(a) Nova Scotia	4	samples.
(b) New Brunswick	1	"
(c) Quebec	9	"

(d) Ontario.......................... .... 12 samples.
(e) Saskatchewan........................... 2 "
(f) British Columbia.. .... 12 "

MISCELLANEOUS:—

Under this caption are placed some 50 specimens for which written reports were furnished; and upwards of 250 others, for which an oral report was made, and of which no record was kept.

Of all these specimens, consisting mainly of rocks and minerals, requiring descriptions only, none were worthy of special mention, either by reason of their own character or through lack of sufficient data as to locality of occurrence.

Mr. M. F. Connor, B.A.Sc., and Mr. H. A. Leverin, Ch.E., have both rendered faithful and efficient service in carrying out the greater part of the work here referred to.

REPORT OF THE DIVISION OF MINERAL RESOURCES AND STATISTICS.

John McLeish, Chief of the Division.

The total value of the mineral production of Canada during the calendar year 1910, according to the returns collected by this Division, exceeded the sum of $105,000,000. The statistical record is, of course, not yet complete, but sufficient information has been received to show approximately the above result.

The statistics show very clearly that the year 1910 was one of exceptional activity in the successful exploitation of Canada's mineral resources. The production is made up from such a great variety of well established mining industries, that the record should be particularly gratifying, not only to those who are directly interested in the development of the mineral resources of the country, but also to the public at large, who indirectly profit thereby.

Not only is the increase over the production of the previous year a large one, having amounted to $13,209,517, or over 14 per cent, but an examination of the details of production shows that the increase has been fairly well distributed amongst the more important ores and minerals produced in Canada.

A Preliminary Report on the Mineral Production of Canada in 1910 has already been published and will be found reproduced as Appendix I to this report, page 163.

The actual work of the staff of this Division during the year 1910, has, of course, been mainly directed towards the collection of the statistics of mineral production in 1909 and the preparation and publication of reports with respect to the same. And while this work has been carried on in much the same manner as in previous years, nevertheless, much improvement has been made, not only in the method but in the extent and general efficiency of the published results.

Reference was made in last year's report to the fact that provision had been made for the addition to the staff of a mining engineer. This position was filled on May 9, by the appointment of Mr. Cosmo T. Cartwright, B.Sc., who had already had a number of years' experience in several of the mining camps of British Columbia.

As soon as convenient after the first of January, letters, and circular requests were sent out to the mining community throughout Canada from whom returns of production were desired; and towards the latter part of February sufficient information had been received and compiled upon which to base a preliminary report on the mineral production of Canada during the calendar year 1909.

The manuscript for this report was sent to press on February 24, and the printed report was received February 28, 1910. Copies were distributed at the annual convention of the Canadian Mining Institute held at Toronto, March 2, 3, and 4, 1910. The writer attended this convention, and read a short paper on the mineral production of Canada, thus placing before the mining community and the public—at the earliest opportunity—information concerning the extent of our mining output.

The annual meeting of the Nova Scotia Mining Society held at Halifax, March 15 and 16, was also attended. An endeavour was made at this meeting, in connexion with the subject of collection of mineral statistics, to show the desirability of having these records collected for the calendar year. At the present time the Provincial Department of Mines of Nova Scotia collects and publishes statistics of mineral production covering a fiscal year ending September 30. As a result of the discussion, the following resolution was submitted by Mr. T. Cantley:—

> "I move that the Council be empowered to take what action it thinks necessary to bring to the notice of the local government the great advisability of having statistics end with the calendar year."

The motion was seconded by W. F. Jennison, and adopted.

The completed report containing the revised statistics of mineral production in Canada during the calendar years 1907 and 1908, was not received from the printers for distribution until the 16th of May, 1910. Parts of this report, however, had already been published in pamphlet form, and distributed during the previous year.

Some difficulty has been experienced in obtaining complete and prompt returns of production of products; such as stone, lime, clay products, etc.; many small producers being under the impression that it was not worth while reporting a small output, some thinking the information was required for purposes of taxation, and some failing to differentiate between the Provincial Bureau of Mines, and the Federal Department of Mines; while others were indifferent, or neglectful of correspondence. With a view to correcting these erroneous impressions and checking our lists of operators, Mr. Cartwright was instructed to visit a large number of those who had neglected to answer repeated correspondence. Some 81 cities, towns, and villages in Ontario were visited, and 109 different producers interviewed: information from remoter points being obtained, as well, by telephone or indirect inquiry. Mr. Cartwright reports that: "With hardly an exception, the most courteous treatment was received, and information was readily obtainable, in so far as those concerned were able to furnish it.

"The failure of many to report may be ascribed to several causes: carelessness; pressure of business; inability, owing to the fact that in many cases no records are kept; and though usually an estimate may be obtained, yet sometimes, even this is impossible, due to a fear that the returns are to be used for taxation purposes. Then, again, the Federal Department of Mines is confused with the Ontario Bureau of Mines—which also collects returns; while in some cases, where production had fallen off, it was not considered worth reporting.

"The majority of brick and tile makers whom I visited were very anxious to obtain any information which would aid them to improve their works and product.

"In the case of common brick, the prices are governed very largely by local conditions. Thus, while brick were being sold in Hamilton at $7.50 to $8.50 per thousand, and the demand steadily increasing; only forty miles distant, $6 to $6.50 per thousand was quoted, with sales on credit, and little demand.

"In districts where sand is plentiful and good clay deposits are scarce, concrete blocks and tiles are finding very extensive use, and in some cases are coming into serious competition with local brick yards. Throughout the Province there was a most noticeable tendency to devote the plants entirely to the production of drain tile. This may very largely be attributed to the demonstrations by the Provincial Government of its use.

"The majority of the tile makers whom I visited reported a demand in excess of their capacity."

The separate publication of advance chapters of the final report inaugurated last year was continued, and in pursuance of the plan the following reports were prepared and sent to press on the dates indicated:—

The Production of Iron and Steel in Canada during the calendar year 1909—September 2.

The Production of Coal and Coke in Canada during the calendar year 1909—September 2.

The Production of Cement, Lime, Clay Products, Stone, and other Structural Material in Canada, during the calendar year 1909—November 14.

These were issued as advance chapters of the complete Report on the Mineral Production of Canada during the calendar year 1909, and were all received and distributed before the close of the year. The complete report was transmitted on December 22, 1910.

PROPOSED CO-OPERATION WITH THE CENSUS OFFICE IN THE COLLECTION OF THE MINING CENSUS.

Early in the year a proposal was made by Mr. A. Blue—chief officer of the Census—for the co-operation of this Division with the Census office in the collection of the Census statistics relating to mining, covering the year 1910.

Co-operation in this work appeared to be most reasonable, particularly in view of the fact that the Department of Mines already collects and publishes annual statistics of mineral production, the collection being chiefly by correspondence, and a duplication of the work by the Census office whose officers are not specially technically qualified for it would seem to be unnecessary.

In the United States where similar departments exist, such a co-operation was carried out in the collection of the census of 1900, and was then in progress in the collection of the census of 1910.

The Director of the United States census very kindly placed at our disposal copies of the special schedules that had been prepared for the joint use of the two departments concerned. After careful study of the subject some 25 special schedules were prepared, based mainly on the schedules already in use by this Division. These were adapted, however, to meet the requirements of the Census office, as well as the Mines Department. It was proposed that a plan of co-operation somewhat similar to that being carried out in the United States, between the U.S. Geological Survey and the Census Bureau at Washington, be entered upon. The special schedules were submitted, with the suggestion that they be adopted as special schedules of the Census office; that the work of collection be undertaken by the Department of Mines, acting under the authority of the Census Act; and that the statistics obtained be equally available to this Department for the preparation of its annual report on Mineral Production, and to the Census office, for the preparation of its special Census report on Mineral Production.

Unfortunately, the Census Act provides that the census shall be taken on a specified day in June, whereas the collection by this Department would require to be begun in January. For this, and other reasons, the proposal did not meet with the complete approval of the Census office, and after some consideration their request for our assistance and co-operation was withdrawn.

SUPPLY AND DEMAND FOR CERTAIN MINERAL PRODUCTS.

Numerous inquiries have been received during the year from prospectors and others desirous of knowing what market there is for various mineral products; many inquiries being also received from prospective buyers both in and outside of Canada, desiring to know where certain minerals or ores could be obtained.

Information as to the market for feldspar has been in special demand, and the following statement as to markets and prices may be of interest to those who have deposits of this mineral.

The annual production of feldspar in Canada at the present time is about 15,000 tons. This is practically all exported, and finds a market amongst the pottery manufacturers of Trenton, N.J., and East Liverpool, Ohio; the principal buyers being:—

The Potters Mining & Milling Company, East Liverpool, Ohio; The Golding Sons Company, East Liverpool, Ohio; The Eureka Flint & Spar Company, Trenton, N.J.; The Pennsylvania Feldspar Company, 706 Franklin Bank Bldg., Philadelphia, Pa.; and the American Feldspar Company, Barnard Station, N.Y. The total consumption in the United States is probably about 100,000 tons per annum.

The Canadian production is all shipped crude, and the producers get about $3 a ton on board cars.

Feldspar is used in Canada chiefly by manufacturers of pottery and enamel ware, and the consumption will probably amount to at least 1,500 or 2,000 tons per annum. These manufacturers, however, require their supplies finely ground, and frequently special grades, and as there are no suitable grinding mills in Canada, the ground spar is imported from the United States and costs from $10 to $14 a ton at Canadian points of consumption.

The principal Canadian users are: The Dominion Sanitary Pottery Company, St. Johns, Que.; The Thos. Davidson Manufacturing Company, Ltd., Montreal, Que.; R. Campbell's Sons, Hamilton, Ont.; The Standard Ideal Company, Ltd., Port Hope, Ont.; The Amherst Foundry Company, Ltd., Amherst, N.S.; The McClary Manufacturing Company, London, Ont.; The Canadian Trenton Potteries Company, Ltd., St. Johns, Que.; The Canada Pottery Company, Ltd., Iberville, Quebec.

Other products for which a market is sought include mica, molybdenite, gypsum, infusorial earth, titanite, actinolite, etc.

Inquiries have been received during the year for arsenical ores, wolfram, graphite, phosphate, salt, dolomite, mica, talc, asphalt, etc.

In the case of phosphate, although a considerable demand was apparent, in the opinion of Canadian producers the prices offered were too low to ensure profitable operations.

There are a considerable number of mineral products in Canada for which there is, perhaps, a fairly large demand in this country, particularly the non-metallics which are being mined and exported. The Canadian buyer usually requires his supplies to have undergone some process of treatment or refinement; while the producer has been content to sell his product crude, not being sure of a sufficient market to justify him in erecting a necessary plant. The mineral talc is an example of a product which was formerly all exported, while the Canadian consumption was being imported. Now, a grinding mill has been erected, and the Canadian product is finding a considerable local market. Feldspar is a product which is at present being altogether exported, although there is a considerable local demand, which is being filled by importation. There are many other products for which the extent of the home market is perhaps not very clearly understood. Amongst these products might be included high grade steels; abrasives—such as pulpstone, garnets, tripolite, corundum, etc.; barytes, magnesite, fluorspar, quartz, manganese, phosphate, and others.

A special investigation, amongst the manufacturers of paints, paper, sulphite, pulp, wallpaper, leather, enamelware, sanitary ware, etc., as to the market for these and similar products, would no doubt be productive of results of considerable value to the mining industry.

The routine correspondence of the Division during the year comprised about 1,384 letters sent and received, in addition to which, about 4,712 circular communications were sent out, and 1,631 received. Five reports of the Division were distributed, comprising about 10,000 copies.

REPORT COVERING THE OPERATIONS OF THE DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C., DURING THE YEAR ENDING DECEMBER 31, 1910.

There were 490 deposits of gold bullion, requiring 534 melts and 534 assays (quadruplicate check assays being made in each instance), including the assembling and remelting of the individual deposits after purchase into bars weighing about 1,000 troy ounces each and the assaying of same. The aggregate weight of the deposits before melting was 46,064·31 troy ounces, and after melting 45,228·92 troy ounces, showing a loss in melting of 1·8135 per cent. The loss in weight by assaying was 5·70 troy ounces (base and parted silver), the average fineness of the resulting bullion, viz., 45,223·22 troy ounces being 0·797 gold and 0·182 silver. The net value of the gold and silver contained in deposits was $746,101.92.

The gold bullion received came from the following sources, viz.:—

Source.	Number of deposits.	Weight.		Net value.
		Before melting.	After melting.	
		Ozs.	Ozs.	$ cts.
Yukon Territory	57	3,688·06	3,594·87	62,094·09
British Columbia	401	35,189·99	34,482·73	571,670·52
Alberta	1	34·03	32·59	595·51
Alaska	29	6,961·43	6,938·11	108,348·01
California	2	190·80	180·62	3,393·79
	490	46,064·31	45,228·92	$ 746,101·92

Weight before melting	46,064·31	ounces.
Weight after melting	45,228·92	"
Loss by melting	835·39	"
Loss percentage by melting		1·8135

Credits and Disbursements for the Purchase of Gold Bullion During the Year Ending December 31, 1910.

Unexpended balance—"Letter of Credit," January 1, 1910		$110,392.04
Credits established during year ending December 31, 1910		700,000.00
"Letter of Credit," balance written off at close of fiscal year, March 31	$ 49,878.40	
Disbursements for purchase of bullion	746,101.92	
Disbursements for purchase of nugget (on hand)—Gold Nugget Collection—per Cheque No. 608	626.58	
Unexpended balance, "Letter of Credit," December 31, 1910	13,785.14	
	$810,392.04	$810,392.04

Disbursements for the Purchase of Gold Bullion and Receipts from Sale of Same During the Year Ending December 31, 1910.

Disbursements for purchase of bullion on hand January 1, 1910, bars Nos. 524, 530, 536 to 548 inclusive		$ 11,169.64
Disbursements for purchase of bullion during year ending December 31, 1910—Cheques Nos. 549 to 607 inclusive, 609 to 612 inclusive, and 1 to 427 inclusive (Cheque No. 608 was issued in payment for nugget (on hand)—Gold Nugget Collection)		746,101.92
Proceeds from sale of bullion during year ending December 31, 1910	$750,455.99	
Value of bullion on hand December 31, 1910, bars Nos. 399, 400, 410, 411, 413, 414, 417 to 427 inclusive	7,514.60	
Difference in favour of this office		699.03
	$757,970.59	$757,970.59

Contingent Account for Year Ending December 31, 1910.

Unexpended balance, January 1, 1910		$ 155.51
Funds provided per official cheques Nos. 655, 751, 819, 10, 58, 194, 302, 398, 482, 570, 695, and 796		4,440.00
Amount remitted Receiver-General, per draft No. 169, at close of fiscal year, March 31, 1910	$ 99.37	
Expenditure during year ending December 31, 1910	4,470.74	
Unexpended balance, December 31, 1910	25.40	
	$4,595.51	$4,595.51

Contingent Expenditure During Year Ending December 31, 1910.

Rent	$2,400.00
Fuel (gas)	248.08
" (coal)	20.00
Light and power	155.17
Express charges on bullion	598.74
New equipment	110.50
Electric vault protection service	300.00
Transferring electric vault protection equipment to new quarters	206.00
Postage and telegrams	15.00
Telephones	68.50
Freight and cartage on assayers' and melters' supplies	11.82
Assayers' and melters' supplies (purchased locally)	206.05
Sundries	130.88
	$4,470.74

Proceeds from Residues Sold March, 1910.

Residue sold to Assay Office, Seattle, Wash. (bar No. A 4)	$351.89
Thirty-eight empty acid bottles sold to B. C. Assay & Chemical Supply Company, Ltd., Vancouver, B.C.	5.70
	$357.59

Residues on Hand December 31, 1910.

Slag from melting of bullion (105 lbs. of which has been treated)	210 lbs.
Recovered from sweepings, slags, old furnaces, old crucibles, etc. (11·51 ounces)—value	$153.20
Twenty-seven empty acid bottles.	

NOTE:—Residues (old furnaces, slags, old crucibles, etc.) are now treated in the office instead of being sold as formerly.

Miscellaneous Receipts.

Draft No. 185, in favour of Deputy Minister of Mines:—(Proceeds of sale of two old heating stoves and sundry office partitions)	$ 55.00
Draft No. 193, in favour of Deputy Minister of Mines:—(Proceeds of sale of old iron grilles, old case for balance, and old chain blocks)	59.00
Draft No. 196, in favour of Deputy Minister of Mines:—(A payment for melting 50 ounces native silver)	2.50
	$116.50

IMPROVEMENT OF EQUIPMENT.

A disc pulverizer for reducing slags to a fine powder was installed during the month of July.

The following shows the business done by the Assay Office since its establishment:—

Year.	Number of deposits.	Weight (troy ounces).	Net value.
1901-2 Fiscal	671	69,925·67	$1,153,014.50
1902-3 "	509	36,295·69	568,888.19
1903-4 "	381	24,516·36	385,152.00
1904-5 "	443	29,573·73	462,939.75
1905-6 "	345	21,050·83	337,820.59
1906-7 Nine months	269	20,695·84	336,675.65
1907-8 Fiscal	482	46,540·25	751,693.97
1908 Nine months	590	90,175·48	1,478,893.74
1909 Calendar	573	48,478·60	789,267.94
1910 "	490	46,064·31	746,101.92

(Signed) G. Middleton,
Manager.

December 31, 1910.

G. Middleton, Esq.,
Manager,
Dominion of Canada Assay Office,
Vancouver, B.C.

Sir,—

The following is a list of the assayers' supplies on hand, viz.:—

Silver nitrate crystals	1	oz.
Calcic chloride	1/3	lb.
Lead foil, C.P.	55	lbs.
Cupels ......about	4,000	
Nitric acid	10	Winchesters.
Sulphuric acid	3/4	Winchester.
Zinc (mossy) C.P.	1/2	lb.
Lead (granulated)	6	lbs.
Scorifiers, 4″	8	
" 2¼″	55	
Spare muffles	21	
" doors	5	
" supports	12	
" back stops	24	
" plugs	12	
Litharge	19	lbs.
Bone ash ......about	10	"
Fireclay ...... "	15	"
Gold cornets	1·93	ounces.
" in solution	11·47	"
" proof	0·70	"
Silver	69·80	"

Yours obediently,

(Signed) A. Kaye,
Assayer.

December 31, 1910.

G. MIDDLETON, ESQ.,
Manager,
Dominion of Canada Assay Office,
Vancouver, B.C.

SIR,—

I beg to inform you that we have on hand in the Melting Department the following supplies, viz.:—

3 sets of linings with supports and covers complete, for No. 1 furnace.
2 " " " " " " " " " " 2 "
2 " " " " " " " " " " 4½ "
3 " " " " " " " " " " 7 "
1 Graphite crucible, No. 6.
6 Graphite crucibles, No. 10.
55 " " " 16.
12 " " " 30.
27 " " " 40.
50 " " " marked o°o
2 Crucible covers, No. 16.
2 lbs. pot. nitrate.
40 lbs. carb. soda.
125 lbs. borax glass.

Your obedient servant,

(Signed) D. Robinson,
Chief Melter.

ACCOUNTANT'S STATEMENT.

(*a*)

The following is a statement of difference in value of assays between Seattle Assay Office and Dominion of Canada Assay Office, from April 1, 1909, to March 31, 1910:—

Paid for bullion at Dominion of Canada Assay Office, Vancouver	$750,121.60
Received for bars from United States Assay Office, Seattle	750,781.36
Difference in favour of Dominion of Canada Assay Office	$659.76

STATEMENT OF DEPOSITS OF GOLD AND EARNINGS.

Deposits of gold	$750,121.60
Earnings:—	
Value of residue sold United States Assay Office	$ 351.89
" " 38 acid bottles sold B. C. Assay & Chemical Supply Company	5.70
	$ 357.59
Difference between amount paid and received for bullion	659.76
	$1,017.35

(*b*)

The following is a statement of appropriation, receipts, and expenditure of Dominion of Canada Assay Office for the year ending March 31, 1910, and shows the unexpended balance to be $3,932.81:—

	Appropriation.	Expenditure.
Appropriation, 1909-10	$18,000.00	
Receipts per the foregoing statement	357.59	
Difference between amount paid and received for bullion	659.76	
Rent		$3,000.00
Fuel		292.55
Power and light		166.68
Postages and telegrams		79.68
Telephone		67.50
Express charges		613.74
Assayers' supplies		257.12
Printing and stationery		96.62
Premium on bonds		570.00
Contingencies		90.65
Electric burglar alarm service		300.00
Wages:—		
G. Middleton		2,500.00
J. B. Farquhar		1,800.00
D. Robinson		1,700.00
A. Kaye		1,500.00
G. N. Ford		1,000.00
G. B. Palmer		900.00
R. H. Filion		150.00
Balance unexpended		3,932.81
	$19,017.35	$19,017.35

Unexpended balance March 31, 1910, lapsed, $3,932.81.

(Signed) John Marshall,
Accountant.

FUEL TESTING STATION, OTTAWA.

B. F. Haanel, B.Sc.

I.

The installation of the peat gas producer and gas engine, purchased by the Mines Branch from Korting Brothers, Hanover, Germany, was completed about April 1, 1910.

The gas analytical laboratory was not completed until November, 1910, so that no complete tests could be carried out until after this date.

Previous to the installation of the gas analytical laboratory, three tests—to determine the consumption of peat per B. H. P. hour—were made with peat manufactured at Victoria Road peat bog. This peat had been manufactured some two years previous to the erection of the machinery at the fuel testing plant, and during this period was stored in a shed fully protected from the weather. It was consequently very dry, containing only 13 per cent moisture. But inasmuch as the producer was designed to gasify peat containing from 25 to 30 per cent moisture, the results of the tests with this peat cannot be considered as a criterion of the performance of the producer when working under proper conditions, viz., utilizing peat with from 25 to 30 per cent moisture.

The results, however, were excellent both as regards fuel consumption and behaviour of the fuel in the producer. The fuel consumption for the three tests averaged a little less than 2·2 pounds per brake horse-power hour.

After the completion of the gas analytical laboratory a complete 30 hour test was made with the peat manufactured at the Government bog at Alfred. The peat used during this test averaged 30 per cent moisture. During the entire test samples of gas were taken and analysed every hour. The calorific value of the gas was determined every 30 minutes by means of the Junker's calorimeter. Readings of both the voltmeter and ammeter were taken every 15 minutes. From these readings the effective horse-power of the engine developed during the test was calculated.

Before making the foregoing test, considerable time was spent in ascertaining the most suitable size to which it was necessary to crush the peat in order to obtain best results in the producer.

As determined by experimentation the peat should be of about the size of a hen's egg—for peat containing 30 per cent moisture. For peat containing less moisture larger sizes may be used, although the smaller sizes offer no difficulties to the operation of the producer regardless of the moisture content.

The satisfactory operation of the producer depends on the condition of the material fed to the lower zone, i.e., the material must be as free from volatile matter as is possible—since any tar distilled from the fuel in the lower zone cannot possibly be broken up, and, therefore, leaves the producer as a deleterious ingredient of the gas.

When these conditions are understood and the proper method of operating the producer learned it requires scarcely any attention from one day to another.

A few of the principal details of this test are as follows:—

	Dec. 6.
Producer cleaned and filled with peat	11·00 a.m.
Test started	11·00 "
Test terminated and producer cleaned and filled	5·00 p.m., Dec. 7.
Duration of test	30 hours.
Total fuel fired	4900 lbs.
Total ashes	153·5 "
Pounds coke lost through cleaning doors when poking and to be subtracted from total fuel fired	22·5 lbs.
Average load on engine	58·18 B.H.P
Consumption of fuel as fired, 30 per cent moisture per B.H.P.H	2·80 lbs.
Consumption of fuel per B.H.P.H. fired dry	1·87 "
Average heating value of gas	Gross 124 B.T.U. per cubic foot. Net 116 " " " " " "

The producer was poked every two hours—the vacuum on the gas main throughout the entire run varied but little from 28 cms. of water (11″). No trouble was experienced during this run nor subsequent runs from clogging of the cleaning system.

An average sample of the total peat charged was taken for analysis and a gas sample taken and analysed every hour. The calorific value of the gas was determined every 30 minutes by means of a Junker's calorimeter.

Composition of the Gas by Volume.

The composition of the gas remained remarkably uniform throughout the later test.

The average composition was as follows:—

CO_2	9·9%
O_2	0·4 "
C_2H_4	0·4 "
CH_4	2·0 "
H	9·8 "
CO	20·6 "
N	56·9 "
	100·0%
Combustible gas	32·8%

In conclusion, it may be stated that the tests so far made have demonstrated that peat can be economically and efficiently utilized in producer gas engine plants, for the production of power. The operation of the Government *peat* gas producer plant has proven to be as simple as that of an *anthracite* producer gas plant: and may be economically substituted for those producer plants using imported coal—when the price of coal is in the vicinity of $3.50 per ton, and the price at which peat can be obtained is not more than $2 per ton.

II.

FUEL TESTING LABORATORY.

Edgar Stansfield, M.Sc., Chemist.

As a chemical laboratory was found to be an essential adjunct to the Fuel Testing Plant, a small room (17 feet × 11 feet)—the only one available—has been temporarily fitted up for the purpose. The work of this laboratory has been seriously hampered, and will be, until it is possible to provide suitable accommodation. Gas analyses and calorimetry—which require a room of constant temperature; furnace work, and all general chemical work in which heat is generated; weighings, etc.—which ought to be done in a clean room, free from chemical fumes liable to attack the balances; chemical work—which produces fumes; and the preparation of samples, which causes dirt, have all to be done in the same room. The accommodation urgently required includes: (1) a constant temperature room; (2) a general laboratory; (3) a room for furnace work; (4) a sample room; (5) a balance room and office, and (6) a store room. It would be possible but not desirable, to unite (2) and (1) or (2) and (3).

The equipment of the laboratory was begun in July, 1910, but it was not until September that the laboratory benches were installed, and that it was possible to begin chemical work there. The equipment includes the following pieces of apparatus, which were originally purchased for the coal tests carried out for the Mines Branch at McGill University, but which have now been installed in this laboratory: Bone and Wheeler gas analysis apparatus; Randall and Barnhart gas analysis apparatus; Boys gas calorimeter with meter and pressure regulator; Simmance and Abady carbon dioxide recorder; Fritz Köhler bomb calorimeter with accessories—including pressure gauge, Beckmann thermometer, and briquetting press; Bunsen combustion furnace with purifying and absorption trains; platinum crucibles, thermometers, and general chemical apparatus and chemicals. In addition to the above, the following have been obtained for the laboratory: two laboratory benches; a tile-topped table for furnaces; shelves; racks, etc.; Hoskins electric muffle furnace; Hoskins electric hot plate; International Instrument Company electric oven with thermo-regulator; Junker gas sampler; Junker gas calorimeter with meter and pressure regulator; two copper gas holders; two high pressure, oxygen gas cylinders; Brady gas filter with electric heating sleeve; induction coil; Sartorius analytical balance; Beranger balance; Sartorius box of weights; Fortin standard barometer with Kew certificate; Keiser & Schmidt pyrometer; Jewel water still; water blast pump with gauge; 16″ diameter, iron ball mill; electric lamp resistance board; and general chemical apparatus and chemicals. Water and electricity—both alternating and direct current—have been provided; and, as city gas is not at present available, gasoline gas is prepared for use in the laboratory by blowing air or producer gas through a small tank of gasoline.

The work which has been done in connexion with the laboratory, in addition to the considerable work of equipment, has included: tests on Blaugas; tests on Fisher's fuel economizer; tests of peat tar; micro-photography of coal dust taken from the mine at Bellevue, Alta., after the explosion on December 9, 1910; 30 determinations of the calorific value of peat and coal; 65 determinations of the calorific value of gas; 65 analyses of gas; 20 determinations of tar and dust in producer gas; and a number of determinations of moisture, ash, volatile matter, etc., in peat, coal, and coke. The samples tested include: 21 samples of peat from the Government peat bog at Alfred, Ont.; 11 from the Holland peat bog at Bradford, Ont.; 4 from Walkerton, Ont.; and 4 sundry peat samples; 12 samples of coal from Edmonton; 1 from Pittsburgh; and 1 sample each of cannel and anthracite coal; 1 sample of gas coke.

THE ORE DRESSING AND METALLURGICAL LABORATORY

George C. MacKenzie, B.Sc.

During the summer and autumn of 1910, the Mines Branch installed a plant at the Fuel Testing Station, Ottawa, for the experimental concentration of low-grade, magnetic, iron ores. This installation consists of a Gröndal wet concentrating unit: comprising an ore crusher, ball mill, and two Gröndal magnetic separators. The machines are of standard, commercial size, the capacity of the unit—depending upon the character of the crude—being anywhere from 50 to 100 tons of ore per 24 hours.

This machinery is placed in the room originally intended for a repair shop at the Fuel Testing Station, and receives its motive power from the gas producer plant which is operated with peat fuel obtained from the Government bog at Alfred.

This machinery was installed with a view to proving the amenability of Canadian low-grade magnetic iron ores to methods of concentration carried out successfully in the United States, England, Sweden, and Norway. The process is both simple and effective, having for its objective the concentration or enrichment of the iron values; together with the elimination of various obnoxious minerals usually associated with low-grade ores.

The process of magnetic concentration, as applied to a certain inferior class of iron ores, has, to-day, a firmly established and well recognized value in the above-mentioned countries. The product is not only high grade, being eminently suitable for the production of the finer grades of iron and steel; but constitutes also a valuable auxiliary to the main supply of natural ores.

The United States leads all other countries in its resources of high-grade, natural iron ores; but notwithstanding this fact, several of the larger iron corporations in that country have found it exceedingly profitable to employ concentration methods in the utilization of low-grade ores. This is the more worthy of note when it is considered that iron and steel manufactured from these concentrated ores are competing successfully with iron and steel made from the natural and apparently cheaper ores.

About 17 per cent of the iron ores smelted in Canadian furnaces during 1909 was of domestic origin. This small proportion is due to the fact that, we have not as yet discovered merchantable deposits of sufficient magnitude to meet requirements.

The iron and steel companies of the Maritime Provinces, it is true, secure the major portion of their ore supply from Newfoundland; but the Ontario furnaceman is almost entirely dependent for his ores upon the American ranges of Minnesota and Michigan, and in 1909 he found it necessary to import from the United States over 71 per cent of the amount required.

While it is true the supply of high-grade merchantable iron ore in Canada is limited, there are in the Dominion enormous quantities of low-grade material not regarded as merchantable, and which have hardly been touched.

To render these impure ores in fit condition for the manufacture of iron and steel necessitates the application of a concentration process; and the fact that the vast majority of our low-grade iron ores are of the magnetic variety, suggests the adoption of magnetic concentration as the means whereby these ores may be utilized with profit.

With a view to showing the extent to which the magnetic concentration process would apply to Canadian ores, it will be illustrative to mention a few of the localities in which they are found.

The sulphurous magnetites occurring on the coast of British Columbia have hitherto been regarded as a doubtful asset, on account of their impurity. Many of these British Columbia magnetites contain copper in appreciable amounts, which might constitute a valuable by-product. The siliceous jaspilite ores of northern Ontario, and the more crystalline and sulphurous ores of the western and mid-eastern portion of the Province, present concentration problems of the utmost importance. The high sulphur ores of Quebec occurring along the Ottawa and Gatineau rivers, and the large titaniferous deposits found on both sides of the St. Lawrence river are worthy of exploitation as regards their profitable use in the manufacture of iron and steel.

The magnetic sands of the lower St. Lawrence river require more accurate investigation as regards their extent and amenability to concentration; and the recent discovery of large bodies of intermixed siliceous magnetic and hematite ores in New Brunswick offer additional problems, as also do the semi-magnetites of the Nictaux range in Nova Scotia.

After the completion of the magnetic concentration plant, the Mines Branch issued a circular letter calling attention to the installation; describing its purpose, and inviting those interested to send in samples of iron ore for testing purposes. All tests are made free of charge; but it is required that samples and specimens shall be delivered to the testing plant in Ottawa carriage paid. The replies to the circular letter received up to date have been most gratifying, and arrangements have been made for the testing of some 80 tons of ores received from different localities: in five, ten, and fifteen ton lots.

A list of the ores received up to date for testing purposes is as follows:—

TABLE I.

List of Iron Ores Received for Testing.

Name of Ore.	Locality.	Shipped by.	Weight of shipment. Tons.
Wilbur, No. 1, Run of mine.	Lots 3 and 4, con. XII. Lots 3 and 4, con. XIII. Township of Lavant, county of Lanark, Ontario.	The Ontario Exploration Syndicate, Wilbur, Ontario.	10
Wilbur, No. 2, Waste dump.	Lots 3 and 4, con. XII. Lots 3 and 4, con. XIII. Township of Lavant, county of Lanark, Ontario.	The Ontario Exploration Syndicate, Wilbur, Ontario.	5
Robertsville.	Lots 3 and 4, con. IX. Township of Palmerston, county of Frontenac, Ontario.	The Ontario Exploration Syndicate. Wilbur, Ontario.	5
Culhane.	N. ½, lot 21, con. VII. Township of Bagot, county of Renfrew, Ont.	Thos. B. Caldwell, Esq., Lanark, Ont.	3
Bathurst.	Lot 12, range XVII. Township of Bathurst, county of Gloucester, New Brunswick.	The Canada Iron Corporation. Limited, Montreal, Quebec.	15
Nictaux Torbrook, hematite vein.	County of Annapolis, Nova Scotia.	The Canada Iron Corporation, Limited, Montreal, Quebec.	15
Nictaux Torbrook, shell vein.	County of Annapolis, Nova Scotia.	The Canada Iron Corporation, Limited, Montreal, Quebec.	15
Goulais river.	Goulais River range. Township 22, range XII. District of Algoma, Ontario.	The Lake Superior Corporation, Sault Ste. Marie, Ontario.	15

As previously stated, the concentrating machinery is installed at the Mines Branch Fuel Testing Station, Ottawa, and is contained in a room 22′-0″ × 18′-0″, originally intended for a repair shop. The smallness of the room necessitated unavoidable crowding of machinery, and the operation of the plant is handicapped somewhat by this lack of space.

The process of operation is as follows: the crude ore is broken to about 1″, by an 8″ × 12″ Hadfield and Jacks solid steel crusher of the Blake type. This crusher is furnished with manganese steel jaws and cheek plates. From the crusher the ore drops to an elevator boot, and is picked up and elevated by belt and bucket elevator to an ore bin of about 1½ tons capacity. The ore bin delivers by ordinary roller feed to a 54″, Hardinge, conical ball mill. The mill is lined with hard iron plates, and takes a charge of iron balls or flint pebbles of from 1 to 1½ tons. A scoop feeder attached to the mill picks up a portion of the crushed ore from a feed box at each revolution; feed water being introduced to the feed box by a ¾″ pipe.

The finely ground ore flows from the ball mill to a 6″ × 48″ Frenier sand pump, which elevates the pulp a vertical distance of 10 feet, to the magnetic separators. The two, No. 5 Gröndal separators are operated in tandem: the first machine eliminating the major portion of the gangue, and the second re-concentrating the heads product from the first.

Concentrates and tailings are laundered to settling tanks, and are drawn off periodically through bottom discharge spigots. During the running of a test, samples of the crude ore are taken every fifteen minutes from the ball mill discharge, and samples of concentrates and tailings taken at the same time from the discharge spigots of the settling tanks.

The crude ore is weighed before crushing; but no attempt is made to dry and weigh concentrates and tailings; their weight being calculated from the weight of the crude, and the analyses of the crude concentrates and tailings.

Power is supplied by a 40 H.P. direct current, Westinghouse electric motor, connected to a generator driven by the gas engine in the adjoining fuel testing plant. The energizing current for the magnetic separators is supplied from the same source.

The amount of power consumed during a test is indicated by ammeters and voltmeters: readings being taken every fifteen minutes.

The amount of water used by the ball mill and the separators is recorded by ordinary water meters.

A PRELIMINARY TEST WITH GOULAIS RIVER ORE.

In November, 1910, the Lake Superior Corporation sent Mr. G. L. Michael to Ottawa with samples of Goulais River low-grade magnetite, for the purpose of consulting with officials of the Mines Branch with regard to methods of concentration.

The samples submitted by Mr. Michael consisted of crypto-crystalline magnetite, in a siliceous gangue. The ore exhibits a marked banded structure; bands of siliceous magnetite alternating with bands of non-ferrous siliceous material. The ore is typical of many of the northern Ontario low-grade iron ores; the crystallization being so fine that concentration can be effected only by fine grinding and wet magnetic concentration.

The samples, marked G. L. M. and L. L. B., weighed 75 and 50 pounds respectively. On account of the smallness of the samples, it was impossible to put the ores through the regular process; for they would have been lost in the Hardinge ball mill. They were, therefore, pulverized in a small laboratory ball mill, to a fineness of 80 mesh, and after grinding, fed by hand to the Gröndal separators.

Further difficulty was experienced in separating the ore, on account of the smallness of the samples. The separators, being of commercial size, were difficult to adjust to the comparatively small sized samples, consequently, a rather heavy loss of iron resulted.

Following are the results of the preliminary test:—

TABLE II.

Preliminary Separation.

	Crude Ore.		Concentrates.		Tailings.	
Sample.	Iron %	Insoluble %	Iron %	Insoluble %	Iron %	Insoluble %
G. L. M.	37·45	47·00	60·27	17·3	19·87	71·28
L. L. B.	35·00	52·00	54·87	24·2	14·8	77·40

Taking the above figures as a basis for calculation, the units of crude required per unit of concentrate, and the percentage of iron recovered in the concentrate are arrived at as follows:—

For Sample G. L. M.

$$\frac{60\cdot27-19\cdot87}{37\cdot45-19\cdot87}=2\cdot32 \text{ unit of crude required per unit of concentrate, and}$$

$$\frac{60\cdot27\times100}{37\cdot45\times2\cdot32}=69\cdot3 \text{ per cent of iron recovered in the concentrate.}$$

For Sample L. L. B.

$$\frac{54\cdot87-14\cdot8}{35\cdot2\ \ -14\cdot8}=2\cdot00 \text{ units of crude required per unit of concentrate,}$$

and

$$\frac{54\cdot87\times100}{35\cdot2\ \ \times2\cdot00}=77\cdot8 \text{ per cent of iron recovered in the concentrate.}$$

Because of the smallness of the samples submitted for testing purposes, the above results, although encouraging, show a heavy loss of iron in the tailings. It was advised, therefore, that a larger quantity of the ore should be sent in, to allow of a test being made under conditions more nearly approaching commercial practice. The Lake Superior Corporation, in compliance with the suggestion, have delivered 15 tons for treatment.

Complete results of the large test will be published in a later report.

MAGNETIC COBBING TESTS WITH WILBUR ORE.

The Exploration Syndicate of Ontario, operating the Wilbur iron mine, on the Kingston and Pembroke railway, conducted certain magnetic cobbing tests with Wilbur ore, December 1910, at the Kingston School of Mines.

As the Mines Branch had undertaken the work of making experimental tests with Wilbur ore by the Gröndal process, the Exploration Syndicate requested that the writer should attend certain of the cobbing tests in Kingston for purposes of consultation.

I was, therefore, instructed to proceed to Kingston and render such assistance as was possible, and the following is a report upon three cobbing tests made at the Kingston School of Mines.

Inasmuch as my absence from duty in Ottawa was limited to three days, it was impossible to do more than see the experiments fairly started, and then hand over the detail work to others. Hence, the report should be considered as a description only, of the general results obtained from the experimental separation of the ore, rather than a forecast of the conditions that will probably obtain in actual practice.

The tests were carried out at the mining laboratory of the Kingston School of Mines by certain members of the school staff, my presence being requested solely for consultation as regards the methods of experimentation to determine certain factors that control the production of merchantable concentrates.

During my stay in Kingston, I superintended the operation of Test No. 1; but had to return to Ottawa before the chemical analyses of the different products were completed. Arrangements were made that I should receive the details of chemical analyses when finished. Up to date, I have received the analytical results of three tests, and having been asked for a report upon the same, I append it herewith.

After consultation with Mr. R. R. Carr-Harris, and Mr. J. G. McNulty—the officials of the Exploration Syndicate of Ontario who were present during the tests—it was decided to experiment for the production of concentrates containing between 55 and 60 per cent of metallic iron, and in such a mechanical condition that they could be utilized in the blast furnace without nodulizing or briquetting; and for tailings containing not more that 10 per cent of metallic iron.

The exact mechanical condition of fineness of concentrated iron ores suitable for direct use in the blast furnace is a much debated point. One furnaceman may not object to a certain proportion of fines that will cause another unlimited trouble. Hence, the mechanical condition that will meet with general favour is difficult to determine.

It was, therefore, thought advisable to limit the proportion of fines in the experimental concentrates to a degree that should parallel as closely as possible the mechanical condition of the well known iron concentrates marketed by Witherbee, Sherman, and Company of Mineville, N.Y., U.S.A. This Company experience no difficulty in finding a sale for their product, which is of such mechanical condition that 65 per cent by weight is larger than 10 mesh.

Accordingly, the first or preliminary test was made with the crude broken to 1″ size, which it was thought would facilitate the production of concentrates possessing a mechanical condition well within the limit, as stated in the previous paragraph.

TEST NO. 1 ON RUN OF MINE, WILBUR ORE.

The ore was first broken to about 1″, and then sized over impact screens. Seven sizes were made in all; six sizes less than 1″, and one oversize. The several portions of the sized crude were then concentrated separately by the Ball and Norton belt separator; making three products: heads, middles, and tails.

The following is a tabulated statement of the results of this test.

TABLE III.

Test No. 1 on Run of Mine: Wilbur Ore.

	Crude Ore.			Concentrates.			Middlings.			Tails.			Loss.	
Mesh size.	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%
40......	42·5	7·1	43·1	26	61·2	65·8	....	....	.....	14	32.9	5·5	2·5	5·9
16......	21	3·5	42·7	13	61·9	59·7	....	....	.....	6·5	30·9	6·7	1·5	1·5
8......	34	5·7	43·2	25	73·5	54·2	....	....	.....	8	23·5	10·1	1	2·9
¼".....	65	10·8	45·2	49·5	76·1	52·2	8	12·3	29·1	5	7·7	8·6	2·5	3·8
½".....	93	15·6	46	81·5	87·6	49·4	5	5·4	28·5	6	6·4	5·7	0·5	0·5
1".....	277	46·3	......	240·5	86·8	50·3	22	7·9	.....	14·5	5·2	6·3	0·0	0·0
Over-size.	65	10·8	......	52	.....	51·4	10	15·4	39·1	3	46	6·1	0·0	0·0
Totals.	597·5	99·8	45·8	487·5	81·6	51·75	45	7·5	32·7	57	9·5	7	8	1·3

It will be noted that the iron content of the concentrates is only 51·75 per cent, a figure too low to be regarded as at all satisfactory. On the other hand, the recovery of iron is good, there being 92·1 per cent of the original iron saved, and the mechanical condition well within the limit: showing 86·8 per cent larger than 8 mesh.

After I had received the analysis of the above test, I advised that for Test No. 2 the ore should be broken to pass ¾" or ½" screen; that certain adjustments of the separating machine should be made to allow the production of more middlings, and at the same time a loss of iron in the tailings to more nearly approach the limit of 10 per cent. By this means a certain proportion of lean particles that contained sufficient magnetite to cause them to enter the concentrate in Test No. 1, and thereby lower its iron content, would be allowed to escape as a middling product for subsequent retreatment.

That this advice was not followed is apparent from the following tabulated results of Test No. 2.

TABLE IV.

Test No. 2 on Run of Mine, Wilbur Ore.

The ore for this test was crushed to pass a ¼" screen, then sized into four products, and separated.

—	Crude Ore.			Concentrates.			Middlings.			Tails.			Dust Loss.	
Mesh size.	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%
40 . . .	218	23·15	45·8	145·5	66·7	65·0	18·5	8·5	4·8	49	22·4	4·3	5·0	2·3
16 . . .	107	11·35	43·7	78	72·9	56·6	10·0	9·3	9·7	17·5	16·3	5·5	1·5	1·4
8 . . .	182·5	19·4	44·2	147	80·5	52·5	14·0	7·7	12·6	19·5	10·7	7·0	2·0	1·1
¼ . . .	434	46·1	46·6	370	85·7	52·0	20·0	4·6	17·2	39·5	9·1	9·0	4·5	1·0
Totals	941·5	100	45·7	740·5	78·6	55·3	62·5	6·6	11·1	125·5	13·3	6·2	13	1·5

Concentrates produced from Test No. 2 were just over the lower limit of the desired iron content, but contained only 49·9 per cent of material larger than 10 mesh, and, therefore, might be objected to on account of their fineness. The saving of iron effected was very satisfactory, being 95·1 per cent of the original.

It is quite possible that concentrates of the general character produced from Test No. 2 would find a market, but it is believed that a more desirable and valuable product would result by limiting the primary crushing to say ¾″ or ⅝″, and then making a larger proportion of middlings for subsequent re-treatment.

A third test was made on ore from the Wilbur No. 2 dump. This ore was taken from an old waste dump, and is of much lower grade than the run of mine.

TABLE V.

Test No. 3, on Ore from Wilbur Mine Dump, No. 2.

The ore was broken to 1″ and then sized, preparatory to concentration. The results of this test are as follows:—

—	Crude Ore.			Concentrates.			Middlings.			Tailings.			Dust Loss.	
Mesh size.	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%	Fe. %	lbs.	%
40......	57	7·6	36·0	30	52·6	60·0	.....	.....	.....	22·5	39·5	3·9	4·5	7·9
16......	29	3·9	33·1	17·5	60·3	49·0	4·5	15·5	9·2	6·0	20·7	4·1	1·0	3·4
8......	46	6·10	34·9	32	69·6	45·0	7·5	16·3	15·4	6·0	13·0	5·5	0·5	1·1
¼″....	67	8·8	36·8	46	68·6	45·3	14·5	21·6	18·7	4·0	5·9	6·2	2·5	3·6
½″....	191	25·3	37·0	157	82·2	41·3	26·0	13·6	22·0	5·0	2·6	4·3	3·0	1·5
1″....	365	48·3	37·1	315	86·3	40·2	23·5	6·4	26·6	23·0	6·3	4·9	3·5	1·0
Totals..	755	100·00	36·6	597·5	79·1	42·3	76·0	10·1	21·4	66·5	8·8	4·6	15	2·0

The concentration effected by this test is not satisfactory, the heads product containing only 42·3 per cent of iron. If any additional tests are to be made, the crude should receive preliminary comminution to at least ½″, and the separating machine adjusted to make a larger middling product and allowing a heavier loss of iron in the tailings.

Summarizing the results of the above preliminary tests, it may be stated that, the production of concentrates having the desired iron content and mechanical condition will not be accomplished easily by the dry method of separation, unless the operators are prepared to allow a considerable percentage of iron going to waste in the tailings.

If an attempt is made to save over 90 per cent of the original iron, it will be found that the concentrates will be either of inferior iron content, or of such mechanical condition as to preclude their use in the blast furnace, without nodulizing.

On the other hand, if the cost of the crude delivered at the concentrating mill is sufficiently low, it may prove admissible to allow a loss of from 15 to 20 per cent of the original iron, in order to produce the desired concentrate.

The percentage of loss allowable will be controlled by the cost of the crude delivered at the mill, the cost of concentrating and the market price of the concentrates. It is impossible to offer even an approximate figure for the allowable loss without complete costs data, but it is suggested that this point should receive careful attention, as it will, in the writer's opinion, prove a vital one in the concentration of Wilbur ore.

WET MAGNETIC CONCENTRATION OF WILBUR ORES.

The following tests were made at the testing laboratories of the Mines Branch in Ottawa.

Test No. 1, Wilbur ore No. 1, run of mine.

Wilbur run of mine is a moderately fine grained crystalline magnetite, the gangue consisting for the most part of quartz, calcite, and chlorite, occurring in seams and stringers throughout the ore. Other gangue minerals present in smaller amounts are hornblende and muscovite. Both sulphur and phosphorus are low.

TABLE VI.

Mill Log of Test No. 1, Wilbur Ore No. 1, Run of Mine.

Time.	Total Load. Amperes.	Separator No. 1. Amperes.	Separator No. 2. Amperes.	Voltage.	Remarks.
8.10 a.m.	....	....	....	....	Start power motor.
8.15	....	....	....	....	Water on separators.
8.20	....	....	....	....	Water on ball mill.
8.20	....	....	....	....	Start crush ore.
8.30	....	....	....	....	
8.45	200	6·25	6·00	110	Samples taken.
9.00	200	6·25	6·00	110	"
9.15	205	6·25	6·00	109	"
9.30	200	6·00	5·75	109	"
9.45	210	6·00	5·75	109	"
10.00	195	6·00	5·75	109	"
10.15	195	6·00	5·75	108	"
10.30	200	6·00	5·75	111	"
10.45	200	5·75	5·50	111	"
11.00	210	5·75	5·50	110	"
11.15	205	5·75	5·50	109	"
11.30	205	5·75	5·50	110	"
11.45	205	5·75	5·50	110	"
12.00	205	5·75	5·50	108	"
12.15 p.m.	210	5·75	5·50	109	"
12.30	210	5·75	5·50	110	"
12.45	200	5·75	5·50	110	"
1.00	200	5·50	5·25	110	"
1.15	200	5·50	5·25	110	"
1.30	195	5·50	5·25	108	"
1.45	195	5·50	5·25	108	"
2.00	200	5·50	5·25	109	"
2.15	210	5·50	5·25	108	"
2.30	210	5·50	5·25	109	"
2.45	200	5·50	5·25	110	"
3.00	200	5·50	5·00	110	"
3.15	205	5·50	5·00	110	"
3.30	200	5·50	5·00	110	Last sample taken.
3.40	200	5·50	5·00	108	All ore fed to ball mill.
4.00	190	5·50	5·00	110	" " "
4.15	195	5·50	5·00	110	Water off ball mill.
4.20	195	5·50	5·00	110	" separators.
4.25	195	5·50	5·00	110	Stop power motor.

Mean total load in amperes while feeding ore .... 202·41
Mean voltage while feeding ore.................................. 109·37

$$\text{Total E. H. P.} = \frac{202\cdot41 \times 109\cdot37}{746} = 29\cdot67$$

Mean amperes on separator No. 1.................................. 5·71
Mean amperes on separator No. 2.................................. 5·40
Mean voltage on separators.. 109·68
E. H. P. required to excite separators

$$= \frac{(5\cdot71 + 5\cdot40)\ 109\cdot68}{746} = 1\cdot63$$

E. H.P. required for Blake crusher, elevator, ball mill, sand pump, and driving separators = 29·67 − 1·63 = 28·04

Weight of crude ore tested 20,165 pounds = 9·00 tons gross.

Time feeding ore	7 hrs. 20 min.
Rate feeding ore	1·22 gross tons per hour.
Rate per day, 24 hours	29·28 gross tons.
E. H. P. day per ton crude ore	1·01

[1]*Water Consumption.*

Ball mill meter end of test	1113 cub. feet.
" " " start "	664 "
Water used	449 cub. feet.

Total time feed water to ball mill, 7 hrs. 55 min.

Rate of feed per minute, 0·99 cub. feet or 6·18 imp. gals.

Rate of feed per gross ton of ore crushed, 48·68 cub. feet or 304·25 imp. gals.

Magnetic separators meter end of test	20,192 cub. feet.
" " " start "	17,112 "
Water used	3080 cub. feet.

Total time feed water to separators, 8 hrs. 5 min.

Rate of feed per minute, 6·35 cub. feet or 39·69 imp. gals.

Rate of feed per gross ton of ore crushed, 312·22 cub. feet or 1951·25 imp. gals.

Total water feed per minute, 7·34 cub. feet or 45·87 imp. gals.

Total water feed per gross ton of ore crushed, 460·9 cub. feet or 2256·0 imp. gals.

Crushing Data.

Crude ore broken in Blake crusher to 1″ and under, fed direct to ball mill.

Ball mill charge	1549 lbs. 4″ hard iron balls.
" " "	500 lbs. 3″ " " "
Total	2049 lbs.

Mechanical condition of ball mill discharge.

	Per cent.
Through 20 on 30 mesh	0·068
" 30 " 40 "	0·273
" 40 " 50 "	1·847
" 50 " 60 "	2·224
" 60 " 70 "	5·029
" 70 " 80 "	1·659
" 80 " 90 "	9·512

[1]Note—One cub. foot of water taken = 6·25 imperial gallons.

	Per cent.
Through 90 on 100 mesh	3·722
" 100 " 120 "	7·801
" 120 " 150 "	14·063
" 150 " 200 "	20·804
" 200 " —	32·985
Total	99·987

TABLE VII.

Analyses of Crude, Concentrates, and Tailings.

—	Crude Ore.	Concentrates.	Tailings.
Iron	48·5	66·10	7·2
Insoluble residue	13·08	3·30	
Sulphur	0·105	0·028	
Phosphorus	0·011	0·004	
Lime	3·00	0·30	
Magnesia	6·40	1·40	

FROM THE ABOVE ANALYSES.

The units of crude required for unit of concentrate $= \frac{66\cdot1 - 7\cdot2}{48\cdot5 - 7\cdot2} = 1\cdot43$

The percentage of iron in crude, saved in the concentrate$= \frac{10 \times 66\cdot1}{48\cdot5 \times 1\cdot43} = 95\cdot306$

Units of tailings made per unit of concentrate $= 0\cdot43$

The percentage of iron in crude lost in the tailings$= \frac{100 \times 7\cdot2 \times 0\cdot43}{48\cdot5 \times 1\cdot43} = 4\cdot464$

Gross tons of concentrate made per gross ton of crude, 0·699

TEST NO. 2, WILBUR ORE NO. 2, WASTE DUMP.

The ore for this test was taken from a waste dump at an old shaft, situated in a northerly direction from the present or main workings.

The physical structure of this ore is similar to the run of mine, the crystallization being moderately fine. Granitic gneiss forms the major part of the associated gangue; but calcite, and chlorite are also present in about the same proportion as in the run of mine.

TABLE VIII.

Mill Log of Test No. 2, Wilbur Ore No. 2, Waste Dump.

Time.	Total Load. Amperes.	Separator No. 1. Amperes.	Separator No. 2. Amperes.	Voltage.	Remarks.
8.30 a.m.	....	....	....	....	Start power motor.
8.35	....	....	....	....	Water on separator.
8.45	....	....	....	....	" ball mill.
8.50	....	....	....	....	Start crush ore.
9.00	200	6·25	6·00	109	"
9.15	220	6·25	6·00	110	Samples taken.
9.30	214	6·25	6·00	110	"
9.45	218	6·25	6·00	110	"
10.00	220	6·00	6·00	110	"
10.15	210	6·00	5·75	110	"
10.30	205	6·00	5·75	110	"
10.45	210	6·00	5·75	110	"
11.00	224	6·00	5·75	108	"
11.15	215	6·00	5·50	110	"
11.30	215	5·75	5·50	109	"
11.45	210	5·75	5·50	109	"
12.00	210	5·75	5·50	110	"
12.15 p.m.	210	5·75	5·50	110	"
12.30	215	5·75	5·50	110	"
12.45	200	5·75	5·50	110	"
1.00	215	5·75	5·50	110	"
1.15	220	5·75.	5·50	108	"
1.30	200	5·75	5·50	108	"
1.45	200	5·75	5·50	109	"
2.00	214	5·50	5·25	109	Last sample taken.
2.10	218	5·50	5·25	110	All ore fed to ball mill.
2.30	200	5·50	5·25	110	
2.45	195	5·50	5·25	110	Water off ball mill.
3.00	195	5·50	5·25	110	" separator.
3.15	195	5·50	5·25	109	Stop power motor.

Mean total load in amperes while feeding ore........................211·5

Mean voltage while feeding ore.................................109·5

$$\text{Total E. H. P.} = \frac{211\cdot5 \times 109\cdot5}{746} = 31\cdot04$$

Mean amperes on separator No. 1.............................. 5·82

Mean amperes on separator No. 2.............................. 5·57

Mean voltage on separators....................................109·53

$$\text{E.H.P. required to excite separators} = \frac{(5\cdot82 + 5\cdot57)\ 109\cdot53}{746} = 1\cdot67$$

E.H.P. required for Blake crusher, elevator, ball mill, sand pump, and driving separators = 31·04 − 1·67 = 29·37

Weight of crude ore tested, 11,777 pounds = 5·257 tons gross.

Time feeding ore............................ 5 hrs. 20 min.

Rate feeding ore............................ 0·985 gross tons per hour.

Rate per day 24 hours........................23·64 gross tons.

E.H.P. day, per ton crude.................... 1·31

Water Consumption.

Ball mill metre end of test	1479 cub. feet.
" " " start "	1119 "
Water used	360 cub. feet.

Total time feed water to ball mill, 6 hrs. 0 min.
Rate of feed per minute, 1·00 cub. feet or 6·25 imp. gals.
Rate of feed per gross ton of ore crushed, 60·91 cub. feet or 380·68 imp. gals.

Magnetic separators meter end of test	23,340 cub. feet.
" " " start "	21,492 "
Water used	1848 cub. feet.

Total time feed water to separators, 6 hrs. 25 min.
Rate of feed per minute, 4·8 cub. feet or 30·0 imp. gals.
Rate of feed per gross ton of ore crushed, 292·3 cub. feet or 1826·8 imp. gals.
Total water feed per minute, 5·8 cub. feet or 36·25 imp. gals.
Total water feed per gross ton of ore crushed, 353·21 cub. feet or 2207·48 imp. gals.

Crushing Data.

Crude ore broken in Blake crusher to 1″ and under, fed direct to ball mill.

Ball mill charge	1549 lbs. 4″ hard iron balls.
" " "	500 lbs. 3″ " " "
Total	2049 lbs.

Mechanical condition of ball mill discharge.

	Per cent.
Through 10 on 20 mesh	0·126
" 20 " 30 "	0·202
" 30 " 40 "	1·530
" 40 " 50 "	4·751
" 50 " 60 "	4·091
" 60 " 70 "	7·227
" 70 " 80 "	1·819
" 80 " 90 "	7·025
" 90 " 100 "	5·025
" 100 " 120 "	6·115
" 120 " 150 "	8·718
" 150 " 200 "	16·880
" 200 —	36·491
	100·000

TABLE IX.

Analyses ot Crude, Concentrates, and Tailings.

	Crude Ore.	Concentrates.	Tailings.
Iron	38·2	64·6	5·
Insoluble Residue	22·18	6·11	
Sulphur	0·101	0·023	
Phosphorus	0·011	0·006	
Lime	3·20	0·14	
Magnesia	7·0	1·64	

From the above Analyses.

The units of crude required per unit of concentrate $= \frac{64 \cdot 6 - 5 \cdot 1}{38 \cdot 2 - 5 \cdot 1} = 1 \cdot 79$

The percentage of iron in crude, saved in the concentrate $= \frac{100 \times 64 \cdot 6}{38 \cdot 2 \times 1 \cdot 79} = 94 \cdot 485$

Units of tailings made per unit of concentrate $= 0 \cdot 79$

The percentage of iron in crude, lost in the tailings $= \frac{100 \times 5 \cdot 1 \times 0 \cdot 79}{38 \cdot 2 \times 1 \cdot 79} = 5 \cdot 892$

Gross tons of concentrates made per gross ton of crude $= 0 \cdot 558$.

GENERAL CONCLUSION.

As regards the purity of the concentrates and the percentages of iron recovered, the above tests clearly demonstrate the value of the Gröndal method of concentration as applied to the above class of inferior iron ores. The low phosphorus content of the concentrates renders them especially valuable for the manufacture of certain low phosphorus steels, and there is no doubt that if a sufficient tonnage of these concentrates can be produced, a profitable market would be found.

It is necessary to state, however, that these finely divided concentrates would require nodulizing or briquetting before they would be accepted for furnace use. This, of course, means an additional item of cost, but not as is generally supposed a prohibitive one.

The data given covering the mechanical operation of the plant during the tests is not satisfactory, the rate of ore fed per hour being very low, with a consequent high figure for electric horse-power per day, per ton of crude. This is in some measure due to the various unfavourable conditions that are always present with the first operation of new and untried machinery. The chief difficulty, however, was lack of water. The plant being supplied from the Ottawa city mains, suffered from the inadequate supply occasioned by a season of almost unprecedented low water condition of the Ottawa river. The two magnetic separators require a normal supply of about 55 gallons of water per minute; and as the total available supply was from 20 to 25 per cent less than this amount, it meant less capacity in ore feed.

After the second test had been completed, the water pressure became so low that it was deemed advisable to cease operation until conditions were more favourable for testing at full capacity.

Tests on the remaining samples will be published in a later report.

All analyses for the tests made in Ottawa were made by H. A. Leverin, Ch. E.

FIELD WORK

PRELIMINARY REPORTS.

ON THE MOLYBDENUM ORES OF ONTARIO AND BRITISH COLUMBIA.

Dr. T. L. Walker.

During the field season of 1910, the writer was engaged in examining some of the Canadian deposits of molybdenite. In the previous year most of the molybdenite localities of importance in the Maritime Provinces and Quebec were visited, and a preliminary report submitted on the same. Most of the past season was employed in studying the chief deposits in Ontario and British Columbia; but in September, attention was directed to some deposits in New Brunswick and Quebec not previously visited.

New Brunswick.—For many years it has been known that molybdenite occurred in quartz veins cutting altered slate near the confluence of the Southwest Miramichi and Burnt Hill brook. An examination of the district shows that no development work has been done, and that the surface showings are not very promising for molybdenum. The veins are not large and the percentage of molybdenite is small. During this investigation the writer discovered that most of these veins carry tungsten in the form of wolframite—fairly large black crystals, and in such abundance as to hold out reasonable reward for development. Since this discovery some attempt is being made to open up some of the veins of wolframite.

Quebec.—The region visited lies about 20 miles south of the Transcontinental railway possibly 150 miles east of Cochrane. In the vicinity of Kewagama lake, especially on Indian peninsula, the country rock is largely granite, which is intersected by dykes of pegmatite, and veins of quartz. These frequently carry molybdenite and bismuthinite in promising proportions. The Height of Land Mining Company was the first to interest itself in this region, and some four years ago a shaft was sunk, and some drifting done. During the past year the St. Maurice Syndicate, and the Peninsular Mining Syndicate have taken up numerous claims on Indian peninsula, and during the past summer considerable development was undertaken.

Ontario.—Numerous deposits of molybdenite have long been known in the northeastern portion of Ontario—principally in the region which drains into the Ottawa river. Many of the previously well known deposits were visited, and some new ones, which had been known only locally, were examined. It is particularly in the county of Renfrew that the most promising deposits occur. While none of the deposits are in operation, several are very promising, and well worth exploration. Samples, representing the type and grade of ore which might be obtained for milling and concentration from the various deposits, were collected for investigation.

British Columbia.—In this Province molybdenite has been reported from a large number of localities. Many of the most promising were visited, but some are almost inaccessible, and can be reached only at an expense altogether out of proportion to the object in view. Some of the deposits in this Province are associated with copper ores, as is the case on Texada island, Rossland, Highland valley near Ashcroft, and Grande Prairie near Kamloops. In the first two cases, the copper deposits have been worked, but so far as can be learned, no income was derived from the molybdenite content.

The details regarding the various deposits examined are being incorporated in a report on the "Molybdenum Ores of Canada," now in the press.

ON THE COPPER MINING INDUSTRY IN ONTARIO, 1910.

Alfred W. G. Wilson, Ph.D.

The first part of the field season of 1910 was spent in visiting the five principal districts in the Province of Ontario in which copper prospects had been reported.

North Hastings.—In the year 1903 copper pyrites was found to underlie iron ore on a prospect that had been opened up as a hematite mine, near Eldorado, on the Central Ontario railway.

As far as could be judged from the abandoned workings, the original hematite ore body, which outcropped at the surface, was a lenticular mass of ore about 175 feet in length, and probably 25 feet in width, at the widest part. The wall rock is a highly metamorphosed and partly altered rock; probably a hornblende-mica schist. The ore body was apparently a zone of rock, highly impregnated with, and partly replaced by, sulphides of iron and copper—the former predominating; subsequently, the upper portion was altered to hematite, the copper being leached out. The mining operations for iron ore disclosed the existence of scattered sulphides at depths which varied between 60 and 80 feet. Diamond drilling is said to have been employed to explore the sulphide portion of the ore body. A small water jacketed matting furnace, which was subsequently erected at the mine, was blown in first, June, 1906, and was operated intermittently for a year or more. Sinking in the ore body was continued until a depth of about 300 feet was reached. The mine was closed in 1907, and both mine and smelter have been idle ever since.

In this connexion, it appears desirable to repeat and emphasize what has already been stated in reports by E. J. Fraleck to the Ontario Bureau of Mines: that sulphides will probably be found in the localities where hematite has been mined in this district. In a number of instances mining operations are stated to have been stopped because the iron ore ran too high in sulphur. Mining was mostly in open-cuts, and was rarely carried below the 100 ft. level. There seem to be reasonable grounds for assuming that these hematite deposits were merely the altered upper portions of larger lenses of sulphides. Now that the market demand for pyrites ore makes it nearly as valuable as the iron ore for which the properties were first exploited, judicious and systematic prospecting might disclose valuable sulphide deposits beneath the old workings.

Parry Sound District.—In the year 1894, finds of copper pyrites were reported from a number of localities in the townships of McDougall, Cowper, and Foley—Parry Sound being the nearest town. On one of these properties—the McGowan mine, lot 146, con. IV, Foley, about 2 miles east of Parry Sound, a small pocket of rich ore, chalcopyrite, and bornite, was found. Smaller bodies of sulphides were found subsequently in several other places. A very considerable amount of exploration appears to have taken place, but no ore in commercial quantities is reported. A visit to several of the principal localities showed only abandoned workings.[1]

[1] See Coleman, Ontario Bureau of Mines Report, Vol. VIII, 1898, pp. 259-262.

Sudbury District.—Copper is one of the most important constituents of the nickeliferous pyrrhotites of the Sudbury district. Detailed investigations of this district have been made both by the Federal Department of Mines and by the Ontario Bureau of Mines. In the annual reports of the Inspector of Mines for Ontario reference is always made to the condition of the mines, to the amount of development work, and to any new discoveries of importance. I spent about ten days in the district, visiting the principal mines and smelting works, for the purpose of becoming personally acquainted with the local conditions. The mining development and prospecting work which has been going on in this district for a number of years, and which has been vigorously pushed during the last two or three years, was being continued and extended. For 1910 the annual output of the copper mines of Ontario—nearly all of which comes from this district—is placed at 19,259,016 pounds by the Division of Mineral Resources and Statistics of the Mines Branch.

North Shore of Lake Huron.—Along the north shore of Lake Huron, westward from the pyrrhotitiferous norites of the Sudbury district, and extending north of the lake for at least 40 miles, is an area largely underlain by basic metamorphic rocks which has been invaded by acid and basic intrusives. Quartz veins, sometimes of considerable width and lineal extent, are found in numerous localities throughout the area. Many of these quartz veins contain small flakes and masses of chalcopyrite, occasionally of considerable size. The number of recorded claims is large, prospecting has been carried on in many localities, and in some few instances extensive development work has succeeded prospecting. Some of the earliest discoveries of copper ores in Ontario were in this district: at the old Wallace mine—now long since abandoned—and at the well known Bruce mines. The varied history of these mines has been described in reports of the Ontario Bureau of Mines, and in papers presented to several mining associations.

At the present time the only property in operation is the Bruce mines, from which about fifty tons of ore per day are being hoisted. This ore, which consists of chalcopyrite in almost pure quartz, is being used at the smelter of the Mond Nickel Company, at Victoria mines, for lining the converters.

Extensive underground exploration, and some development work has been done on three other properties in the district: viz., the Superior, the Hermina, and the Massey mines. Prospecting work has also been carried on at a number of other properties, but none of them have been operated for any great length of time. Ore shipments were made continuously, for a few years, from each of the three larger properties mentioned above. At the time of my visit to the locality in July, no work was being done at the Superior mine, and the Hermina had just closed down. At the Massey mine preparations are in progress for further explorations by the Vermilion River Copper Company.

The ores which come from the district are all highly siliceous; and with the exception of that from the Bruce mine, there is a large quantity of basic rock material mixed with the ore. This has reduced the silica content, and lowered the value for use in the smelting operations at Victoria Mines and at Copper Cliff.

It should also be noted that, the company controlling the Hermina mine erected a small reverberatory furnace, fired with producer gas, in an attempt to produce matte directly from the Hermina ores. This plant, which is located at Thessalon, is now idle.

It has long been known that occurrences of copper minerals are widespread in this district. Many prospects have been discovered which contain low grade ores. They have rarely been sufficiently explored to demonstrate their extent. The difficulty of recovering the copper content economically has not yet been surmounted. Without some adequate method of concentration, it has not been possible to exploit the prospects for any length of time in any locality. Nearly all the companies which have operated in the district have at some time or other erected concentrating plants, but no method has yet been employed which has been operated more than a short period. The hard quartz gangue, associated with the relatively soft and friable chalcopyrite, renders it very difficult to crush the ore without producing an undue quantity of fines; while the losses in concentration are unusually high.

Keweenawan Areas.—Amygdaloidal diabases carrying native copper—very similar to the deposits of the famous Keweenaw peninsula in Michigan—occur on the east shore of Lake Superior, between Batchawana bay and Point aux Mines, at Michipicoten island; and on the north shore on several islands in Nipigon bay, especially St. Ignace island. Native copper has been found at many places, both in veins and in the amygdaloidal portions of the trap sheets. Mining claims were first taken up on the areas about 1847. At several points extensive operations were carried on for a number of years, but, probably, never at a profit. At the present time all the properties are idle.

In the years 1906-8, the Calumet and Hecla Mining Company put down drill holes on a line running northeast from near Sand Bay, crossing portions of the Pancake Point and Sand Bay locations, on the east shore of Lake Superior. No important copper bearing beds were disclosed in this set of holes. The drill cores were afterwards examined in detail by Dr. Alfred C. Lane—at that time State Geologist of Michigan—and a brief geological study was made of these two localities.

In a memorandum which Dr. Lane has kindly supplied to me, he states that:—

"The rocks and associated prehnite, epidote, and other secondary minerals are like those at Keweenaw peninsula. The trap flows have amygdaloidal tops, and the upper or south-western beds, like the central beds of Keweenaw point, are largely ophites, with mottles in one case over half an inch across. They dip towards the lake 23° and more, and veer in strike from N. 45° W. to N. 10° W. They are cut by numerous faults, the most prominent set of which run nearly north and dip 45° to the east. Thus troughs or shoots are produced which pitch to the south. Native copper is, I think, more common in the bedded lodes. Both native copper and sulphides (chalcocite mainly) occur in the fissures in and near which most of the concentration seemed to occur. Felsites are also abundant, in part at least intrusive, and drilling by the Calumet and Hecla disclosed the same (with pyrites not found to carry values along the contents) in drift-covered areas. With these and faults to make explorations expensive, nothing was found nearly as attractive as in places in Michigan, though the upper 2,000 feet of beds were cut. Yet the work has been confined practically to the upper part of the formation and the shoots above mentioned will no doubt be further investigated by some one."

It may be added that arrangements have been made, with the consent of the manager of the Calumet and Hecla Mining Company, for Dr. Lane to contribute a chapter on these Keweenawan copper-bearing amygdaloids to the report on the copper resources of Canada, which is now in course of preparation.

A small amount of diamond drilling was done at Cape Gargantua in 1909, but no satisfactory results appear to have been obtained.

During the past summer the British North American Mining Company were carrying on exploration work at the old Prince location, on the north shore of Lake Superior, and at Spar island. The annual report to the shareholders indicates that, in drifting they have encountered both native copper and native silver. It is intended to continue the exploration work during the winter.

During the early part of 1910 a number of buildings were erected and a good deal of costeaning was done on the north side of Michipicoten island on and near the old Bonner location. Small pieces of native copper and a few large pieces were recovered by washing the beach gravels at certain points on this shore. No discoveries of importance were made. It may be noted that at this point there are several superposed trap sheets with amygdaloidal upper portions. The amygdales are either pink or white coloured minerals, and where the beds are washed by the waves the amygdaloidal portions of the trap beds are clearly distinguishable because of their prevailing light colour. In the same locality there are a few narrow veins, rarely lying parallel to the bedding structure. These amygdaloidal beds have erroneously been called veins. Had the nature of these beds, with which the native copper seems to be associated, been recognized, and their definite relation to the other portion of the individual trap sheets—with which each is associated—been determined, much needless expenditure for excavation across, what under all normal conditions are barren portions of the trap sheets, would have been avoided.

While it may be stated that these Keweenawan rocks afford ample opportunity for careful and systematic exploration, with reasonable expectations of discovering low grade native copper ores in economic quantities, fuller discussion must be reserved for the final report.

Other Localities.—Copper ores have been reported from a number of other localities, along the north shore of Lake Superior, west of Port Arthur, and in, or adjacent to, the Timagami Forest Reserve. No important mines have been developed, in only a few instances have any mining operations been carried on, and, in the majority of cases, their distance from established lines of transportation would practically prohibit mining operations unless a deposit of very large size was discovered. No attempt was made to visit any of the outlying prospects, though in future years some of them may prove to be of importance.

Conclusion.—In concluding the portion of this summary report relating to Ontario, I wish to state that there are three areas in Ontario of which detailed geological surveys should be made, and maps prepared. These districts are:—

(1) Central Ontario embracing the northern portion of the county of Hastings and some areas to the east.[1]

(2) North shore of Lake Huron between the Sudbury district and Lake Superior.

(3) Keweenawan areas as a whole.

Such studies and maps are now universally recognized as a primary prerequisite to systematic and intelligent economic exploration.

[1]The southeast corner of the district is covered by Geological Survey Maps Nos. 708 and 770.

THE COPPER MINING INDUSTRY IN THE MARITIME PROVINCES, 1910.

At the present time there are no copper producing properties in the Maritime Provinces. Copper minerals have been found in many localities. During the last fifty years prospecting, and some development work have been done in a number of places, and shipments of small quantities of rich ores have been made at irregular intervals, from some of these localities. Some of the properties have more than once been closed down and re-opened.

The majority of occurrences of copper minerals which have been reported in the Provinces of New Brunswick and Nova Scotia are already recorded in a report by Dr. R. W. Ells.[1] Many of these were, probably, never of sufficient magnitude to warrant any extensive exploration. Many years ago, others were prospected for a time, but no reliable record as to the results of this exploration can now be obtained. The fact that they were not operated for any length of time is generally taken as an indication that the results obtained were not very satisfactory. A few properties gave promise of containing ore in economic quantities, and were operated for a time, and small quantities of commercial ore were obtained. Various difficulties appear to have arisen, because, after operating for periods of time, varying in different cases, the work was stopped. In some instances this cessation was caused by financial difficulties, and closure took place before it had been demonstrated whether ore was present in commercial quantities. In others, work was stopped because the ore played out.

In all the districts visited, both in New Brunswick and in Nova Scotia, there is an overburden of loose soil which makes it difficult to draw any conclusions from surface conditions. The individual rock outcrops are usually small, and the sulphide deposits, if they exist in quantity in any locality, would be very apt to be found, not at the outcrops, but in the soil covered hollows adjacent to them. This makes surface prospecting difficult, and underground exploration is usually necessary to prove even the smallest deposits.

New Brunswick.—Up to the present time, I have not found in New Brunswick, any properties which have been proved to contain copper ores in commercial quantities. There are, however, several localities in which recently made discoveries warrant further search, in the expectation of finding pay ore.

Near Scotch Settlement siding, on the New Brunswick Coal and Railway Company's line, 11 miles north of Norton, a deposit of chalcopyrite and pyrite was discovered some time ago. The property, which is under control of G. W. Ganong, St. Stephen, N.B., was being prospected during the past summer, by means of trenching and a trial shaft. The metallic sulphides are found associated with chlorite schist and quartz. The prospecting work had disclosed a showing of good ore, at the time of my visit; but much further work will be necessary to ascertain if ore occurs in the locality in commercial quantities.

Another property which may contain commercial ore is the old Freeze mine in the township of Ireland, about 8 miles south of Elgin. The old mine workings lie in a valley close beside a branch of the Salmon river. No rock outcrops are visible immediately in the vicinity of the mine, and further exploration work will

[1] Bulletin on the ores of copper in the Provinces of Nova Scotia, New Brunswick, and Quebec, Geol. Surv. Can., 1904.

have to be done, either by drilling, or by sinking and drifting. The present shaft is said to be 163 feet in depth, and there is some drifting. A small water-jacketed matting furnace was operated on this property for a short time. The ore is chalcopyrite and pyrite, in a schist which consists chiefly of hydro-mica and quartz. The ore resembles that found in the King and Suffield mines in Quebec.

At a prospect known as the Lumsden property, situated on Ratty Brook branch of Crooked creek, in Albert county, a considerable amount of surface and underground prospecting has been done. Samples of ore found on the property are said to contain values in gold and silver, in addition to lead and copper.

During parts of the years 1908 and 1909 the old Vernon mine near Martins Head, on the Bay of Fundy, was reopened, and operated on a small scale. About 50 tons of ore—a portion of which was rich bornite—were mined and shipped. The greater portion of the work was of an exploratory nature. This work is said to have disclosed a vein carrying rich bornite ore. No work was carried on there during the past season.

Copper minerals have been reported from a number of other localities in southern New Brunswick, and in some other cases a limited amount of prospecting work has been done. Some of these localities are doubtless worthy of further exploration. On none of them—as far as I have been able to learn—has there been sufficient development to show commercial ore in quantity. In the circumstances, it was felt that no useful purpose would be served by spending time in making further personal inspection of undeveloped prospects.

Copper ore in the form of chalcocite occurs associated with carbonaceous fossils in the sandstones of the upper Carboniferous formation at many points along the south side of Northumberland strait and westward in Albert county in New Brunswick. During the past sixty years numerous attempts have been made to work these ores profitably, and in some few cases small shipments of rich natural concentrates have been made. In no place, however, have these ores ever been discovered in sufficient quantity to make their exploitation, for any length of time, a profitable venture. During the month of December, 1909, and the early months of 1910, two drill holes were put down in a search for ores of this character on a property just south of the old Intercolonial Copper Company's property, about 4 miles from Dorchester, New Brunswick. The results obtained by this work are not available. At the time of my visit in October, work had ceased, and the drill had been removed.

Nova Scotia.—Localities in which copper ores occur in Nova Scotia, that are worthy of special note, are: Cape d'Or; Copper lake; Cheticamp; and Coxheath.

At Cape d'Or, in Cumberland county, on the north side of Minas channel, native copper has been found associated with some diabase sheets. With reference to this locality, Dr. A. C. Lane, who has studied the district in some detail, and who had at his disposal the results of the drilling operations carried on by the Colonial Copper Company some years ago, has supplied the following memorandum in which he draws a comparison between the Cape d'Or locality and the Keweenawan of Michigan.

"The Cape d'Or locality has many points of likeness to the Keweenawan district of Lake Superior, though the trap sheets were formed at the beginning of the Mesozoic instead of the beginning of the Palæozoic. In both the beds are old basalt flows which dip towards the water, but at Cape d'Or the dips are lower, lying between 10° and 25°. In both the beds are cut by nearly vertical faults, many of which run about south, in both native copper is the most abundant ore, and it occurs in fissures and throughout shattered belts of rock along the faults more than with amygdales, so far as could be ascertained.

"The associated minerals are different, stilbite, heulandite, and analcite being abundant at Cape d'Or. The drilling and shafts of the Colonial Copper Company seem to show five lava flows (135, 58, 32, 10 to 15+, and 556 feet thick respectively)—the uppermost being more markedly porphyritic. The intermediate flows are thinner and where these were crossed and shattered by fissures some areas of stoping rock were found. These shoots are cut off by the ocean which has done some concentration on its own account. The lowest trap exposed, the Cape Spencer trap, is apparently about 600 feet thick making about 800 feet in all. The chemical analyses you have had made show this to be a bandose, while the uppermost bed is also akin to the enstatite diabases and belongs to class 3, subclass 1, order, rang and subrang 4, and may be called a dorose. Beneath this come sediments, but no mining has shown what concentration of copper may occur just below this heavy Cape Spencer trap, which—judging from Lake Superior and New Jersey experience—would be desirable. The amount of copper which can be picked up along the beach at Cape d'Or is due largely to the marine erosion attacking some amygdaloids which are dipping towards the ocean. Whether these amygdaloids, if struck somewhere deep down under the Bay of Fundy, would be found to have copper in abundance, and whether the contact of the series of traps with the red gypsiferons Triassic beds beneath shown in one hole would show copper, are questions which the explorations so far conducted have not answered."

At Copper Lake mine, in Antigonish county, about 17 miles from Antigonish and 16 miles from Country harbour, the Copper Lake Mining Company have been prospecting for several years. Two shafts, 180, and 290 feet, respectively, have been sunk on the property, the deeper shaft being inclined and located on the ore body. An adit has been driven to the first level. The total length of the ore body exposed along this level is about 350 feet. On the second level, about 50 feet of drifting has been done. A number of exploratory cross-cuts have also been driven into the hanging and foot walls.

The ore body is a most interesting one. The gangue consists almost wholly of siderite. A clean piece, purposely selected free from sulphides, gave the following analysis:—[1]

SiO_2	0·65
FeO	45·77
Fe_2O_3	0·53
Al_2O_3	0·20
CuO	trace
MnO	trace
CaO	0·61
MgO	10·80
CO_2	40·20
H_2O	0·80
P	0·004
S	0·040

The ore body, as disclosed by the development work, appears to be a portion of a vein located in a fracture zone. The upper part of the vein has been removed by erosion. At the east end of the ore body which has been explored, the vein narrows and finally breaks into a number of smaller veins. The west end has not

[1] Mr. H. A. Leverin, analyst.

been explored beyond the adit, as the vein at, and near the surface, has been eroded, and possibly passes beneath Copper lake. The Copper Lake Company is now contemplating the work of following the vein in this direction beneath the lake. The ore body also narrows at depth; the maximum width of the ore body is stated to be 11 feet in the shaft above the second level. The average width of the ore body on the first level is about 5 feet. Development work has not yet disclosed whether the ore body is an isolated lenticular mass of ore, or whether it is a portion of a much larger vein which has been constricted at certain points. The discovery of float vein material in the adjacent fields, and the nature of the locus of the portion of the vein already developed make it quite reasonable to expect that the vein has a much greater lateral extent than is now known. Further systematic exploration will be required to determine this extension with certainty.

The metallic sulphides present are chiefly pyrite and chalcopyrite, with a small amount of pyrrhotite in places. The pyrrhotite is reported to carry low nickel values. It is stated that the copper content of the ore body, so far exposed by development work, will exceed 3 per cent metallic copper.

The Lake Copper Company is also interested in some copper prospects about 2 miles west of Lochaber lake in Antigonish county. The first prospecting shaft on this property was sunk about 35 years ago. Since that time additional trial pits and shafts have been put down. On the bases of old reports officers of the Company regard these prospects with favour, and are planning to re-open them for further exploration. Little information can be obtained from the surface showings as to the probable occurrence of copper ore.

Copper minerals have been found at a number of other localities in Antigonish county and prospecting work has been carried on from time to time. The majority of these mineral occurrences have already been noted in reports by officers of the Geological Survey Branch. No occurrences of commercial quantities of ore have been found except at Copper Lake.

According to Fletcher[1] prospecting for copper ores was carried on at Cheticamp, in Cape Breton, prior to 1864. Since that date the prospects have been re-opened at several different periods. The properties are at present controlled by the Cheticamp Copper Company, Limited, which was incorporated in 1904 to take over the interests of several independent companies which controlled properties on and adjacent to the Cheticamp river in Inverness county. This Company and its immediate predecessors have performed extensive development work on the prospects, and the present Company has also built a good road which connects the property with Eastern harbour. Operations were discontinued in 1906 and the plant and buildings have been allowed to depreciate. The Company has in its possession a number of very favourable reports on its property, but it has never carried its development work to the shipping stage except for experimental purposes.

The Cheticamp ore is chalcopyrite impregnating a mass of sericitic and chloritic schists. It also carries low values in gold and silver. The reports of those who have examined the property would indicate that, there is a very large body

[1] G. S. C. Report 1882-84, p. 95, H.

of low-grade copper ore present. The practical problem which has not yet been solved is the development and application of a process of extracting the copper from these ores, at a profit. The finely disseminated character of the ore, and the nature of the rock in which it occurs, make this a very difficult problem.

More than thirty years ago the occurrence of metallic sulphides, associated with a felsitic rock, was noted at Coxheath, about 10 miles from Sydney, C.B. The first exploration work was performed on the prospects in 1880. During the next twelve years, a number of shafts were sunk, and extensive explorations were carried on, underground. Since 1892, no work has been done on the property. It is stated that there is a considerable quantity of developed ore available in the mine. The expenditure on development work has been very large, but as yet no commercial shipments have been made.

Copper minerals have been reported from a number of other localities in Nova Scotia. Native copper has also been found in the western part of the Province, associated with the trap sheets of North mountain. Much prospecting has been done on a small scale at many points, but as far as could be learned, no important ore bodies have been discovered. A more extended reference will be made in the final report to a number of these prospects; and especially to the occurrences of chalcocite associated with carbonaceous material in the sandstones along the southern shore of the straits of Northumberland.

THE AUSTIN BROOK IRON-BEARING DISTRICT, NEW BRUNSWICK.

E. Lindeman, M.E.

The first part of the field season of 1910 was spent in the Austin Brook iron-bearing district, New Brunswick; with the object of extending the magnetic survey commenced by the writer in the fall of 1906, but suspended during the following years. During the summer a magnetometric and topographical survey was made of an area comprising about 1·5 square miles. W. M. Morrison, B.Sc., acted as assistant, and performed his duties in a highly satisfactory manner. For the many courtesies received during the field work the writer is indebted to Mr. Fulton, local superintendent of the Canada Iron Corporation, Limited

Location and Topography.—The iron ore deposits are situated in the county of Gloucester about 20 miles south, southwest of the town of Bathurst, in the vicinity of Austin brook—a small tributary of the Nipisiguit river.

The elevation of the district is about 350 to 500 feet above sea-level. Its main topographical feature is the Nipisiguit valley, with generally steep banks, rising to a height of 100 to 140 feet above the river. Back from the river the country becomes comparatively flat, with a few occasionally outstanding small hills, generally having a north and southerly trend. The district is thickly wooded with spruce, cedar, balsam, poplar, birch, and maple. Owing to the covering of glacial drift, and a number of swamps—which occupy a large part of the area—few exposures of ore can be seen. Any estimate of the size or general attitude of the ore bodies must, therefore, largely depend on the evidence furnished by a few diamond drill holes, and on the magnetometric survey.

History.—The first discovery of ore was made in 1897, by Mr. Wm. Hussey of Bathurst. In 1902, this gentleman, together with Mr. T. Burns of Bathurst, secured "Rights to search" upon several 5 mile locations in the district. During 1903, a representative of the Dominion Iron and Steel Company visited the locality, and some trenching and test-pitting was done. In the fall of 1906—at the request of O. Turgeon, M.P.—the writer was instructed to make a magnetometric survey of the district. The result of this investigation showed the field to contain a number of magnetic iron ore bodies, some of which were of large extent. In order to fully ascertain the quality of these bodies, the Provincial Government of New Brunswick was petitioned for the use of the diamond drill of the Province. The petition was granted, and during the year 1907 seven drill holes were put down. The records of five of these holes are given in the following pages. In November of 1907, the property passed into the control of the Canada Iron Corporation, Limited. A standard gauge railway 16 miles long has been constructed by this Company, connecting the property with the Intercolonial railway at Blacks Cut, about 4 miles south of the station of Bathurst. Ore docks for the trans-shipment of the ore have also been completed at Newcastle, with a storage capacity of 10,000 tons, and with a loading capacity of 3,000 tons per ho ur.

SUMMARY OF LITERATURE ON THE SUBJECT.

Ells, R. W.—

Report on the geology of Northern New Brunswick, embracing portions of the counties of Restigouche, Gloucester, and Northumberland. In Report of Progress for 1879-80 of the Geological and Natural History of Canada, pp. 1 D-47 D.

Lindeman, E.—

Magnetometric survey of iron ore deposits at Austin Brook, Gloucester county, N.B. In the annual report of the Superintendent of Mines, Department of Interior, Ottawa, for 1907, pp. 33-37.

Hardman, J. E.—

A new iron ore field in the Province of New Brunswick. In the Journal of the "Canadian Mining Institute," Vol. XI, 1908, pp. 156-164.

Young, G. A.—

Bathurst district of New Brunswick. In the Summary Report of the Geological Survey Branch of the Department of Mines, Ottawa, for 1909, pp. 217-224.

GENERAL GEOLOGY.

The greater part of the area under consideration is underlain by quartz porphyry, generally of schistose structure, owing to the intense folding and shearing to which it has been subjected. Its general strike is about north and south, with a steep dip towards the west. Associated with the porphyry are bands of chloritic and sericitic schists, which may be merely alteration phases of the porphyry. Generally, the porphyry shows distinct phenocrysts of feldspar and quartz, in a dense grey matrix.

In the southern and western part of the area eruptive rocks of basic character are found intruding into the porphyry. These rocks have been classed as gabbro diorites in the field; but their exact petrographical nature is not known, at present. They are usually of a greenish grey colour, and have a granitoid or granular structure. Other intrusions in the porphyry are numerous quartz veins. These are also very common in the ore but are rarely seen in the gabbro. They vary in size from a fraction of an inch, up to several inches in width.

Sedimentary rocks consisting of black and grey slates, highly tilted, and conformable to the porphyry, outcrop on the banks of the Nipisiguit river at Great falls, about 1½ miles below the mouth of Austin brook, but have, so far, not been observed within the area under consideration. Similar rocks are also exposed about one mile above Austin brook, and farther up the Nipisiguit river, at the Narrows, fragments of black slates were seen embedded in the porphyry. The porphyry seems, therefore, to be intrusive in this slate formation, the geological age of which is early Palaeozoic, probably Ordovician.[1]

[1] See Summary Report of the Geological Survey for 1909, pp. 218.

Ore Deposits.—As far as present knowledge goes, the ore occurs as elongated lenses in the quartz porphyry, and shows in common with this a prominent parting or schistosity, the plane of schistosity being parallel to that of the country rock. The ore bodies lie in three main groups, which for reference have been numbered I, II, and III.

Group I is situated west of Austin brook, and consists of one ore body: the total length of which is about 2,000 feet. The northern end of this deposit is well exposed, rising abruptly to a height of 75 feet above Austin brook. Farther south, it is covered by gravel of considerable depth, but outcrops again about 100 feet from the Nipisiguit river, where its contact with the schistose porphyry is well exposed. The horizontal width of the ore body is, where drill hole No. 1 was sunk, 106 feet. This hole was put down vertically on the hanging wall, about 250 feet south of the northern end of the deposit. It struck the ore body at a depth of 35 feet, and continued in the iron-bearing formation to 162 feet, when the foot-wall was reached, giving a calculated thickness to the ore body of about 85 feet. Drill hole No. 2 was sunk vertically, about 700 feet south of No. 1. After going through gravel, etc., it struck the ore body at a depth of 49 feet, and reached the foot-wall at 162 feet, giving a calculated thickness to the iron-bearing formation of about 60 feet. Drill hole No. 3 was located on the hanging wall of the deposit, about 150 feet from Nipisiguit river, and drilled vertically to a depth of 49 feet, giving a calculated width to the iron-bearing formation of about 8 feet. Drill hole No. 4 was sunk 380 feet west of No. 2, at an angle of 70°, the bearing of the hole being S. 80° E.

The total depth attained by the hole was 527 feet. It struck the iron-bearing formation at a depth of 434 feet, and continued in it to 514 feet, when the foot-wall was reached, giving a calculated thickness to the iron-bearing formation of about 64 feet.

Group II lies east of Austin brook, and is made up of several ore lenses, which for reference have been numbered 1, 2, 3, and 4.

No. 1 deposit outcrops on the hillslope towards the Nipisiguit river, but is, according to the magnetic survey, of inconsiderable extent. No. 2 deposit outcrops on the eastern bank of Austin brook. The southern end of the deposit is well exposed, showing a width of 42 feet, with well defined walls. Farther north the deposit is covered by gravel, and few outcrops are available, but judging from the magnetic survey, we may assume the length of the deposit to be about 250 feet. At the north end its width is about 19 feet. No. 3 deposit lies in a gully about 180 feet north of No. 2, and is completely concealed by humus, except along the east bank, where its contact with the porphyry is exposed, in a few places. The total length of the ore body is estimated at about 350 feet. No. 4 deposit is located east of No. 3. It has a length of about 400 feet. At the southern end of the deposit the width was proved by stripping to be 30 feet, but is decreasing towards the north.

North of groups I and II, there is no indication of iron ore for a distance of about 1,600 feet, then, group III is encountered. This is for the most part covered by swamp, and it is only at its southern end that a few outcrops of ore can be seen. According to the result of the magnetometric survey, this iron-bearing area extends in a northerly direction for about 4,400 feet. It does not, however, consist of one continuous ore body, but is made up of a great number of ore lenses, which vary considerably in size. On the main deposit, which lies in the southern half of the area, drill holes No. 5 and No. 6 have been sunk vertically. In No. 5, ore was encountered at a depth of 23 feet, and the core was continuously in ore to 347 feet. Drill hole No. 6 was sunk to a depth of 276 feet, showing, however, very lean ore, thickly streaked with jasper. The average width of the deposit at the surface is about 100 feet, and its total length according to the magnetometric survey may approximately be estimated at about 830 feet. About 150 feet north of this deposit another ore lens is situated, on which drill hole No. 7 was sunk. This ore body has a total length of about 400 feet, with a maximum width at the surface of about 90 feet. Besides these two ore bodies the magnetometric survey indicates the presence of a number of others which are all covered by humus, and on which no diamond drilling, so far, has been done.

Character of Ore.—The ore of the district consists of a very fine-grained, siliceous magnetite, mixed with a considerable amount of hematite. It is often found interbanded with jasper and a green slaty gangue material, which gives the deposits a conspicuous bedded structure. Veins of quartz are also, as already mentioned, of common occurrence, and generally follow the bedding planes of the ore. The metallic iron content of the various layers varies, therefore, considerably, ranging from 59 down to 35 per cent: the average being about 43 to 47 per cent.

The average phosphorus content is about 0·8 per cent, with the sulphur ranging from 0·03 to 0·1 per cent. Locally, however, the sulphur content is much higher. This is especially the case near the contact of the ore with the country rock, where layers of iron pyrites, varying in thickness from a fraction of an inch up to several feet, often occur.

The following tables give a number of analyses representing average samples taken by the writer:—

TABLE No. 1.

No. of Sample.	Metallic Iron %	Insoluble %	Phosphorus %	Sulphur %	Manganese %	Notes.
1.	43·7	26·3	0·64	0·05	1·00	Average sample from deposit No. 1 about 230 feet south of its northerly end.
2.	42·5	34·6	1·20	0·03	Not determined.	Average sample from deposit No. 1 about 100 feet north of Nipisiguit river.
3.	46·0	21·6	1·21	0·05	Not determined.	Average sample from deposit No. 1.
4.	46·6	24·7	1·04	0·02	1·8	Average sample from the southerly end of deposit No. 2.
5.	43·4	25·2	0·82	0·02	....	Average sample from the northerly end of deposit No. 2.
6.	43·6	33·1	0·40	0·007	0·5	Average sample from deposit No. 4.
7.	44·5	28·5	0·83	0·03	....	Average sample from group III.
8.	47·5	22·7	0·65	0·05	1·2	Average sample from group III.

Table 2 gives the records of four drill holes. The cores were shipped to the laboratory of the Mines Branch, at Ottawa, and analysed there by Mr. H. A. Leverin. With few exceptions, the average length of core represented by each analysis is 10 feet. The core of hole No. 7 was analysed at the laboratory of the Canada Iron Corporation, and the results, kindly placed at the disposal of the writer by Mr. Fulton, are given in Table 3.

TABLE No. 2.

Designation of Drill Hole.	Direction of Drill Hole.	Angle of Drill Hole.	Depth.	Analysis. Iron. %	Insoluble. %	Phosphorus. %	Sulphur. %	Manganese %	Remarks.
			Feet						
Drill hole No. 1.	....	90°	0 - 35′	......	......	......	......	.....	Hanging wall, porphyry and schist.
			35′- 40′	48·0	17·5	0·95	0·11	.....	Iron formation.
			40′- 50′	50·5	15·5	1·01	0·10	.....	
			50′- 60′	45·6	21·2	0·87	0·07	.....	
			60′- 70′	45·5	18·4	0·69	0·43	.....	
			70′- 80′	50·9	16·2	0·49	0·09	.....	
			80′- 90′	51·6	8·0	0·86	0·70	.....	
			90′-100′	39·6	24·7	0·85	0·10	.....	
			100′-110′	51·6	12·3	0·79	0·05	.....	
			110′-120′	44·5	20·9	0·75	0·08	.....	
			120′-130′	41·3	27·7	0·57	0·13	.....	
			130′-140′	53·9	12·6	0·74	0·65	.....	
			140′-150′	57·2	11·9	0·87	0·69	.....	
			150′-160′	49·8	16·6	0·94	0·78	.....	
			160′-162′	55·7	8·4	0·76	1·30	.....	
			162′-192′	......	......	......	......	.....	Footwall, porphyry and schist.
Drill hole No. 2.	....	90°	0 - 49′	......	......	......	......	.....	Gravel, etc.
			49′- 50′	49·9	25·6	0·74	0·03	.....	Iron formation.
			50′- 60′	58·1	17·1	0·55	0·15	.....	
			60′- 70′	58·7	13·3	0·70	0·03	.....	
			70′- 72′	49·7	23·6	0·91	0·17	.....	
			72′- 82′	......	......	......	......	.....	Schist.
			82′- 90′	44·5	12·4	0·83	0·27	.....	Iron formation
			90′-100′	51·7	19·0	0·60	0·27	.....	
			100′-110′	50·1	19·6	0·88	0·04	.....	
			110′-120′	48·3	16·0	0·72	0·19	.....	
			120′-130′	50·1	16·4	0·71	0·10	.....	
			130′-140′	52·0	14·6	0·97	0·58	.....	
			140′-150′	45·1	10·1	1·08	18·21	.....	
			150′-160′	35·0	15·2	0·53	32·97	.....	
			160′-162′	44·1	6·9	0·50	37·08	.....	
			162′-172′	......	......	......	......	.....	Footwall, porphyry and schist.
Drill hole No. 4.	S. 80° E.	70°	0-8′	......	......	......	......	.....	Gravel.
			8′-434′						Hanging wall, gabbro, porphyry, and quartz.
			434′-444′	44·2	28·0	0·38	0·04	.....	Iron formation.
			444′-454′	42·5	24·0	0·73	0·09	.....	
			454′-464′	48·5	17·3	0·98	0·05	.....	
			464′-474′	45·4	16·1	1·00	0·06	.....	
			474′-484′	46·7	16·2	1·08	0·08	.....	
			484′-494′	50·8	14·8	0·87	0·15	.....	
			494′-504′	50·1	15·3	1·13	0·75	.....	
			504′-514′	......	......	......	19·4	.....	
			514′-527′	......	......	......	10·8	.....	Footwall, porphyry.

TABLE NO. 2. *(Continued.)*

Designation of Drill Hole.	Direction of Drill Hole.	Angle of Drill Hole.	Depth.	Analysis. Iron. %	Insoluble. %	Phosphorus. %	Sulphur. %	Manganese %	Remarks.
			Feet						
Drill hole No. 5.	....	90°	0 - 23′	......	....	......	....	.....	Peat and gravel.
			23′- 32′	50·5	17·8	0·90	0·09	.....	Iron formation.
			32′- 42′	52·2	10·7	1·61	0·03	.....	
			42′- 52′	52·1	13·8	1·03	0·04	.....	
			52′- 62′	52·8	14·1	0·52	0·04	.....	
			62′- 72′	55·8	10·5	0·90	0·04	.....	
			72′- 82′	48·8	18·0	1·04	0·06	.....	
			82′- 92′	50·2	18·0	0·96	0·06	.....	
			92′-102′	41·7	22·5	0·37	0·04	.....	
			102′-112′	43·0	20·5	0·81	0·04	.....	
			112′-122′	39·5	23·1	1·22	0·03	.....	
			122′-132′	51·1	15·0	0·98	0·04	.....	
			132′-142′	54·1	15·0	0·53	0·06	.....	
			142′-152′	42·7	17·6	0·90	0·35	.....	
			152′-162′	41·7	18·5	0·64	0·12	.....	
			162′-172′	45·1	18·0	0·88	0·07	.....	
			172′-182′	47·0	17·5	1·18	0·11	.....	
			182′-192′	47·9	16·8	0·73	1·38	.....	
			192′-202′	38·2	21·8	0·96	1·49	.....	
			202′-212′	47·9	12·6	0·62	0·90	.....	
			212′-222′	51·6	13·8	0·91	0·14	.....	
			222′-232′	49·5	16·6	0·96	2·43	.....	
			232′-242′	53·5	13·4	0·81	0·08	.....	
			242′-252′	56·5	12·6	0·67	0·08	.....	
			252′-262′	55·3	7·9	0·70	0·13	.....	
			262′-272′	48·5	15·3	1·09	0·13	.....	
			272′-282′	42·6	19·1	0·71	0·09	.....	
			282′-292′	48·0	17·3	0·81	0·03	.....	
			292′-302′	45·6	21·1	0·78	0·07	.....	
			302′-312′	51·5	13·7	0·98	0·05	.....	
			312′-322′	52·3	13·0	1·07	0·03	.....	
			322′-332′	54·9	13·3	0·93	0·06	.....	
			332′-342′	50·7	14·6	0·78	0·37	.....	
			342′-347′	59·5	6·5	0·72	0·20	.....	
			347′-353′	......	....	......	18·2	.....	

TABLE No. 3.

Designation of Hole.	Direction of Hole.	Angle of Hole.	Depth of Hole.	Metallic Iron.	Insoluble.	Phosphorus.	Manganese.	Sulphur.	Alumina.	Lime.	Magnesia.	Remarks.
Drill hole No. 7.	N. 75° E.	15°	Feet	%	%	%	%	%	%	%	%	
			0 - 10′	....	....	....	....	....	....	....	....	Gravel.
			10′- 29′	....	....	....	....	....	....	....	....	Hanging wall, porphyry.
			29′- 40′	36·3	25·0	....	....	....	....	....	....	Iron formation.
			40′- 45′	52·9	12·3	....	....	....	....	....	....	
			45′- 50′	55·1	17·3	0·51	1·0	0·10	1·0	1·3	0·7	
			50′- 55′	53·8	19·7	0·49	0·8	0·07	0·4	1·5	0·5	
			55′- 61′	51·3	18·8	0·50	1·1	0·37	0·3	1·3	0·6	
			61′- 62′	....	....	....	....	....	....	....	....	No core.
			62′- 63′	55·1	12·6	....	....	....	....	....	....	Iron formation.
			63′- 65′	....	....	....	....	....	....	....	....	High in sulphur.
			65′- 71′	52·5	19·2	0·81	1·2	0·11	0·1	1·9	0·4	Iron formation.
			71′- 78′	52·7	17·5	0·73	1·2	0·10	0·1	1·8	0·4	
			78′- 83′	53·5	15·9	0·71	2·0	0·13	0·2	1·7	0·3	
			83′- 88′	28·6	39·9	....	....	....	....	....	....	
			88′- 92′	48·2	17·7	....	....	....	....	....	....	
			92′- 99′	55·6	13·0	....	....	....	....	....	....	
			99′-106′	54·2	14·1	....	....	....	....	....	....	
			106′-109′	46·6	28·5	....	....	....	....	....	....	
			109′-129′	....	....	....	....	....	....	....	....	Porphyry and iron pyrites.

Mining Operations.—So far, actual mining operations have been confined to the north end of deposit No. 1. The ore is won by overhand stoping from an open-cut about 75 feet high, trammed and hoisted up an inclined trestle to a No. 8 Gates crusher from which it passes to a picking belt, where it is hand picked by boys, and conveyed to a storage bin for loading into railway cars.

The power plant consists of 3 horizontal boilers, 125 H.P. each; an air compressor of 8 drills capacity, and a 200 H.P. engine. Other buildings erected are: office, manager's house, blacksmith and carpenter shops, storehouse, loading house, and several houses for lodging the staff and miners.

During 1910, about 5,000 tons of ore were reported as having been shipped.

IRON ORE DEPOSITS AT BESSEMER, IN MAYO TOWNSHIP, COUNTY OF HASTINGS.

In the beginning of October, an investigation of the iron ore deposits along Central Ontario railway was commenced by the writer, assisted by Mr. W. Morrison. The season's field work was confined to Bessemer in Mayo township, where a number of magnetite deposits occur on lots 1, 2, 3, and 4, concession VI. A magnetometric survey was made of lot 4, extending the survey of lots 1, 2, and 3, made by Mr. Fréchette in 1907, and published in the Summary Report of the Mines Branch for 1908. In addition to the magnetometric survey of lot 4, lots 1, 2, 3, and 4, were topographically surveyed.

History.—The first discovery of ore at Bessemer dates back to 1898, and in 1902 the Mineral Range Iron Mining Company was organized by Mr. H. C. Farnum to take over certain iron bearing properties in the townships of Dungannon and Mayo. The first shipment of ore was made in 1901, the ore being hauled by team to L'Amable station—a distance of about 5 miles. In 1906, a branch line called the Bessemer and Barrys Bay railway, was built, connecting the village of Bessemer with the Central Ontario railway at a point about 1 mile south of L'Amable station. Mining operations were carried on by the Mineral Range Iron Company, until the beginning of 1908, when the properties were leased to the Canada Iron Furnace Company. This Company continued operations until April, 1910, when the lease was allowed to expire, and since then, no mining operations have been carried on.

The following table gives the total amount of ore shipped:—

1901	3,000	short tons.
1902	1,396	"
1903	50	"
1904	....	
1905	....	
1906	2,500	"
1907	20,660	"
1908	28,956	"
1909	19,635	"
1910	7,356	"
Total	83,553	"

Geology.

The area under consideration is underlain chiefly by granite and dark coloured basic metamorphic rocks, interstratified with bands of crystalline limestone. The chief constituents of these metamorphic rocks, classified under the general name of amphibolites, are plagioclase and hornblende, replaced in part by pyroxene or biotite.

They are believed to represent highly altered sediments, or at least to contain sedimentary material, and are invaded and penetrated by the granite.

Ore Deposits.—The ore deposits occur as isolated lenses of varying extent, associated with the amphibolites, along, or adjacent to, the granite contact. The general strike of the formation is northeast-southwest, with a steep dip towards the southeast, averaging about 60 degrees. The ore consists of a fairly coarse-grained, crystalline magnetite, and its quality varies greatly in different parts of the field. In some cases a clean magnetite of high iron content is observed; in others the magnetite is closely associated with epidote, garnet, hornblende, and calcite, and often appears to pass gradually into such gangue minerals. The best quality of the ore averages about 54 per cent of iron, but considerable cobbing has had to be done in order to keep it up to that standard, since a large percentage of the ore does not average more than 40 up to 48 per cent. This latter has so far been relegated to the waste dumps, or left in the mine. Locally, stringers and patches of iron pyrites are found, making the average percentage of sulphur in the ore rather high. It has, however, been possible, by handcobbing, to keep the sulphur down to somewhere near 0·06 per cent. The percentage of phosphorus is very low, averaging from 0·010 to 0·025 per cent.

An average analysis of the shipping ore supplied by the Canada Iron Furnace Company, Midland, Ontario, is as follows:—

	Per cent.
Metallic iron (Fe)	54·29
Lime (CaO)	6·86
Magnesia (MgO)	1·35
Alumina (Al_2O_3)	2·02
Silica (SiO_2)	9·84
Phosphorus (P)	0·019
Sulphur (S)	0·062

An average analysis of 25 carloads shipped to Midland during 1908, is as follows:—

Iron	54·0
Sulphur	0·075
Phosphorus	0·022

Two average samples of discarded ore taken by the writer from No. 4 mine, gave the following analysis:—

	No. 1.	No. 2.
Metallic iron (Fe)	47·70	42·50
Lime (CaO)	8·75	13·05
Magnesia (MgO)	4·07	2·80
Alumina (Al_2O_3)	2·34	2·79
Silica (SiO_2)	15·30	19·20
Phosphorus (P)	0·004	0·30
Sulphur (S)	0·63	0·30

The ore bodies occur in four groups, which have been designated as mines No. 1, No. 2, No. 3, and No. 4.

No. 1 is situated on lot 1, concession VI. The magnetometric survey indicates here the presence of a number of small lenses of magnetite of little economic importance.

At No. 2 mine, which is situated on lot 2, concession VI, an open-cut reveals some magnetite intermixed with various gangue minerals. The magnetometric survey indicates, however, this deposit to be a mere pocket. It also shows the presence of a few other deposits east of No. 2, but of comparatively small extent.

No. 3 mine is situated on lot 3, about 1,300 feet east of No. 2. It consists of two open pits, which have been opened up on two ore-lenses, separated from each other by about 50 feet of gangue rock. From these pits a considerable amount of ore has been mined. Besides these ore lenses, the result of the magnetometric survey indicates, a short distance east and west of mine No. 3, several other deposits. They are, however, of small extent.

Mine No. 4, which is the principal deposit at Bessemer, is situated on lot 4, concession VI. According to the magnetometric survey the total length of this deposit may be estimated at about 1,000 feet, its western end extending 450 feet under Little Mullets lake. The average width of the deposit is roughly estimated to be about 50 feet.

So far, the mining operations have been confined to the eastern half of the deposit, and the greater part of the ore taken from an open-cut 265 feet long, 40 to 60 feet wide, and with a maximum depth of about 60 feet. At the west end of the open-cut, an inclined shaft has been sunk, following the dip of the ore body. The vertical depth of the shaft is 100 feet, with stations and levels cut at a depth of 50 and 94 feet. Ore has also been mined on the west side of the shaft, where, for a distance of about 100 feet, the ore has been stoped out between the 50 and 94 ft. levels. In width, the stope varies from 29 to 17 feet, with its north side still in ore. The ore is here, however, of low grade, highly mixed with gangue minerals, and also carrying a rather high percentage of iron pyrites, and has, therefore, been left.

Owing to the irregular geological relations of the ore deposits, and the small amount of prospecting work done, no definite estimate of the horizontal extent of the ore bodies can be made. But judging from the results of the magnetometric surveys, confirmed by the distribution of a few natural exposures, we may estimate the total ore area of the four lots to be about 81,000 square feet, divided as follows:—

Lot 1, concession VII	7,000
" 2, " "	6,000
" 3, " "	20,000
" 4, " "	50,000
Total	83,000

This estimate does not, however, pretend to be more than a very rough approximation; besides, a considerable portion of this area contains ore which has either too low iron content, or contains too much sulphur to be suitable for economic iron smelting without previous concentration; a process to which the ore is well adapted on account of its physical character.

Regarding the extent of the ore in depth, mining operations at No. 4 have proved this deposit to a depth of 100 feet below the surface; but both the geological appearance and the result of the magnetometric survey indicate a considerably greater depth.

INVESTIGATION OF IRON ORE DEPOSITS AT TORBROOK, ANNAPOLIS CO., N.S.; AND MAGNESITE DEPOSITS, TOWNSHIP OF GRENVILLE, ARGENTEUIL CO., QUE.

Howells Fréchette, M.Sc.

I.

In accordance with instructions, I spent the summer season of 1910 examining the western portion of the Torbrook iron ore deposits for the purpose of determining the position of the ore beds, and the possibility of tapping the ore at other points than along the present known lines of outcrop.

The area under examination was about 1¾ miles northeast and southwest, by 2 miles northwest and southeast. It is situated directly to the east of the Nictaux river about 5 miles southeast of Middleton, Annapolis county, Nova Scotia.

The northwest portion of this district has an altitude varying from 320 to 400 feet above sea-level, and the southeastern from 400 to 575 feet. Intervening is a valley through which the Torbrook or Black river flows, the bottom of which grades from 350 feet to 230 feet above the sea.

The history and general description of the iron ore deposits of this locality are dealt with by Dr. J. E. Woodman in his report on the Iron Ore Deposits of Nova Scotia[1]; part II, chapter II. The geology and stratigraphy have been described by Prof. L. W. Bailey[2], and the late Mr. Hugh Fletcher[3].

There are two principal zones of ore parallel to one another, and distant about one mile. One is on the northwest side of the area under examination, which, for convenience, will be referred to as the north side, and the other across the valley of Black river near the southeast side of the area. This will be referred to as the south side, or, as it is locally known, South mountain.

The ore is in beds conformable with the slates and quartzites, in which they occur. The strike of the beds is N·40° E.[4] On the north side there are two main beds dipping about 80° to the southeast. The northernmost, or "Leckie," is a hard hematite, which is slightly magnetic. About 75 feet south of this is a bed of fossiliferous magnetite, known as the "Shell" bed. On South mountain only one bed is seen. The dip of this is from 78° to 87° to the northwest. The ore in most parts of this bed is a low grade magnetite containing a few fossils. It is highly siliceous, and is of a waxy lustre.

It has been contended by previous observers, that the strata lie in a syncline, and that the bed seen on South mountain is identical with one of those on the north side.

---

[1] Publication No. 20, Mines Branch, Department of Mines.
[2] Geol. Survey Annual Report, Vol. IX, p. 91 M.
[3] Geol. Survey Annual Report, Vol. XVI, p. 302 A.
[4] All bearings are referred to astronomic north.

Mr. Fletcher, in his report for 1905,[1] states that certain investigations at the old mines in the eastern portion of the Torbrook district seem to prove that, the rocks lie in several synclines.

If there is multiple folding in the area under present examination, and the folds are large, the ore beds might be expected to outcrop or approach within workable distance of the surface within the Black River basin. However, there is insufficient evidence to be seen in the dip and sequence of the strata to make it possible to state that there is multiple folding here.

SURVEYS.

Magnetometric surveys were made on both the south and north sides of the area, with lines of observation connecting.

South Side.—A base line 6,400 feet long, approximately following the line of pits in the South Mountain ore, was laid off, and cross lines were turned at intervals of 300 feet, and in some places intermediate lines were run. The length of the cross lines averaged 1,700 feet to the north of the base line and 1,250 feet to the south. Magnetometric observations for vertical and horizontal intensity were made at intervals of 50 feet along these lines, and at such other points as were deemed necessary. It had been hoped to locate the presence of additional beds and discover lines along which the ore beds approach the surface, due to multiple folding. Unfortunately, no such results were obtained, but the known bed was traced from the pit on Obadiah Brown's farm westward to Black river. Only one marked break in the continuity of the bed was observed. The maps issued with the reports of Fletcher and Woodman show an offset of the bed at Black river. The line of outcrop from the east is shown as meeting the river immediately below the mouth of a small creek and the line of outcrop from the west as meeting Black river at a point about 1,100 feet below. This was found to be incorrect. The bed *crosses* Black river at the point 1,100 feet below the mouth of the creek and shows no jog. No outcrop was found above this point on Black river, nor did the magnetometer indicate magnetic disturbances.

North Side.—A base line 8,850 feet long was run, parallel to the south base line, near the north beds. Cross lines were run at intervals of from 50 feet to 200 feet, averaging in length 650 to the north of the base line and 450 feet south. Magnetometer readings were taken at intervals of 50 feet along these lines, and in the neighbourhood of the ore, additional readings were taken every 12′-6″. Besides the two main beds, a number of other beds were observed, and their relative position determined. These other beds do not appear to be of any practical importance. The presence of numerous faults was noted.

In connexion with the magnetometric surveys a topographic survey was made by the transit-stadia method, a plan of which is in course of preparation.

NATURE OF ORE.

South Mountain.—The following analyses, taken largely from Woodman's report, will serve to show the character of the ore on South mountain.

[1] Summary Report of Geol. Survey, 1905, page 120.

Analysis of South Mountain Ore.

Sample Numbers.	1	2	3	4	5	6	7	8
Metallic iron	22·92	33·60	47·88	55·69	47·09	49·51	36·41	34·73
Insoluble matter	58·62	40·17	16·75	15·48	(20·20*)	(19·56*)	....	.....
Alumina					3·70	5·46	....	.....
Lime					4·55	2·15	....	.....
Magnesia					0·45	0·90	....	.....
Phosphorus					1·39	0·745	....	.....
Sulphur					0·051	0·009	....	.....
Titanic acid				nil	....	....	....	.....

* Silica.

Analysis of South Mountain Ore.

Sample Numbers.	9	10	11	12	13	14	15	16	17
Metallic Iron	34·72	55·45	54·53	36·41	48·03	45·82	43·40	46·64	30·88
Insoluble matter	20·49	13·03	(12·68*)	.....	(19·11*)	(22·16*)	.....	.....	(33·16*)
Alumina			2·50	......	6·20	4·93	.....	.....	
Lime			0·95	......	2·95	4·15	.....	.....	
Magnesia			0·43	......	0·38	0·42	.....	.....	
Phosphorus	3·192	......	1·00	......	1·32	1·44	.....	.....	1·738
Sulphur			0·003	......	0·005	0·01	.....	.....	

* Silica.

(1) Selected sample of best "ore" from a pit on the west bank of Black river at the point where the South Mountain bed crosses the river.

Nos. 2 to 17 were also taken from this bed at various distances northeasterly from Black river.

(2) Average sample taken from an outcrop 1,100 feet from Black river.

(3) Sample from a pit 2,100 feet from Black river.

(4) Sample from a pit 2,250 feet from Black river.

(5) Sample from dump beside a pit 2,650 feet from Black river.

(6) Sample from the same pit as No. 5.

(7) Sample selected from a 3 ton dump beside a trench 3,000 feet from Black river.

(8) Sample from a 4 ft. belt of ore in the same trench as No. 7.

(9) and (10) Samples from the same trench as Nos. 7 and 8.

(11) Samples selected from a 2 ton dump beside a pit on the east side of S. McConnell's farm, 3,400 feet from Black river.

(12) Sample selected from the main belt of ore in the same pit as No. 11.

(13) Sample selected from a 1 ton dump beside a pit 4,000 feet from Black river.

(14) Sample from a 4 ft. belt of ore in the same pit as No. 13.

(15) Sample selected from a 1 ton dump beside a pit on Obadiah Brown's farm, 5,900 feet from Black river.

(16) and (17) Samples from the same pit as No. 15.

It will be noted that in most places the ore is very low in iron, and highly siliceous. The analyses which show high iron content are from picked samples, or are samples from narrow bands in the ore bed.

The bed is made up of alternate narrow bands of ore and slate. The widest of these ore bands seldom attains a thickness of more than 5 feet. The aggregate thickness of ore averages about 8′-4″ in a total bed thickness of 18′-10″. These figures are from sections measured by Mr. Fletcher.

Considering the South Mountain bed as a whole, in this section it can hardly be looked upon as showing much commercial possibility on account of the low-grade character of the ore, and the difficulties of transportation.

North Side.—The "Shell" bed, as before stated, is magnetite containing numerous fossils of lower Oriskany or Eo-Devonian age. On page 14, part I, of Woodman's report, he gives the following average analysis of the shell ore. This is compiled from analyses from various sources:—

	Percentage.	No. of analyses.
Iron	44·132	81
Silica	16·605	81
Alumina	4·843	6
Lime	6·790	7
Phosphorus	0·750	25
Sulphur	0·098	11

There are a number of openings in this bed from which ore has been shipped, but at present no ore is being mined. The chief of these—known as the Wheelock mine—was opened in 1905. The ore was shipped to Londonderry, N.S., until 1908, when the mine was closed. The following analysis is given by Woodman as the average of ore shipped:—

	Per cent.
Iron	43·693
Insoluble	17·460
Phosphorus	1·110

About 3,500 feet west of the Wheelock mine the shell bed has been stripped for a distance of about 500 feet. The bed here is 4 feet wide. A general sample gives the following analysis:—

	Per cent.
Iron	53·92
Insoluble	8·25

On the west side of the Bloomington road a sample was taken from some ore lying near an old pit. It gives the following analysis:—

	Per cent.
Iron	51·49
Insoluble	15·37

The average thickness of the shell bed is 5 feet.

The Leckie bed, which averages 4′-6″ in thickness, is of hematite, practically devoid of fossils. In the western part of the field this ore is slightly magnetic. An average of numerous analyses is given by Woodman as follows:—

	Percentage.	No. of analyses.
Iron	49·427	250
Silica	14·868	55
Alumina	4·168	15
Lime	4·235	11
Magnesia	0·534	9
Manganese dioxide	0·591	11
Phosphorus	0·952	75
Sulphur	0·071	17

The Canada Iron Corporation has opened a mine in this bed, about 2,000 feet west of the Wheelock mine. The shaft is down 500 feet. There are five levels on both sides of the shaft. On the west side, they all measure about 325 feet in length; while on the east side they vary from 150 feet to 650 feet. Cross-cuts have been driven from the 2nd and 5th levels to the shell bed, which at this point is 100 feet to the south. In the levels the ore is found to vary in thickness from 3′-9″ to 6′-6″, with an average of 5 feet.

During the past year about 11,000 tons of ore were shipped, which ran about 48 per cent in metallic iron, and 1·5 per cent in phosphorus.

The total quantity of ore raised from this mine was about 55,000 tons at the end of 1910.

At present all the ore shipped is crushed to 3″, and passed over Zimmer shaking tables, where it is hand picked. By further concentration the percentage of iron might be increased materially, as the ore carries considerable included rock.

Transportation.—The ore is shipped over a branch line to the Halifax and Southwestern railway at Nictaux, a distance of about 3½ miles, thence to Port Wade, where a large ore dock has recently been built, or to Middleton where connexion is made with the Dominion Atlantic railway. At present all the ore is shipped to Port Wade, a distance of 55 miles from the mine, and there transferred to vessels.

During the season's work at Torbrook, Mr. A. B. Clark of Bear River, N.S., ably filled the position of field assistant.

II.

In November I visited the magnesite deposits in the township of Grenville, Argenteuil county, Quebec.

Quarrying operations have recently been renewed on lot 18, range XI, in a deposit of magnesite. A small plant has been installed, equipped with a steam derrick, and a small air compressor to supply air to the drills.

The covering of earth has been removed from the magnesite over a considerable area, and a few test pits sunk; but the limits of the deposit have not been revealed. The deposit has been proved for 300 feet north and south, and 60 feet east and west. A porphyritic basalt dyke 1 foot wide crosses the deposit immediately to the north of the quarry pit.

Of the following analyses No. 1 is from an average sample taken from the face of the quarry, which is 20 feet in height; and No. 2 from a surface sample representative of the exposed portion of the deposit:—

	No. 1.	No. 2.
Magnesia (MgO)	42·00%	35·67%
Lime (CaO)	7·40	13·48
Ferric oxide (Fe_2O_3)	0·17	0·40
Silica (SiO_2)	1·67	4·27
Carbon dioxide (CO_2)	47·56	42·96

or otherwise expressed:—

	No. 1.	No. 2.
Magnesium carbonate ($MgCO_3$)	79·70	61·80
Calcium carbonate ($CaCO_3$)	13·21	24·07
Magnesia (MgO) other than in form of carbonate	4·05	6·24
Silica (SiO_2)	1·67	4·27
Ferric oxide (Fe_2O_3)	0·17	0·40

The magnesite is hauled in winter to Calumet, a distance of 13 miles. From thence it is shipped over the Canadian Pacific railway to Montreal. The carbon dioxide is extracted and saved, and the residue goes to the paper makers.

Lot 15, range IX, of the same township, was also visited. On the north half of this lot there is a deposit of magnesite, which appears to be about 200 feet in width, and of unknown length. The magnesite is of very good grade in places, but in others carries considerable chondrodite. It was impossible to gain any definite knowledge of this deposit, or to gather representative samples, as the ground was covered with snow at the time of visiting.

INVESTIGATION OF REPORTED DISCOVERY OF TIN ORE IN THE VICINITY OF ARNPRIOR, ONT.

L. Heber Cole.

I.

In accordance with instructions, I left Ottawa on August 30, 1910, for Arnprior, Ont., to look into the truth of the reported discovery of tin ore in that vicinity.

On making inquiries, I was referred to Mr. Claud McPhee of Arnprior, who has the property on which the reported discovery was made under option. Permission was obtained to examine and take samples. I drove out to the property, but found the shaft full of water; and as there was nothing to be seen on the dump, postponed my examination until the shaft was dry.

Having been informed that the shaft was unwatered, I again visited Arnprior in the first week of December and made a thorough examination: taking samples where advisable.

The property is situated in Carleton county, Fitzroy township, about 1½ miles northwest of Galetta—a station on the Ottawa, Arnprior, and Parry Sound railway. The lots cover an area of about 1,000 acres.

The property was first opened up prospecting for galena and zinc blende. The rock of the district is highly altered, and consists of alternating bands of decomposed granites, hornblende schists, and crystalline limestone. These bands strike northeast and southwest, and dip to the northwest at about 70°. The vein, which lies along the contact between the limestone and schist, consists of badly disintegrated calcite, barite, and feldspar; but on this property it is not very well exposed. The thickness is variable, averaging about 2 feet.

Two openings have been made on the contact: one a shaft, and the other an open-cut. The shaft has one compartment, is 45 feet deep, and a cross-cut has been driven from the bottom, 15′-0″ into the hanging wall. The open-cut consisted in stripping the overburden for a length of 15 feet, a width of 4 feet, and a depth of 6 feet.

The material on the dump at the shaft consists of calcite, barite, and crystalline limestone, carrying occasional specks of zinc-blende. Crystals, more or less perfect, were found of both calcite and barite.

Shaft.—This was sunk on the vein for the first 20 feet, at which depth the latter goes off in the hanging wall, the shaft being vertical. The walls show calcite in crystalline form for this distance, and then the limestone country rock with cross stringers of quartz holds to the bottom. The cross-cut showed up the vein about 10 feet from the hanging wall of the shaft, but was abandoned because the vein was very porous, and open to the surface, allowing surface waters to penetrate, carrying with them considerable clay and rounded pebbles (about 1″diameter). This clay material, which can be dug out by hand, fills in the spaces around the calcite crystals which have formed to considerable size in the cavities of the vein. Zinc-blende is found scattered throughout the altered limestone on the contact with the vein, and several lumps about 2″ diameter were found, and taken for a sample. No indication of any other economic mineral was found.

Samples were taken as follows from the shaft:—[1]

	Cassiterite.
No. 1—5 feet along east wall of cross-cut across vein..	Nil.
No. 2—6 feet along north side of shaft, 40 feet from collar..................................	Nil.
No. 3—General sample from material in bottom of shaft and cross-cut........................	Nil.
No. 4—Sample of clay in cavities.................	Nil.
No. 5—Vein in back of cross-cut, 2 feet across.......	Nil.
No. 6—Special sample (mostly zinc-blende) picked from walls in cross-cut.	

Open-cut.—This shows much iron stain and chlorite, formed by the alteration of an iron-bearing mineral, probably hornblende. The hanging wall consists of mica schist, and all the rocks appear greatly altered. This pit is about 100 yards to the northwest of the shaft.

A sample was taken from the centre of the east breast, where the rock showed a schistose structure, and contained several garnets.

	Cassiterite.
No. 7—Sample from open-cut....................	Nil.

On examining and testing all these samples thoroughly, the analyst failed to find a trace of cassiterite.

Judging from samples taken, the appearance of the prospect, and other conditions, there is not much likelihood of tin being found in this district.

II.

COBALT AND SURROUNDING DISTRICTS, PROVINCE OF ONTARIO.

In accordance with instructions, I left Ottawa on September 1, 1910, to obtain information regarding the mining operations being carried on at Cobalt, and the surrounding country; special attention being paid to the concentration of the silver-cobalt ores. A hurried trip was also made into the Porcupine gold camp.

The respective districts are dealt with in the following order:—

(1) Cobalt silver district,

(2) Gowganda and Elk Lake silver district,

(3) Shiningtree and Rosey Creek silver district,

(4) Porcupine gold district.

A map showing the relative positions of the districts and the principal lines of transportation, has been prepared, and accompanies this report at the end.

Appreciative acknowledgment is due to the mine managers and engineers of the districts investigated for their courtesy and readiness in furnishing information; which greatly facilitated the work.

[1] Analyst, M. F. Connor.

THE COBALT SILVER DISTRICT.

In 1904, Canada stood eighth in the list of silver producers throughout the world. In the same year the Cobalt district first came into prominence, and shipped its first ton of cobalt ore. The following table shows the influence that the phenomenal production of this camp has had on Canadian production of silver; the rest of Canada having increased its output only slightly during these years:—

1904	Canada stood 8th in the list of producers.
1905	" " 6th " " "
1906	" " 5th " " "
1907	" " 4th " " "
1908, 1909, 1910	" " 3rd " " "

The following table shows the production, in 1909-1910,[1] of several of the more important silver producing countries:—

	1909.	1910.
Mexico	73,949,432 ounces.	72,574,220 ounces.
United States	54,721,500 "	54,438,695 "
Canada	27,529,473 "	31,983,328 "
Australia	16,359,284 "	16,359,284 "
South America	16,038,182 "	16,476,928 "

The output in 1910, for the Cobalt and surrounding districts was 29,375,000 ounces: after deducting 5 per cent from the settlement assays of ores sent to the smelters to allow for smelting losses. This is an increase of about 4,552,900 ounces, or about 18 per cent more than the production of 1909. Taking the average value of the price of silver for the year 1910 as 53·486 cents, the value of the Cobalt shipments was over $15,711,513.

Shipments.—The shipments from the Cobalt camp have shown a steady increase from year to year:—

1904	191·55 tons.
1909	29,942·99 "
1910	33,976·97 "

These figures are the shipping weights recorded in the office of A. A. Cole, Mining Engineer, to the Timiskaming & Northern Ontario Railway Commission.

The Cobalt ore shipped during the twelve months of 1910 was distributed as follows:—

Canada	9,922·40 tons or	29·20 per cent.
Great Britain	393·73 " "	1·15 "
U. S. A.	23,428·70 " "	68·96 "
Germany	232·14 " "	0·69 "
Totals	33,976·97 tons or	100·00 per cent.

[1] Eng. and Min. Journal.

The value of the ore handled in the Canadian smelters is over 50 per cent of the total production of the district. Although the United States is taking a considerably larger tonnage, this is due to the fact that in Canada only a very small percentage of the low grade ore is being treated.

Power.—Three companies, having developed some of the water-powers of the district, are now supplying power to the mines at Cobalt for about $50 per horse-power per annum. This power development has greatly reduced the operating costs of the mines, which before were dependent on steam-power at an average cost of $150 per horse-power per annum. The companies supplying power to the camp are:—

The British Canadian Power Co . . . compressed air and electricity.
The Cobalt Hydraulic Power Co. . . compressed air.
The Cobalt Power Co. . . . . electricity.

The first of these corporations develops its power at the falls on the Matabitchuan river—a few miles from where it enters Lake Timiskaming; while both the other companies are developing power at falls on the Montreal river. The Cobalt Hydraulic Power Company employs the Taylor system of compressor. The total power development is about 16,000 potential horse-power.

Prospecting.—Surface prospecting is carried on by a system of cross-trenching, into blocks 50 feet square; following this up with complete stripping where ground is promising. One company is installing a complete hydraulic plant, with monitor, and the ensuing summer will see a considerable area laid bare, by means of a powerful stream of water, which will wash the overburden into Cobalt lake.

Mining.—The veins, as a rule, are nearly vertical, hence, with very few exceptions, the mines have adopted vertical shafts, having levels varying between 60 and 100 feet apart, according to the regularity of the veins.

Two methods of underground development are being followed. The first is by driving a drift alongside the vein, leaving the vein on the wall, and breaking it down separately, as required. This reduces the fines to a minimum. The other method, which has been adopted more frequently of late, is to keep the vein in the centre of the drift. This has the advantage of prospecting both walls on each side of the vein: a matter which is seen to be of great importance in many of the mines, on account of a larger number of the veins having walls which are heavily impregnated with silver.

Concentration.—From the very beginning it was known that concentration would play a very prominent part in the life of the camp. The ores found were unique, and afforded concentration problems never before encountered in any part of the country. Since there were no precedents on which to work, the operating process had to be worked out from the beginning, and experiments were made on small lots at the various mining schools and testing plants in Canada, and at many similar plants in the United States. These investigations led to the establishment of concentrators, three of which were put in operation before the end of 1907, while others were under construction.

There are now fourteen mills in active operation, and several others in contemplation. The mills at present working are treating about 1,350 tons of low-grade ore each day. This ore will average 20 to 25 ounces silver per ton. The losses in the tailings vary greatly according to the method of treatment and with the grade of ore treated, and will range from 2 to 6 ounces per ton. Recovery averages about 80 to 85 per cent of the total silver content of the ores.

The method of treatment varies among the different mines, but most of them employ a system of water concentration alone; while a few employ the cyanide treatment, either wholly, or in combination with water concentration. Considering the peculiar difficulties which have had to be overcome, and the extremely rapid growth of this branch of the work in the camp, the results now being obtained are remarkable, and reflect great credit on the men who have undertaken this work so systematically. New improvements are constantly being put into practice, so that young though the camp is, the results obtained compare favourably with the other silver camps on the continent.

Sampling.—A customs sampling plant is now in operation in the town of Cobalt; and the returns from this plant are accepted by a number of the mines as a basis for settlement with the smelters.

Smelting.—There were twelve smelters or refineries in the market for Cobalt ores during 1910, representing four countries as follows:—

Canada	6
United States	4
England	1
Germany	1
Total	12

Three of the Canadian refineries were only started in the latter part of the year. None of these purchasers allow anything for the Cobalt content of the ores.

Although the shipments for this district have been steadily increasing, the total reserves have not as yet shown any decrease, but rather an increase. The development and extension of concentrating facilities has made available for treatment a large tonnage of low-grade ore that could not be economically shipped in the early days of the camp. During the year of 1910 there were twenty-nine mines shipping ore, and several others are expected to become shippers during 1911.

THE GOWGANDA AND ELK LAKE SILVER DISTRICT.

This district is situated around the headwaters of the Montreal river, and is sometimes called the Montreal River district. It is the largest silver producer among the camps in the country around Cobalt.

From Cobalt to Gowganda lake—in an air line—is about 55 miles; whereas to Elk lake, the distance is about 33 miles. The routes by which these districts can be reached are very much longer.

Gowganda lake, from which the district gets its name, lies on the boundary between the townships of Nicol and Milner. Elk lake, in the eastern part of the district, is in the township of James.

The route generally used in summer is by boat from Latchford on the Timiskaming & Northern Ontario railway—where the latter crosses the Montreal river. A boat line on this trip makes connexions with the trains on the Timiskaming & Northern Ontario railway, both north and south bound. This route embraces three portages, and four boats are engaged on the route. It covers a total distance of about 52 miles to Elk City and Smyth—two towns situated on opposite sides of Elk lake at the mouth of Bear creek. From Smyth, a stage runs each day to Gowganda, situated on the northeast arm of the lake of the same name.

The trip is over a Government built road—a distance of 27 miles. The town of Gowganda has a population of about 500 inhabitants. A winter road from Elk City to Charlton—a station on a branch of the Timiskaming & Northern Ontario railway from Englehart—is now being improved by the Ontario Government, so that it may be used the whole year round.

The country in the vicinity of these lakes is very rugged and broken, with numerous ridges, lakes, and swamps. Where the soil permits, it is well wooded with the usual timber of the northern parts of Ontario, mostly of medium size. During the last year or so the forest has been badly devastated by fires.

As the Cobalt district gradually became all staked, the prospectors, searching for fresh territory, ascended the Montreal river and spread out over the adjacent country. The result was, that in the summer of 1907 reports of silver discoveries began to be received from the Gowganda and Elk Lake district; and one of the biggest "rushes" known in the history of Ontario took place. It was estimated that during the winter of 1908-9 over 1,000 teams were at work on the winter road, hauling freight into this district from Charlton.

The mines of the district are much scattered, and, with only one exception, the ores are found in the diabase. The exception is in the conglomerate, and is a vein of smaltite with high silver values.

At the western end of the district, to the west side of Gowganda lake and around Miller lake, a group of mines are steadily at work with small forces ranging from 10 to 100 men on each property; all of which have small, but complete installations of machinery. In the eastern part of the district, the working properties are chiefly along the shores of Elk lake, on the Montreal river. Other properties which are being operated are scattered singly throughout the district.

Considerable underground development has been done on all the properties, mostly at a depth of about 100 feet. Extensive surface prospecting and development has been carried on in a manner similar to that employed in the Cobalt district, namely, by cross-trenching the claim into 50 ft. squares, and then by stripping the veins discovered.

Up to date, the shipments from this camp have come from a small number of mines; although on several new properties ore is sacked and ready for shipment. This winter there should be a substantial increase in the shipments. The following shipments had been made from this district up to the end of December, 1910:—

Mine.	Amount shipped.
Milleret	346·30 tons.
Dobie-Reeve	61·00 "
Miller Lake-O'Brien	31·00 "
Boyd-Gordon	30·00 "
Lucky-Godfrey	17·00 "
Bonsall	6·78 "
Bartlett	2·00 "
Burke-Remey	2·00 "
Welsh	1·25 "
Total	497·33 "

Concentrators, so far, have played no part in the development of this district. There are, however, two mills under construction, one of which is nearly completed. They will serve to demonstrate whether others should be erected.

The district has been greatly handicapped by the lack of good transportation facilities.

THE SHININGTREE AND ROSEY CREEK SILVER DISTRICT.

This district, situated about 15 miles to the south and west of Gowganda lake, has only lately been seriously considered as a possible producer of silver. Development work is only commencing, and no shipments have as yet been made.

Access to the district in summer, although difficult, is feasible by three routes: two by way of Gowganda Junction—a point on the Canadian Northern railway, 69 miles north of Sudbury; and the other from Latchford, on the Timiskaming & Northern Ontario railway, via Elk City and Gowganda. In winter, sleigh roads connect with both these railways.

In summer, one route from Gowganda Junction by canoe is possible through Blue lake, Wigwam lake into Oshawong lake, and the headwaters of the Wanapitei river. Following down this river and turning north into Rosey creek, Shiningtree lake may be reached by hard portaging. Another canoe route is practicable from Gowganda Junction, south through Blue lake; portaging to Pants lake, then through Gladys, Barnett, Prune, and Welcome lakes, into the Wanapitei river; and thence north, via Sylvester creek, to Tracey lake; portaging to Shiningtree lake. Both routes entail considerable portaging, and, therefore, supplies are generally taken in over the winter roads.

Much diabase, similar to that found in the Cobalt district, occurs throughout this area, and most of the veins are found in this rock. The veins of calcite, averaging from ½″ to 3″ in width, are numerous, and small diabase aplite dykes also appear. The veins carry smaltite, and in some few cases native silver has been found in the loose, cementing material, along the sides of the veins. Near the surface the characteristic cobalt bloom is often found. Other minerals, such as galena, chalcopyrite, stibnite, chromite, and specular iron, occur in these veins, but only in small amounts. In several places samples of an actinolite schist were found in the diorite, badly shattered, varying in width from ½″ to 4″. The fibres were well formed, but very brittle. A vein of barite free from impurities, and averaging 12″ in width, was noticed on the north shore of the Wanapitei river, about 2 miles west of the mouth of Sylvester creek.

The work so far done in this district is of a very preliminary nature. Two or three properties are using steam power for hoisting purposes, but most of the work consists of stripping the veins of their overburden. Because of the difficulties of bringing machinery into the district, this method of prospecting proves the simplest and most efficient means of development work for the prospector. In many cases the work has been very systematically undertaken, and has given good results in showing up the veins.

Most of the properties are still in the hands of the original locators, and in only a few cases have companies been formed to operate in this district.

THE PORCUPINE GOLD DISTRICT.

The district known as Porcupine, situated in the northern part of New Ontario, is the youngest mining camp in Eastern Canada. At present, active prospecting is principally confined to the townships of Tisdale, Deloro, Whitney, and Shaw, in the Sudbury district, but many claims have been located in adjoining townships.

The first claims were recorded in the summer of 1906; but very little interest was taken in the findings until the spring and summer of 1909. At present the principal properties are situated in Tisdale township, to the west of Porcupine lake; but the ensuing spring will see active work being carried on in the three other townships mentioned.

The camp is reached in summer by three different routes: two from the Timiskaming & Northern Ontario railway, at mileages 205 (Matheson) and 222 (Kelso) respectively; and the third from Bisco on the Canadian Pacific railway. This latter route is by canoes down the Mattagami river to a point about 3 miles west of Miller lake on the west boundary line of Tisdale township. The most popular route during the past summer was from mileage 222 at Kelso—a distance of 467 miles by rail from Ottawa. From thence, a stage operates for a distance of 12 miles, to the point where the Frederick House river enters the lake of the same name. A gasoline launch service from this place runs up the Frederick House river, across the north end of Nighthawk lake, and up the Porcupine river for a couple of miles to Hill's stopping place. A government road, 6½ miles long—built by convict labour—is completed from the last named place to the north end of Porcupine lake. The Kelso winter road, over which most of the freight is going this winter, follows a more direct route after leaving the mouth of the Frederick House river; and shortens the trip from Kelso to the north end of Porcupine lake to 25 miles.

The Timiskaming & Northern Ontario railway is at present at work on the construction of a branch line into the camp, and it is expected that this will be completed by the end of June, 1911.

There are three townsites in this district: all situated on the shore of Porcupine lake. At the northeast end is the government townsite called Porcupine, and immediately across the lake to the northwest is Pottsville, where the post-office is located. At the southwest end of the lake another townsite has been established.

In summer, a gasoline launch service plies on the lake between the different townsites. The lake is 2½ miles long.

Much of the country is low-lying and swampy, and is covered with a heavy growth of small timber. On account of the impervious clay bed which lies only a few feet below the surface of the swamps, the land is very difficult to drain, and this greatly hinders trenching. The rock outcrops through this overburden in scattered spots throughout the whole district.

At present most of the properties are in the preliminary stages of development. This development consists principally of stripping the loose overburden from the vein, to its full width, by a series of cross trenches, each about 4 feet wide, and averaging 50 feet apart. In some cases the veins are stripped completely. On many of the properties test pits are now being sunk at regular intervals on the vein, with the intention of connecting them later by drifts underground. Of the larger properties, five have shafts down, ranging from 60 to 100 feet in depth; and the owners are now driving cross-cuts and drifts at the depths indicated, to prove up the tonnage. This underground work has been pushed forward at a fair speed considering the disadvantages of the district; so that by the end of December, 1910, 1,500 feet approximately of drifting and cross-cutting had been opened up from the bottom of these workings.

Steam power in the camp has already been developed, to about 500 B.H.P.; for hoisting purposes and running drills, but many of the properties are still using only manual labor.

The installation of electric power plants on the Mattagami river at Sandy falls and Wawaitan falls is well under way.

It is expected that they will be able to furnish sufficient power next summer to run all the stamp mills then in operation.

Three experimental plants, consisting of Nissen or Tremaine stamps, amalgam plates, and tables, have been working on these ores with satisfactory results.

Orders have now been placed for mills of larger tonnage. According to present indications, by the middle of next summer, fully 75 stamps will be dropping in this camp: crushing about 250 tons of ore per day.

A complete telephone system has been established, connecting all the important properties and different townsites, and these in their turn are in direct communication with Kelso and Matheson on the Timiskaming & Northern Ontario Railway telephone system.

Although the Porcupine camp is still in its infancy, it produced in the latter half of 1910, more gold than the whole Province of Ontario produced in 1909. It gives promise of developing several good properties, which may become prominent producers in the list of Canada's gold mines.

ON THE MICA DEPOSITS OF ONTARIO AND QUEBEC.

Hugh S. de Schmid, M.E.

The summer season of 1910 was devoted to an examination of the principal mica regions of Ontario and Quebec; with the object of gathering material for a revised edition of the monograph on mica, issued by the Mines Branch in 1905.

While the chief purpose of the tour was to examine and report upon the mica deposits at present being worked, time was also devoted to an examination of old mines, with the object of collecting geological data bearing on the origin of the mica, and of compiling as complete a map as possible of the localities in which the mineral has been found to exist in commercial quantities. While it was found impracticable to visit every small surface pit from which mica has, in the past, been taken, all available information regarding such was collected, and will be embodied in the full report.

Individual township maps of those districts in which the more important deposits occur, are in process of preparation, and the comprehensive regional maps are being enlarged to a scale of 2 miles to the inch; instead of 3·95 miles, as in the former report. An additional key map, showing practically the entire mica region examined—is also being prepared.

Photographs of the mines and pits were obtained wherever practicable, and specimens showing the typical occurrence of the associated minerals, contacts, etc., were obtained for the purpose of photographing, and for illustrative reproduction.

A number of rock and mineral specimens have been sent to Germany to be prepared for microscopical examination; while a similar examination of the micas from the different mines will be undertaken. A chemical analysis of a number of mica samples is also to be made, for the purpose of determining the possible variations in the percentage of iron contained in the light and dark-coloured varieties.

A large number of the mines were idle and the workings under water, hence no detailed examination of these could be made: and reliance had to be placed on local hearsay for information relating to mining operations; while an examination of dump material and surface formations had to suffice for the gathering of geological data.

A large collection of rock and mineral specimens was made, however, and these should prove sufficient for an investigation into the origin of the mica deposits.

QUEBEC.

Since the original monograph was published in 1905, new amber mica occurrences have been located and worked in Quebec, north of the districts covered by Mr. Cirkel's report, and it would appear that the mica-bearing region extends considerably north even of the area which had already been prospected.

In the Lièvre River district, the most northerly workings are situated a few miles from Notre Dame de Laus, in the township of Bigelow, where Mr. W. Parker of Buckingham has carried on considerable surface work, and discovered extensive deposits of mica on range V, lot 52. The mica is a rather dark amber, and of only medium splitting quality.

In the Gatineau region the mineral has been mined as far north as range II, lot 28, of the township of Egan, where Mr. Joanis of Maniwaki has taken out several thousand dollars worth of fair amber mica.

Prospectors were met with in the vicinity of Pemichangau lake, who reported favourable indications on ranges V and VII of the township of Blake.

The most westerly mica deposits which have as yet been worked in the area under consideration are situated in Litchfield and Huddersfield townships, where Messrs. Bowling Bros., of Thornby, and the Calumet Mica Company of Bryson, have carried on some surface work.

It may be remarked that the mica-bearing dykes (pyroxenites) are to be found cutting the Laurentian rocks throughout almost the entire district situated immediately north of Ottawa and the Ottawa river, and over an area of which the boundaries to the north, east, and west are as yet but poorly defined. The presence of these pyroxenite dykes, while indicative always of a possible occurrence of mica, does not necessarily imply the existence of a commercially valuable deposit. In some districts mica in quantity is to be found in pockets throughout the entire mass of such a dyke, while in others but scanty traces of the mineral are to be met with, though the rock, to all appearances, is identical in both places.

Owing to its occurrence in such sporadic fashion, mica is among the most uncertain, and, from a miner's point of view, one of the most disappointing of minerals to follow. Often when the indications of a continuance in depth of the deposit are most favourable, the fissures narrow down, and all traces of the mica are lost; on the other hand, seemingly barren rock will suddenly yield large quantities of high-grade crystals, which, however, may form only an isolated group, and be underlain by many feet of rock before mica is again met.

While it is not intended to assert that mica in quantity exists on every lot in the region between the Lièvre and Gatineau rivers, the district is nevertheless so extensively traversed by pyroxenite dykes exhibiting traces of the mineral that the possible existence of deposits on almost any lot cannot be said to be precluded.

In addition to the localities mentioned, mica also occurs farther to the east, in Argenteuil county, Wentworth township, where several operators have mined on a small scale. The mica in the last-named district, as in the Saguenay region, Berthier county, still farther to the east, is chiefly of the muscovite variety.

ONTARIO.

The mica-mining region of Ontario has not been extended by any new discoveries of importance since the publication of the last report.

The chief centres of mining activity are Sydenham and Micaville, in the townships of Loughborough and North Burgess, respectively. In the former district, the General Electric Company's mine—the old Smith and Lacey—still remains the chief producer, and employs an average staff of 35 men. The output and reserves of this mine play an important role in fixing the market price of the mineral, and the General Electric Company, which carries on its mining operations under the name of the Loughborough Mining Company, can be said to practically control the market.

The above Company also owns various other mines in different parts of the country, chief among which are the Cantin mine, on lot 1, range IV of South Burgess township; the Hanlon mine on lot 11, range VI of North Burgess; and the Chaibee mine on lot 7, range A of the township of Wright (Quebec). None of the latter mines were working when visited.

The occurrence of a yellowish, and rather brittle mica, whose composition and exact species have not yet been determined, in a highly metamorphosed rock in the Sydenham district, may be mentioned here as constituting a type of mica deposit in many respects dissimilar to the majority of occurrences visited. The deposit in question is at present being worked by Mr. J. Richardson of Kingston, with an average staff of half a dozen men, and is situated on lot 1, range X, of the township of Loughborough.

The intrusive rock to which the mica probably owes its origin had not, at the time of my visit, been met with—the depth reached by the workings not exceeding 60 feet. The mica appears to have been deposited by pneumatolytic emanations from the igneous intrusion of some basic rock which did not reach the surface, but which will probably be met with at an inconsiderable depth.

Three beds, from 1 to 2 feet thick, of a reddish quartzite, are met with in the workings. These layers contain no mica, and the rock in their immediate proximity is also practically devoid of the mineral.

The source of the mica is, in all probability, a basic laccolite.

A similar mica is also found on lot 5, range II, of Bedford township, this occurrence being almost identical with the foregoing. In this case, however, the country rock is limestone, belonging to the Archæan formation, and is of the normal white, coarsely crystalline type.

The association with the mica of secondary minerals such as vesuvianite, actinolite, garnet, etc., at both the above-mentioned mines, is interesting, and will be further described in the full report.

QUALITIES OF MICA.

With the exception of some half dozen, all the mines and prospects visited, numbering over 200, were concerned with phlogopite, or amber mica deposits. The colour of the mica was found to range from almost black, in which case the resemblance to biotite was very close, to almost colourless: the very dark and the very light-coloured varieties being, as a rule, the poorest splitters.

The suitablity of mica for electrical purposes depends essentially on two factors: (1) its degree of cleavage, and (2) its non-conducting properties. Consumers of the mineral seem to vary in their opinions, some preferring a relatively dark mica of medium splitting quality, while others refuse to take any but the light-coloured variety—on account of its apparent freedom from iron—though its cleavage may be much inferior to that of the dark-coloured.

Brittleness also is an important consideration with consumers, this being a fault which affects both the dark and the light micas.

With the advent, however, of mica-board manufacturing, brittleness has ceased to prove such a detrimental factor, since even the most brittle mica is sufficiently flexible in very thin layers (½ to 1 mil.) to be used in the building up of mica plate.

Some manufacturers use both dark and light amber mica, and mix in a certain proportion of Indian white mica (muscovite) the resulting plate possessing, it is claimed, all the qualities necessary to the manufacture of electrical appliances.

STATUS OF THE MICA INDUSTRY.

The condition of the mica market, though inclined to show a slightly better tendency, towards the latter part of 1910, has not conduced to any great activity on the part of operators during the past few years. Some few of the larger owners are continuing to work, but practically all the smaller mines are idle.

A peculiar feature is, that while in the Quebec mica districts mining was declared to be unprofitable under present mining conditions, operators in Ontario, while admitting that prices were low, yet contrived to find a satisfactory enough market to enable them to continue working their properties, and even to consider the re-opening of mines which have been idle for some years. The cause of this divergence of opinion is difficult to arrive at, since wages and general mining expenses are, if anything, lower in Quebec than in Ontario.

Owing to this inactivity amongst mica-miners, fully 80 per cent of the mines visited were found to be idle, and the pits more or less full of water, and consequently inaccessible.

Although in the past, Canadian producers have, for the most part, seemed to be content with the market provided by the United States, shipments are now being made in increasing quantity to English consumers, and inquiries were often made during the past season as to names and addresses of buyers in the United Kingdom.

While appreciating the superiority of Canadian amber mica for electrical purposes, English and Continental manufacturers nevertheless still procure the greater part of the mica they require from India.

Subjoined are tables showing the amount of mica imported into the United Kingdom during the past five years from Canada and India respectively, and also the imports of Canadian mica into the United States for the same period.

TABLE 1.

Exports of Mica from Canada to Great Britain.*

Calendar Year.	Tons.	Value.	Average Value per Ton.
		$	$ cts.
1905	179	25,717	143.07
1906	167	58,735	351.71
1907	80	43,913	548.91
1908	156	81,050	519.55
1909	30	24,316	810.53

* Compiled from Mines Branch statistics.

TABLE 2.

Imports of Mica into Great Britain from Canada.*

Calendar Year.	Tons.	Value.	Average Value per Ton.
		$	$ cts.
1905	130	24,349	187.30
1906	209	51,618	246.98
1907	88	51,497	585.19
1908	122	74,362	609.52
1909	34	30,749	904.38.

* Compiled from British Board of Trade Returns, 1910.

TABLE 3.

Imports of Mica into the United Kingdom from India.*

Calendar Year.	Tons.	Value.	Average Value per Ton.
		$	$ cts.
1905	901	369,506	384.50
1906	1,845	782,397	423.15
1907	1,778	672,532	378.25
1908	1,369	415,773	303.71
1909	1,302	480,042	368.69

* Compiled from British Board of Trade Returns, 1910.

TABLE 4.

Imports of Mica into the United States from Canada.*

Calendar Year.	Tons.	Value.	Average Value per Ton.
		$	$ cts.
1905	253	121,560	480.47
1906	539	328,991	610.35
1907	767	596,321	777.47
1908	172	140,166	814.92
1909	107	132,941	796.05

* The Foreign Commerce and Navigation of the United States.

It will be seen that in 1905—the year in which the greatest quantity of mica during the quinquennial period in question was shipped from Canada to English consumers—this quantity was exceeded by the Indian shipments by more than five times; while in 1909, the Canadian mica imports were only one forty-third of the Indian.

A comparison of Tables 2 and 4, showing the average value per ton of the mica shipped to the United States and of that sent to English buyers, discloses a rather remarkable difference of price: in one case (1905) the latter would appear to have paid $336.80 per ton more for their mica than the Americans, while in 1909 the reverse is the case, the prices being in favour of the English consumers by $14.48 per ton.

The accurate average price is not, however, claimed to be shown in the above tables; in fact the figures given in the British Board of Trade returns show discrepancies when compared with those compiled from statements published by Canadian shippers amounting in one year (1906) to as much as $104.73: the average price paid per ton, calculated from the British Board of Trade returns, being $246.98; while the figure arrived at from the statements furnished to the Mines Branch statistical department was $351.71.

A comparison of the figures given in Tables 1 and 2 will show how greatly these two sources of information vary in their statements both as regards tonnage and value.

The cause of the wide difference in value of the English and American shipments, given in the two tables—differences which render any sort of comparison futile—is probably to be found in the various grades of mica shipped to the different countries.

Shippers, being bound by no compulsory system of classification or grading other than may be agreed upon between themselves and the buyers, may, in one instance, forward a consignment of more or less roughly trimmed mica of comparatively low unit value, while to another purchaser only high-grade sheets are sent, the difference in value of equal weight shipments being accordingly very great, while both consignments would be similarly classed in the Trade Returns as "mica," without distinction as to quality.

It is worthy of remark that, while the yearly average unit value of the Indian mica imported into the United Kingdom in the five years shows a maximum variation of $119.44, that of the Canadian mica similarly imported reaches the high figure of $691.97 (mean value calculated from Tables 1 and 2).

The comparatively small difference in the case of the Indian mica is doubtless due to the standard quality of the mineral, which varies little in colour and general character (elasticity, brittleness, etc.) whereas the amber mica possesses all these attributes in greatly varying degree—its price varying accordingly.

It is due to the fact that the Indian mica can always be depended upon to be of the same standard quality, that buyers in the United Kingdom have generally preferred this variety to the amber, which can seldom be relied upon, even in a single shipment, to be of uniform grade and colour.

Canadian producers, while realizing this, yet appear reluctant to fall in with the wishes of the English market, and cannot agree to the request of prospective purchasers in the United Kingdom to furnish shipments which are uniform in quality with samples submitted by them.

There can be no doubt that, could a satisfactory system of sorting be devised and agreed upon amongst mica dealers, the market relations and conditions between Canada and Great Britain would be materially improved.

For the purpose of further emphasizing the discrepancy between tables calculated from returns furnished by shippers on the one hand and by Foreign Trade returns on the other, an additional table (5), of exports of Canadian mica to the United States, is given: the figures here given are taken from "Trade and Navigation."

TABLE 5.

Exports of Mica from Canada to the United States.*

Calendar Year.	Tons.	Value.	Average Value per Ton.
		$	$ cts.
1905	351	150,767	429.62
1906	735	519,479	706.77
1907	468	372,798	796.58
1908	132	115,005	871.25
1909	325	229,689	706.74

* Trade and Navigation.

The following table (6) gives the total annual production of mica in Canada for the same period:—

TABLE 6.

Total Annual Production of Mica in Canada.[1]

Calendar Year.	Tons.	Value.
		$
1905	...	178,235
1906	574	303,913
1907	774	312,599
1908	436	139,871
1909	369	147,782

[1] Mines Branch returns.

The fact that, in some cases, the total annual production falls short of the combined exports to Great Britain and to the United States for the year, is due to the practice made by some producers of accumulating large stocks of mica: these reserves, in many cases, remain on the mine, and so do not figure in the production returns.

At the present time, large quantities of mica are being held in reserve, which owners are not disposed to ship at current prices.

PRELIMINARY REPORT ON THE BUILDING AND ORNAMENTAL STONES OF ONTARIO: SOUTH OF THE OTTAWA AND FRENCH RIVERS.

Dr. W. A. Parks.

Pursuant to instructions, I spent three and a half months of the field season of 1910 in making an examination of the stone quarries of the southern part of Ontario. The inquiry was conducted with the object of ascertaining the status of the building stone industry and it was restricted to that part of Ontario lying south of the Ottawa and French rivers. It is proposed to issue the report as the first part of a work on the Building and Ornamental Stones of Canada.

In addition to examining the quarries in Ontario, I spent a week in the granite and in the marble areas of Vermont, as well as a short time in the slate region of western New York. The quarries of the Missisquoi Marble Company at Philipsburg, Que., were also visited.

Limestone, sandstone, granite, and marble are quarried in the Province; but although the outlook is bright in certain directions, it cannot be said that the industry as a whole is in a flourishing condition. In all, 240 quarries were visited; but of these only about 70 are at present actually producing stone. This number includes certain quarries in which building stone is produced incidentally only to operations for crushed stone or lime. Quarries known to be worked for lime making only, are not included in the figures given above. As far as I am aware, all quarries at present producing building or ornamental stone were examined; but it is not to be supposed that the numbers given above include all openings from which building stone may have been obtained from time to time. From the properties visited about 300 specimens were collected which will be subjected to various physical and chemical tests with the object of ascertaining their durability, strength, and ease of dressing.

LIMESTONE.

In the Province of Ontario, limestone is obtained from a number of different geological formations. The stones from these formations are determinable by certain more or less fixed characteristics, which make a geological basis of classification the most easily understood.

The Beekmantown or Calciferous limestones, which are exposed over considerable areas eastward of Brockville, are of dark colour and liable to be marred by the presence of cavities. This stone may be recognized in buildings in eastern Ontario by the brown colour it assumes on weathering. It was formerly quarried to a large extent near Brockville and Prescott, for bridge and canal construction. Very few quarries are now in operation, and these are worked from time to time only, to fill the demands of local building.

Roughly speaking, the Chazy limestones form a ring which extends from the Ottawa to the St. Lawrence, in that part of the Province lying east of Ottawa. The stone is for the most part of a grey colour and has the property of retaining its tint on weathering. On the Ottawa, small operations have been conducted near L'Orignal, and more extensive work on a deposit of high-grade stone east of Hawkesbury. In the vicinity of Winchester are many small openings, worked intermittently only. Along the St. Lawrence the quarry on Sheek island near Mille Roches is the most important.

The Trenton and Black River limestones occupy the middle of the Chazy ring in the east of the Province, and occur as narrow strips in the Ottawa valley as far up as Pembroke. A broad belt of this rock also occurs between Georgian bay and Lake Ontario, forming the shore of the latter body of water from Kingston to Bowmanville. The stone when fresh quarried is light grey to dark bluish-grey in colour, and may be recognized in buildings by the fact that it assumes a much lighter colour on weathering, in some cases becoming almost white. The stone of these formations has been much used in the past for canal and bridge work as well as for ordinary building. Some of the largest quarries now in operation are in Black River or Trenton areas, more particularly at Ottawa, Point Ann, Kingston, Longford, and Tweed.

The Niagara limestones occur as a narrow belt from Queenston Heights to the Bruce peninsula: forming the brow of the Niagara escarpment which owes its existence to the presence of these hard limestones. Different types of stone occur, but they are all of a light colour, with a tendency to yellow rather than to grey tones. Great quantities of Niagara stone were formerly quarried for canal and bridge construction, at Beamsville, Thorold, and Queenston. Good building stone is now obtained at the two latter places as well as at Hamilton, Wiarton, and Owen Sound. Much crushed stone is made from Niagara rock, more particularly at Ancaster, Dundas, and Owen Sound (Clinton).

The Guelph rock occurs as a narrow lenticular patch west of the Niagara formation, stretching about 80 miles northward from Paris. The freshly quarried stone is always of a yellow or buff colour, but tends to a grey tint on weathering, and is highly magnesian in character. This stone was formerly largely employed for building in Guelph, Galt, Preston, Hespeler, Fergus, Elora, and Durham. Most of the present output of Galt, Guelph, Fergus, etc., is converted into crushed stone, but a little material for building is still produced at Guelph, and near Erin.

In the western peninsula of Ontario, the only formation productive of limestone is the Onondaga (Corniferous). The stone is of a light grey colour, and turns somewhat darker on weathering. The only important quarries now in operation are at St. Marys; but excellent building stone occurs in the Amherstburg quarries, which are, however, now being worked for other purposes. A large amount of material is being quarried at Port Colborne, and at Hagersville, but it is nearly all used for flux, road making, and in the manufacture of Portland cement. Very pure limestone for lime making, and for use in the chemical industries, is obtained near Beechville.

SANDSTONE.

In the eastern part of the Province, there occurs along the Rideau lakes, and in other small areas, a standstone of Potsdam, or in part Beekmantown (Calciferous) age. This material has been quarried from the vicinity of Brockville, to Perth and Smiths Falls. Some of the stone is white, other parts are spotted; and near Perth is a small deposit of purple banded stone. The only quarry now in operation is near Westport, where a heavy example of the stone is being obtained for canal construction. Farther north, in the township of Nepean, a white and yellow banded sandstone—the so-called Nepean stone—has been quarried for many years, and has been used in many structures in Ottawa; more particularly the Parliament buildings, and recently, the new Museum. The chief output of the quarries is paving blocks. The building stone is produced only when contracts are obtained.

The Medina sandstone—unquestionably the finest building stone that has been quarried to any extent in the Province—occurs at many places along the face of the Niagara escarpment, from Merritton to Orangeville. Three types of this stone may be recognized: a grey, a brown, and a mottled. The grey stone is still obtained in considerable quantity from Milton to Inglewood, and is largely used in Toronto. The brown stone, of which the Parliament buildings and numerous other structures in Toronto are built, was obtained from the Medina formation at the Forks of the Credit. These quarries are now all idle, as the increasing difficulty of production has made the cost of extraction too high for present economic conditions.

The Oriskany sandstone occurs only in the county of Haldimand, and is, throughout most of its extent, an inferior stone for building purposes. The best grade of stone is found north of Cayuga, but it is now being quarried on a very small scale at one point only.

CRYSTALLINE LIMESTONE.

The great Archæan or crystalline area, which occupies the central and northern part of the Province, is rich in bands of crystalline limestone, in Renfrew, Lanark, Haliburton, Hastings, Frontenac, etc. At a great many places a small amount of quarrying has been done, but no extensive operations have ever been conducted. The most important structure built of this stone is the post-office in Renfrew. Older buildings at Marmora, and at Lanark, show the stone to be durable, and of excellent appearance. The only quarries of any importance now in operation are those near Renfrew, which are worked more particularly for the making of lime.

MARBLE.

Many of the belts of crystalline limestone are sufficiently fine in grain to deserve the name of marble. Most of these marbles are not white, but are variegated in colour, many of them presenting a very attractive appearance when polished. Geological Survey reports contain numerous references to deposits of this kind at various points in the area. At the present time two companies are actively engaged in the production of marble, and with every chance of success. The Ontario Marble Company is operating near Bancroft on a marble belt which is yielding a number of varieties of variegated stone of exceptional beauty. The North Lanark Marble Company is engaged in extensive operations to the eastward of Clyde Forks on the Kingston and Pembroke railway. The stone consists of a white or lavender coloured base with cloudings of buff or green serpentine.

DECORATIVE MATERIALS.

Of the decorative stones other than marble, there is no present production. The unique blue mineral sodalite, formerly obtained near Bancroft, is no longer quarried, although the deposit is by no means exhausted. Serpentines and iridescent feldspars are known to occur in the Archæan area, but, as there is no actual production, they do not properly come within the scope of the present report.

GRANITE.

The Archæan area contains many granitic masses, which will eventually be quarried for building and monumental purposes. Hitherto, very little attention has been directed to this class of stone in Ontario, particularly in the interior. At Kingston, quarrying operations were carried on many years ago, and small amounts were also obtained near Gananoque, and at Brockville. At the present time, the only quarries of importance are being worked north of Gananoque, more particularly for the making of paving blocks. A small amount of building and monumental stone is, however, produced.

GNEISS.

Gneiss has been quarried to a very small extent near North Bay and Gravenhurst. More recently a small quarry was opened near Parry Sound, which is still in operation.

While a considerable amount of fairly good building stone will continue to be produced from the different formations throughout the Province, I am of the opinion that, we must look to a development of the crystalline limestones, marbles, and granites, for a regeneration of the stone industry. Concrete is taking the place of stone for all heavy construction, and is rapidly replacing it for the cheaper types of building. With increase of wealth, the highest grades of stone are demanded for buildings of a monumental character. Most of our standstones and limestones fall short of this standard, but when more is known of the crystalline limestones and marbles they will be more largely employed for structures of the highest type.

In the erection of fine buildings in the cities, there is a growing tendency towards the use of granite, which is likewise replacing limestone for monument bases. Modern quarrying methods and machinery have largely reduced the difference in cost of quarrying and working granite, as compared with the softer stones. In consequence, we may confidently expect to see a steadily increasing demand for granite. This demand can not be met either by the quality or the amount of granite at present produced in the Province. Is it not a reasonable assumption that some at least of the numerous deposits of granite in the Province will be able to supply the demands of the future?

It cannot be denied that there is a serious decline in the production of building stone. The chief causes for this decline, and the reasons for the present condition of the industry are tabulated below:—

(1) The use of cement for heavy construction, such as the building of bridges and canals.

(2) The use of cement blocks and artificial stone for architectural purposes.

(3) The cheap importation of Indiana limestone, and Ohio sandstone.

(4) The modern custom of erecting steel buildings, and facing them with terra-cotta, glazed brick, or artificial stone.

(5) The failure of the Medina brown stone.

(6) The increasing demand for granite, to which the Province has failed to respond.

(7) The high wages demanded by stone-cutters, and the difficulty of procuring a sufficient number of competent men.

(8) The fact that most of the stone quarries are in the hands of very small operators, who work them only on receiving an order. In consequence, there is always a delay in delivery, and stone of a mixed character is shipped. These same owners do not devote their time to the stone business: it is merely incidental, hence receives little attention. If there were more strong companies actively and aggressively carrying on stone quarrying as a business, the cost of stone would be reduced, and the use of concrete, for architectural purposes, restricted.

ON THE INVESTIGATION OF THE PEAT BOGS OF CANADA, AND MANUFACTURE OF PEAT FUEL AT THE GOVERNMENT PEAT PLANT, ALFRED, ONT.

A. Anrep, Jr.

Early in the season of 1910—in accordance with instructions—I started the peat plant at Alfred, Prescott county, Ontario, in full working order; and when, upon the advent of autumn, manufacturing and general operations ceased, I commenced and completed a thorough investigation of the Holland peat bog, situated in West and East Gwillimburg and King townships, Simcoe and York counties, near Bradford, Ont. The total area covered by the bog is approximately 14,641 acres; varying in depth from 5′-0″ to 20′-0″. It is estimated that this bog contains 61,641,981 cubic yards of raw peat, capable of producing, say, 9,631,552 tons of peat fuel, with 25 per cent moisture.

The bog is well situated as regards freight facilities and market: being only 42 miles from Toronto. The Grand Trunk railway crosses the middle of the bog, and the Canadian Pacific railway passes on the south side of the bog.

Inasmuch as a systematic investigation of a peat bog occupies considerable time, and as I was without an assistant, it was found impossible to investigate more than one bog during the season of 1910.

ALFRED PEAT BOG.

Part of May, the months of June, July, August, September, and part of October, were spent at Alfred, superintending the operations of the peat plant, where peat was made during a period of 50 days.

SALE OF PEAT IN OTTAWA.

The peat sold to private parties in Ottawa proved to be an excellent fuel; indeed so satisfactory, that those who used the peat not only expressed their satisfaction by letter, but have applied for further supplies for next season.

The following tonnage was distributed:—

24 tons,	900 lbs.	sold to Public Works Department.
441 "	400 "	" by C. C. Ray Company for domestic use.
61 "	1,424 "	" by Mines Branch for domestic use,
160 "		" by Mines Branch (to Fuel Testing Plant),
98 "	1,000	" at the bog,
9 "		" by Mines Branch to Germany.
794 tons,	1,724 lbs.	

DEVELOPMENT.

While the plant was in operation, the following development work was carried on:—

(1) Continuation of necessary drainage of Alfred peat bog, not accomplished during the season of 1909.

Four open ditches, each 1,000 feet long, 2 feet wide at the top, and 1′-4″ at the bottom, by 3 feet deep = 741 cubic yards.

(2) Levelling the surface of bog. Two-thirds—about 47 acres of the ground—have been levelled and cleared from trees, trunks, and brush.

(3) Buildings: peat shed for storage of dried peat, 200 feet long, 22 feet wide, and 18 feet high, with platform for loading the peat into railway cars.

(4) Railway siding 500 feet long.

REPORT ON TESTS OF BLAUGAS.

Edgar Stansfield, M.Sc.

Tests made on gas from a cylinder supplied by Mr. James Ogilvie of the Railway Commission.

EXPLOSIVES LIMITS.

Lower Limit.—It was found that a mixture of gas and air containing 5·2 per cent of the gas *did not* explode, whilst one containing 5·5 per cent *did* explode.

Upper Limit.—A mixture of gas and air containing 10·6 per cent of the gas *did not* explode, whilst one containing 10·1 per cent *did* explode.

The limits of explosibility are, therefore, between about 5·4 per cent and 10·4 per cent of the gas with air; that is, a range of 5·0 per cent.

The explosive limits of any gas vary markedly—according to the apparatus used for testing. The apparatus used in the above experiments consisted of a stout glass tube of approximately $\frac{3}{4}''$ inside diameter. The gases were fired by means of a strong electric spark passing between two platinum points, about $\frac{1}{16}''$ apart, and placed at one end of the tube. The gases were enclosed over mercury, and the pressure adjusted to atmospheric pressure before firing.

In order to compare this apparatus with the apparatus used by other experimenters, the limits of explosibility of hydrogen were determined in exactly the same way as with Blaugas.

Lower Limit.—8·9 per cent of hydrogen *did not* explode, whilst 9·7 per cent *did* explode.

Upper Limit.—66·4 per cent *did not* explode, whilst 66·0 per cent *did*.

The range of hydrogen is, therefore, between about 9·3 per cent and 66·2 per cent, that is, a range of 56·9 per cent.

Table of Explosive Limits of Gases with Air.

Results obtained by Edgar Stansfield:—

	Lower Limit.	Upper Limit.	Range.
	% of gas.	% of gas.	
Hydrogen	9·3	66·2	57
Blaugas	5·4	10·4	5

Results quoted in Travers' "Study of Gases" (1901):—

—	Lower Limit.	Upper Limit.	Range.
	% of gas.	% of gas.	
Acetylene	3	82	79
Hydrogen	5	72	67
Carbon monoxide	13	75	62
Ethylene	4	22	18
Methane	5	13	8

Judging from the range of explosibility, Blaugas is an unusually safe gas; but although this is the criterion by which a gas is often judged, a low, lower limit must constitute a grave danger in cases of leaks of the gas into the air of a room. Blaugas has a distinctly low, lower limit. On the other hand, it should be stated that, with no mixture of the gas with air was there at all a violent explosion; the explosion wave travelling slowly and quietly down the tube, as a visible flame. A larger volume of air and gas would doubtless have given a more distinct explosion; but there was a marked difference from the sharp crack obtained with suitable mixtures of air and hydrogen in the same apparatus.

Blaugas has a distinct and characteristic, though not unpleasant, smell; this is an advantage, as with reasonable care leaks of the gas in a room should be detected before enough escaped to form an explosive mixture.

ANALYSIS OF GAS.

A complete analysis of Blaugas would be an extremely difficult matter, as it is evidently a very complex mixture, and the result would be of no practical value.

The normal method for gas analysis consists in treating the gas with a succession of reagents, and determining the volume of gas absorbed by each reagent. The reagents used in analysing the Blaugas were as follows: (1) caustic potash for absorbing carbon dioxide; (2) an alkaline solution of pyrogallic acid, or yellow phosphorus, for absorbing oxygen; (3) a solution of bromine in potassium bromide solution, or fuming sulphuric acid containing 15 per cent sulphur trioxide, for absorbing unsaturated hydrocarbons; and (4) an ammoniacal, or acid, solution of cuprous chloride for absorbing carbon monoxide: the unabsorbed gases consisting of hydrogen, nitrogen, and saturated hydrocarbons, such as methane, etc.

It is claimed for Blaugas that it is non-asphyxiating and non-poisonous. As it contains only a trace of oxygen, the first claim is obviously incorrect; carbon monoxide is the only poisonous gas to be expected, so that the accuracy of the second claim appears to turn on its absence or presence.

Ethylene is the simplest unsaturated hydrocarbon, and is easily removed by bromine or fuming sulphuric acid. The more complex unsaturated hydrocarbons—especially those of the aromatic series—are more difficult to remove, and traces left unremoved are liable to be absorbed by the cuprous chloride solution, and thus appear to be carbon monoxide. As Blaugas is very rich in unsaturated hydrocarbons, some of which are very difficult to remove, the exact determination of carbon monoxide is not easy. Six experiments, in a Randall and Barnhart gas analysis apparatus in which water is the confining liquid, and using bromine to absorb ethylene, etc., gave a mean of 0·92 per cent carbon monoxide. Two experiments in a Bone and Wheeler apparatus—where mercury is used instead of water—using bromine as absorbent as before, gave a mean of 1·04 per cent carbon monoxide; and three experiments in the same apparatus—using fuming sulphuric acid as absorbent—gave a mean of 1·30 per cent.

As a check on the above, a slow stream of the gas was passed through the following purifying train: one wash bottle containing bromine in potassium bromide solution; one wash bottle of alcohol; two U tubes of fuming sulphuric acid; one wash bottle of caustic potash solution, and one U tube with solid caustic potash; the purified gas being collected over mercury and the stream being so slow that not more than 20 c.c an hour passed through. This would appear to be certainly sufficient to remove all carbon dioxide and unsaturated hydrocarbons, and would be liable to remove some carbon monoxide. The resultant gas analysed in the Bone & Wheeler apparatus was shown to be practically free from unsaturated hydrocarbons, but to contain, as a mean of four experiments, 0·24 per cent of carbon monoxide.

Blaugas, when shaken up with a dilute blood solution, gave it a distinct rose tint, and with a stronger blood solution it caused the precipitate, produced by the addition of tannin, to be distinctly redder than that produced from normal blood in the same way. Both the above are characteristic qualitative tests for carbon monoxide.

From the above tests it appears certain that carbon monoxide was present in the sample of Blaugas supplied, and to an extent of not less than one-fourth of one per cent, nor more than one per cent; the lower figure being the more probable.

Carbon monoxide is an extremely poisonous gas, but as Blaugas contains such a small percentage of it the risk from poisoning due to leaks of the gas is negligibly small. A sample of Montreal city gas was found to contain nearly 15 per cent of carbon monoxide. The smell of Blaugas, as already mentioned, adds to its safety. From time to time the gas was allowed to escape into the laboratory, in amounts sufficient to give a very distinct smell, but no ill effects were observed by those in the room.

As Blaugas is liquified in the supply cylinders, it is probable that the composition of the gas will change as the cylinder is emptied, also that at any time the composition of the gas will be different according to the rate at which it is tapped off. This point was not carefully examined, but no marked changes were observed.

RESULT OF ANALYSIS.

	Per cent
Carbon dioxide	0·3
Unsaturated hydrocarbons	53·9
Oxygen	0·4
Carbon monoxide	0·3
Hydrogen, nitrogen, methane, etc	45·1

REPORT ON THE EXPLOSIVES INDUSTRY IN THE DOMINION OF CANADA.

Captain Arthur Desborough, H. M. Inspector of Explosives.

OTTAWA, October 1, 1910.

TO DR. EUGENE HAANEL,
Director of Mines, Ottawa.

SIR:—I have the honour to submit the following report on my investigation of the explosives industry in the Dominion of Canada.

Before offering any criticisms or recommendations, I propose to state briefly the more important principles upon which the British regulations are based; these general principles being, in many cases, equally applicable to the regulation of the industry in the Dominion.

(1) *Authorization of Explosives.*—No explosive may be manufactured in or imported into the United Kingdom for sale until it has been subjected to examination by the chemical advisers of the Explosives Department. It is the duty of these gentlemen to satisfy themselves that the explosive is not unduly sensitive to friction or percussion, and that it also possesses a reasonable degree of chemical stability. Explosives which are found to be of the requisite standard are included in the list of authorized explosives as soon as a license is obtained to allow of their being manufactured or imported.

(2) *Manufacture of Explosives.*—No explosives may be manufactured except in an authorized place. A person, therefore, who wishes to manufacture explosives has to obtain a license. By the terms of his license he is only permitted to erect buildings of a specified construction, on the sites shown on a plan attached to his license. The maximum number of work-persons, and the maximum quantity of explosives allowed to be present in each building are specified, as is also the nature of the operations proposed to be carried on in the buildings. The factory buildings are required to be at certain distances from one another, and certain distances must also be observed from buildings and works outside the factory. The distances are determined by the quantity of explosives allowed to be present in the building. A table showing quantities of explosives and distances was drawn up some years ago from data obtained by noting the damage caused by explosions of known quantities of explosive; suitable interpolations were made to render the application of the table practical. Since the adoption of this system of distances, no member of the general public has been killed, and no dwelling house has sustained any serious structural damage by an explosion in any factory. From recent explosions it appears that the distances are hardly adequate where the explosive involved consists of nitro-glycerine unmixed with other ingredients.

Generally speaking, the buildings in which operations of manufacture are carried out are required to be of light construction, having close joined wooden floors and being lined with wood or other suitable material. I will refer to magazine construction under the head of storage.

No responsibility is taken by the Explosives Department regarding the machinery employed, but in the event of any particular type of machine proving to be dangerous, the question of its discontinuance is taken up with the occupier of the factory.

The maximum number of work people allowed to be present in a building is determined by the nature of the operations carried out in the particular building, and, as a rule, varies from two to six. This number is exclusive of the men employed to convey explosives or ingredients to or from the building and who are essentially non-producers.

I may add that the death rate among the employes has been for a considerable number of years well below 1 per 1,000.

Storage of Explosives.—Magazine licenses are issued by the Home Office for the storage of explosives. As in the case of factory licenses, the terms require that the building should maintain certain distances from the buildings and works depending on the quantity of explosives allowed to be kept. Only half the specified distance need be maintained if the building is screened by substantial earth banks, and if satisfactory screening is afforded by the natural features of the ground the distances are sometimes diminished by 75 per cent. Magazines are almost invariably constructed of substantial masonry or brickwork, as it is considered that if the explosive is of good quality the only dangers to be feared are those which will arise from outside the building. The only objection to this form of construction is, that should an explosion occur in a building not surrounded by earth banks considerable damage may be caused by the projection of heavy debris. In the past thirty years, three magazines have been destroyed by explosions and in no case were any lives lost or surrounding property seriously damaged.

Licenses for the storage of limited quantities (2 tons of gunpowder or 1 ton of high explosive) are granted by the local authorities, if specified conditions as to construction and distances are observed.

Home Office Licenses.—Both factory and magazine licenses are prepared in draft by the applicant in consultation with the Explosives Department. When the draft has been agreed upon, the applicant is given permission by the Secretary of State to lay the draft before the local authority, in whose jurisdiction the proposed buildings are situated, in order to receive their assent. If the local authority give their assent, the draft license is confirmed. If, however, they refuse their assent, an inquiry is held by an officer of the Explosives Department, and the Secretary of State, on receipt of the report, either upholds the local authority or inserts additional terms to cover their objections, or over-rides their decision.

Transportation.—Accidents in transportation are practically unknown and this may be fairly ascribed to the quality of the explosives, the specified method of packing, and the care in handling the traffic. The method of packing and general regulations as to transportation are prescribed in Orders of Secretary of State made under the Act. Railway companies, canal companies, and harbour authorities have, however, to make by-laws regarding the transportation, loading, and unloading of explosives. These by-laws have to receive the sanction of the Board of Trade before they are operative.

Importation.—Only authorized explosives may be imported for sale. A person desiring to import explosives has to obtain an importation license from the Home Office. Before a license is granted he is required to show that he has an authorized place of storage at his disposal. Generally the importer owns licensed magazines, but if not he obtains a certificate from an occupier of a licensed magazine, that sufficient storage accommodation is available for the importation. When the importation is effected, the customs officers take samples which are forwarded for examination and the explosive is deposited in the specified magazines. If the samples are reported on as coming up to the required standard, the explosive is placed at the disposal of the importer. Otherwise, further samples are obtained (if the importer so desires), or the explosive is definitely condemned as being unfit for distribution. In certain doubtful cases the explosive is released, on the importer guaranteeing that it will all be used up in a limited time.

Use of Explosives.—The use of explosives is not governed by the Explosives Act. The use in mines and quarries is regulated by general rules contained in the Mines and Quarries Acts, and by special rules made under those Acts. A Bill was introduced into Parliament last year giving the Secretary of State power to make regulations regarding the use of explosives in construction works, but, owing to the large amount of other legislation before the House, the Bill was dropped.

Home Office Testing Station.—The station was established in 1897 under a section of the Coal Mines Regulation Act, 1896, and the work carried on there must not be confused with the purely chemical work of the chemical advisers of the Explosives Department. The station is used for testing explosives for use in coal mines where danger is to be feared from fire-damp, or coal dust. The test consists in firing charges from a cannon into a chamber filled with an explosive atmosphere of air and coal gas. The details of the test are about to be considerably modified and for this purpose a new apparatus is being erected in the north of England. Only authorized explosives may be submitted to the test and the names of those which have passed this test and the conditions under which they may be used are published from time to time in an Order of the Secretary of State. These explosives are known as Permitted Explosives.

Explosives Industry in the Dominion.

I have had the opportunity of visiting the majority of the more important factories. As was to be expected, the standard of precautionary measures against accidents varied considerably. Any criticism I may make must not be considered as being directed against any particular factory, as I purposely avoided making a detailed inspection of any one plant, feeling that with the very limited time at my disposal, the utmost I could do would be to obtain a general impression as to the conditions under which explosives were manufactured.

As regards the quality of the explosives, I will defer comment until I discuss the question of use, as the only information I have obtained was gained in course of conversation with the users of explosives.

Most of the factories appear to suffer from the defect of having been started in a small way and then added to as business expanded. Had the probability of expansion been recognized at the commencement, there is little doubt but that the buildings would have been placed in more suitable positions and overcrowding thus avoided. In some instances the quantities in the buildings were considerably greater than the distances from other buildings would allow. This was sometimes due to the fact that explosive which had been operated on was allowed to remain in a building while a second batch was being operated on and a third was being brought into the building. As a general principle, a batch of explosives should be removed from a building as soon as it has been operated on; if the building in which the next operation is to take place is not available, it should be placed in an expense magazine situated at a suitable distance. The chief danger of explosion must of necessity be with the explosive which is being operated on; it is, therefore, unwise, to say the least of it, to expose a second or third batch to the certainty of communicated explosion. In other cases the excessive quantities were due to overcrowding of the factory buildings.

The actual operations of manufacturing nitro-glycerine appear to be generally carried out in one building, owing to climatic conditions, and this entails the accumulation of large quantities, sometimes amounting to over five tons, in one building. The majority of the factories have only one nitrating plant, and I think manufacturers should consider whether it would not be advisable to install a second plant, which could be used alternatively, and thus prevent such large accumulations in one building. An explosion in a nitrating plant must put a factory out of action for some considerable time, unless there is a duplicate plant available.

In some factories there were too many cartridge packing machines in one building. The objection to this practice does not lie in the number of machines but in the large number of men who must be present in the buildings to attend to the machines. In one instance, all the machines in the factory were under one roof, and no less than 15 men were present. Apart from humanitarian objections to the exposing of so many lives to one risk, I am strongly of opinion that it is economically unwise to concentrate all the cartridge packing in one building. I understand that in one factory last year 11 lives were lost, due to explosions which occurred in the packing house. This number exceeds the annual average number of deaths in all the explosives factories in Great Britain. Generally speaking, there appears to be a tendency to allow unnecessary articles to accumulate in danger buildings. The object of the manufacturer should be to reduce the number of movable implements to the minimum. When it is remembered that a thin layer of most explosives can be exploded by a blow from a comparatively light weight falling a distance of a few feet, the importance of this point will be realized. I may mention in this connexion that I have more than once witnessed the experiment of a thin layer of gunpowder spread on a wooden floor being ignited by a glancing blow from a wooden broom stick.

The presence of iron hammers and other tools is also objectionable. When they are required, they should only be used by a responsible person and should be removed as soon as they are no longer wanted.

Greater care should be exercised to prevent grit getting into the explosive and also to prevent explosive from lodging in crevices in the walls and floors of buildings. The iron framework of machines should be painted to prevent the detachment of rust, which is otherwise almost certain to find its way into the explosive.

I do not think that manufacturers pay sufficient attention to details, and it is only by studying details that it is possible to make the manufacture of explosives relatively safe. Apart from the risk of spontaneous decomposition, which may arise on rare occasions during the manufacture of nitro-glycerine, there is the risk of spontaneous decomposition from explosive dust settling on heating pipes and being left there, and from accumulations of explosive in cracks and crevices. With reasonable precaution these latter risks should be practically non-existent. The heating pipes should be so placed that they are readily accessible to inspection and the walls should be lined with a suitable material; the floor, if not close joined, should also be covered. I understand that rubberoid has been employed both as a lining for the walls and a floor covering by several manufacturers with excellent results.

Another risk to be guarded against is the ignition of a thin film of explosive by a blow. As I have already stated, as few movable articles as possible should be present in a building. When it is remembered that most explosives when heated are much more sensitive to friction or percussion, special precautions should be taken in drying houses to eliminate this risk, and I think that the explosive should be allowed to cool down to the normal temperature before it is handled or the drying racks removed.

Grit mixed with explosive renders it far more sensitive; precautions should, therefore, be taken to prevent its introduction either by the work persons themselves, or by its adhering to boxes and packages brought into the building. It is impossible to prevent a certain amount of grit entering a building, and this grit will, of necessity, be mostly present on the floors of the buildings; it is important, therefore, to minimize the quantity of explosive spilt on the floor and also to have the floors swept periodically.

In buildings in which explosion is likely to be preceded by fire it is especially necessary to provide adequate means of escape for the work people, and care should be taken that the exits are not blocked by boxes or packages.

Sufficient forethought does not seem to be paid to the wiring of the electric light system. Apart from the dangers of ordinary wear and tear, there is always the risk that the concussion caused by an explosion in a neighbouring building may so dislocate the wiring as to cause a fire.

Storage of Explosives.

I have not had the opportunity of visiting many magazines. In most instances the distances maintained from other buildings were inadequate, owing to the large quantities stored. I cannot help thinking that it would be wiser to erect a greater number of buildings and to store in each smaller quantities of from 25 to 50 tons.

In some instances I found packages of damaged explosive which had been returned by the users. Damaged explosive should be destroyed, as, if left in a magazine, it is liable to be overlooked and if of the nitro-compound class may ignite spontaneously.

Transportation of Explosives.

My attention was drawn to two instances of the transportation of explosives by water, which I think are deserving of comment. In one case, after over 100 tons of dynamite had been loaded into a vessel, a number of cans of gasoline were placed on top of the explosive. Highly inflammable and volatile liquids, such as gasoline, should not be transported with explosive. In another instance, cargoes of explosive were habitually conveyed in a gasoline launch. I do not think it can be claimed that gasoline launches have reached such a state of perfection that the possibility of fire can even be regarded as remote. If such a launch caught fire in a crowded harbour, the result would be disastrous.

Use of Explosives.

In the course of conversation with the users of explosives I have frequently been told that the quality of the explosives manufactured in the Dominion leaves much to be desired. It was asserted that no two charges fired in similar circumstances would do the same amount of work. Except so far as shot firing in coal mines is concerned, I do not think this unevenness of explosive can be said to be a positive danger, apart from the production of an unnecessarily large volume of deleterious gases from an overcharged shot. In the case of coal mines, where there is risk of igniting gas or dust, the danger is very appreciable. A miner will always gauge the weight of his charge by the weakest shot he has fired and the tendency will always be to overcharge. The gases produced from the surplus of explosive not having any work to do will not cool down rapidly, and should they come in contact with fire-damp or coal dust in suspension would probably cause an ignition. It is imperative, therefore, that steps should be taken to ensure an even quality of explosive for use in coal mines.

A thin film of explosive on the exterior of a cartridge, a state of affairs which I frequently noticed in the buildings in which cartridges were being packed into boxes, can hardly be conducive to safety in ramming. In the absence of specific information as to the accidents which occur from the use of explosives, I do not feel that it is possible for me to offer any further comments.

It will not be out of place, however, to give a word of warning as to the misleading effects of demonstrations of the safety of explosives. These experiments generally consist in burning a cartridge in the open or throwing a small quantity on to a fire. Such experiments can generally be performed with blasting explosives without risk. The behaviour of the explosive when confined in a bore hole or when ignited in bulk so that a certain amount of pressure is generated would be a much more reasonable test; but such experiments would not suit the demonstrator as they would be much more likely to result in an explosion. I may instance the case of many of the ammonium nitrate explosives, which are very difficult to ignite in the open, and when thrown on a red hot sheet of iron merely melt, but which in the confinement of a shot hole have been found, under certain conditions, to burn fairly readily until sufficient pressure is set up to cause the unburnt portion to explode.

It cannot be pressed too strongly upon the user of explosives that the function of an explosive is to explode, and that, no matter what assertions are made by an interested person as to the safety of his explosive, all explosives should be regarded as dangerous.

Recommendations.

In the following pages I have acted on the assumption that the Dominion Government has the power to legislate on these matters.

It is not possible for me to mention in detail all the points which I think should be included in the draft bill which is in course of preparation. I propose, therefore, under the above heading to discuss shortly some of the more important provisions which should be included in the proposed legislation and also to offer some suggestions on matters which, though they do not come directly within the scope of the bill, are of sufficient importance to warrant my commenting on them.

The following are the essential points which I propose to discuss:—

1. Authorization of explosives.
2. Licensing of factories.
3. Control of storage not otherwise provided for.
4. Control of transportation not otherwise provided for.
5. Control of importation.
6. Inspection and sampling.
7. Establishment of chemical laboratory and testing station.
8. Investigation of accidents in factories.
9. Investigation of accidents in storage, transportation, and use.
10. Appointment of staff.

(1) *Authorization of Explosives.*—I think the system in Great Britain should be adopted. It will undoubtedly improve the quality of the explosives manufactured in the Dominion and should thereby have a tendency to diminish accidents in use; it must not be expected, however, that fool-proof explosives will ever be produced. It will also prevent the user being at the mercy of the enthusiastic inventor who persuades him to try a new explosive which has probably been invented many years previously and then discarded on account of its danger or unsuitability.

(2) *Licensing of Factories.*—Factories should be licensed on the principle of limiting the amount of explosive allowed to be present in a building, in accordance with the distances that the building can maintain from the other buildings in the factory, and buildings and works outside the factory. Limitations should also be assigned as to types of construction adopted, the number of work persons allowed to be present, and the nature of the operations to be carried on in the various buildings. If these points are enforced in a reasonable manner, I do not think that manufacturers will find their trade unduly hampered.

As regards existing factories, I do not think the occupiers should be required to immediately conform to the new system, but that a definite time limit should be assigned, so as to admit of the change being made gradually. If, however, there happen to be particular buildings in a factory, which constitute a very definite menace to the public safety by reason of their proximity to a city, I think the occupier should be required either to remove the building forthwith, or to reduce the quantity of explosive in the building, so as to diminish the danger zone. It is not possible to lay down a hard and fast rule and each case chould be considered separately and treated on its merits.

(3) *Control of Storage.*—The special points to which attention should be paid are the situation, quantity of explosive, and construction. The first and second should be governed by the table of distances. As regards the third, two somewhat antagonistic features have to be considered. First, the building should be protected from dangers from without, such as rifle bullets, and should have security against unlawful entry and fire. Second, in the event of an explosion occurring the projection of heavy debris should be minimized; this feature is probably of greater importance in the Dominion than it is in Great Britain, owing to the fact of the large number of frame dwelling houses which are to be found here, whilst they are almost non-existent in the latter country.

The ideal construction for a magazine would be to have a relatively lightly constructed building, surrounded by substantial earth banks; but it is difficult to make this type reasonably secure against unlawful entry and other dangers from without. It must always be remembered, however, that with the system of the authorization of explosives there should be little risk of the explosive igniting spontaneously, and as no operation should be carried on in a magazine the principal danger of explosion comes from causes outside the building. The results of some experiments carried out in Germany were recently published and the conclusion arrived at by the experimenters was, that a certain type of reinforced concrete gave the best result. It was found that with the particular form of construction very little debris was projected when an explosion occurred in the building, as the concrete was so pulverized that the fragments did not carry any great distance. If funds are available, it would be of considerable value to have experiments carried out on similar lines with buildings constructed to suit Canadian requirements.

In Great Britain there is a statutory requirement that every magazine should be fitted with an efficient lightning conductor; there are, however, no suggestions given as to what constitutes such a conductor. As I understand that parts of this country are frequently visited by severe electrical storms, I think the question of protecting magazines from lightning should be considered. I would venture to suggest that the scientific staff of some of the Universities and representatives of the explosives manufacturers should be invited to co-operate with your Department to inquire into the most efficient and economical system of securing the necessary protection. There is a system of storage in Great Britain, which I have not met with in the Dominion, but which might be found of use where the climatic conditions will admit of it. In the rivers Thames and Mersey vessels are moored at places specially selected by the Harbour Authorities, and these vessels are licensed by the Home Office as Magazines. Where there is a considerable water-borne trade, the use of such vessels as distributing centres might prove of advantage.

(4) *Control of Transportation.*—The control of transportation by rail is in the hands of the Railway Commissioners, and the only way in which the proposed legislation will affect this method of transportation will be as regards the quality of the explosive conveyed. I understand that the regulations adopted by the Commissioners are those promulgated by Col. Dunne's bureau in New York. The great value of these regulations has been amply proved; but being a private concern there are not the same facilities for maintaining the standards of quality of the explosives as will be the case when the authorization of explosives is in the hands of the Government.

I understand that at present it is practically impossible to transport legally small quantities of explosive by rail. It is generally certain that this traffic is carried on, probably in passenger trains, and with detonators and blasting explosive packed together. I would venture to suggest, therefore, that your Department should approach the Railway Commissioners, with a view to discussing the question of recognizing and controlling the transportation of small quantities. I may mention that in Great Britain the railway companies have agreed to transport small quantities of explosive in cars loaded with other freight, when packed in a special manner.

As regards transportation by water or road, I think power should be included in the bill to regulate generally the method of stowage, the method of packing, the limiting of the nature of freight which may be transported with explosives, and the limiting the quantity of explosive transported at any one time, according to the nature of the vessel or vehicle in which the transportation is being effected.

(5) *Importation.*—Before any explosive is imported into the Dominion for sale or use, a sample should be submitted for authorization. The terms of the license for subsequent importations should require the importer to have at his disposal a licensed place of storage, in which the explosive would be detained until the chemical department have satisfied themselves by examination of the samples taken by the Customs that the explosive is of the requisite standard.

(6) *Inspection and Sampling.*—I need only remark that when a factory or magazine has been licensed it is necessary that they should be periodically inspected, to ascertain that the terms of the licenses are being complied with. Similarly, it is essential that after an explosive has once been authorized, samples should be periodically examined to see that the manufacturer is maintaining the required standard. Most explosives deteriorate in quality and chemical stability after prolonged storage. It is necessary, therefore, to obtain samples not only from factories and distributing magazines, but also from magazines in the occupation of the users of explosives. I have reason to believe that the Provincial authorities will be glad to co-operate with your Department in this respect.

(7) *Establishment of Testing Station.*—Apart from the chemical laboratory, which will be in the hands of the chemical advisers of the explosives department, it will be necessary to establish a station for the testing of explosives for use in coal mines. I understand that it is also considered desirable to erect an apparatus for testing types of safety lamps. I would suggest, however, that before deciding on the final details of the tests it would be well to await the conclusion of the experiments which are shortly to be carried out in Great Britain. It may be of interest to state that the Home Government have not contemplated instituting an

official test for the so-called rescue apparatus. The word 'rescue' appears to give the general public the idea that after an explosion has occurred in a coal mine it is only necessary for men wearing these breathing apparatus to enter the mine, to enable them to rescue the unfortunate miners who have been exposed to the effects of the explosion and the deadly effect of after damp. I think the more reasonable view to hold as regards the practical utility of breathing apparatus is that their chief scope lies in the direction of coping with fires below ground in the early stages, and it is only in the sense of preventing the spread of a fire which would endanger the lives of those present in the mine that the term 'rescue' can be applied to them.

Apparatus should be installed at the testing station to enable comparisons to be made between the kinetic energy of different natures of explosives and also to determine the velocity of detonation of explosives. Information on these two points should prove of value to the users of explosives, to enable them to select the explosive most suitable for the work which they are undertaking.

(8) *Accidents in Explosives Factories.*—It is of the utmost importance that the explosives department should have full information regarding all accidents which occur in factories either by fire or explosion, even when no personal injuries are sustained. It is often from an accident in which no persons are injured that the most valuable information can be derived. I think that it should be obligatory for the occupiers of factories to report as soon as possible all such accidents, and to leave things untouched as far as is practicable, in case it should be deemed advisable to have the circumstances of the accident investigated by an official of the department.

(9) *Accidents in Storage, Transportation, and Use.*—Accidents which occur by fire or explosion in the storage and transportation of explosives should also be brought to the notice of the department; in those cases in which the storage or transportation comes under the control of the new Act, it may be desirable to have an inquiry held by an official of the department. In other cases, the co-operation of the Provincial Governments and the Railway Commissioners should be sought, in order to obtain as complete a record as possible of such accidents. Doubtless, the Provincial Inspectors of mines will be willing to inform the new department of the results of their investigations. As regards accidents in transportation by rail, the services of an inspector of explosives should be placed at the disposal of the Railway Commissioners, should they so desire it, to assist in carrying out investigations.

By far the larger number of accidents which occur with explosives arise from their use; it is of the utmost importance that all accidents occurring when the explosives are in use should be thoroughly investigated and classified. I have reason to believe that the Provincial Inspectors of Mines will be willing to co-operate with the department by forwarding accounts of accidents occurring in the mines under their jurisdiction. I understand, however, that a large number of accidents occur in works where there is no legislation affecting the use of explosives. I think it would be advisable for the Minister of Mines to take power in the proposed bill to frame rules to regulate the storage and use of explosives in such works, to require the reporting of accidents, and to have investigations made when such a course appears necessary.

It may be of interest to summarize the causes of the more frequently occurring accidents which arise from the use of explosives in mines, quarries, and construction works in Great Britain.

1. *Prematures.*—Often due to the use of short or bad fuse, or the use of straws and squibs to ignite the charge. May arise from a man attempting to light too many shots and thus being unable to take cover.

2. *Hang-fires.*—Often due to irregular fuse, or the ignition of explosive, which burns until sufficient pressure is set up to cause it to explode; this may be due to inferior quality of explosive or a weak detonator. Sometimes due to miscounting shots and returning too soon.

3. *Electrical Prematures.*—Generally due to the shot firer allowing another man to connect the detonator leads to the firing cable, which has been previously attached to the battery.

4. *Ramming.*—Due to frozen nitro-glycerine explosive, broken cartridge leaving a thin film of explosive in the bore hole. Cartridge sticking in the bore hole and being violently forced home. It is of the utmost importance that no explosive which is unduly sensitive to friction or percussion should be authorized for use.

5. *Striking Unexploded Charge when Removing Debris.*—Generally due to frozen nitro-glycerine explosive, or to weak detonator which fails to cause propagation of detonation through all the cartridges, or to the cartridges becoming separated by a layer of dirt in the shot hole.

6. *Boring into a Missed Shot.*

7. *Tampering with a Missed Shot.*

8. *Not Taking Proper Cover.*—In the case of electrical firing generally due to use of too short a cable.

9. *Fumes.*—Either due to defective ventilation, men returning too soon, or ignition instead of detonation of high explosive. The gases evolved by burning nitro-glycerine explosives are very poisonous. The burning may be originated by weak detonator or inferior quality of explosive.

10. *Preparing Charges.*—Generally due to frozen nitro-glycerine explosive, unduly sensitive explosive, recklessness, or lack of skill.

11. *Ignition of Explosive by Spark.*—Principally confined to gunpowder, where open lights are used below ground.

12. *Socketting or Springing.*—Due to re-charging before sufficient time has elapsed.

13. *Ignition of Fire-damp or Coal Dust*—Apart from the quality of the explosive, generally due to the firing of two shots, one after the other, without examining for gas after firing the first shot. The firing of overcharged shots is perhaps the more usual cause.

It may be of interest to state that during 1909 over 30 million pounds of blasting explosives were used in mines, quarries, and construction works in Great Britain, and that (exclusive of fatalities from explosions of fire-damp or coal dust) 53 lives were lost thereby.

Staff of the Explosives Department.—The technical staff of the new department should, I think, consist of a Chief Inspector, two Inspectors, and a Chemist. I cannot state too emphatically that the Chief Inspector should have sufficient technical knowledge not only to enable him to administer what must of necessity be a very technical act, but also to deserve the confidence of the explosives manufacturers. As men possessing such qualifications are rare, I would venture to suggest that it would be very unwise to attempt to economize by offering an inadequate salary. As regards the two inspectors, it will hardly be possible to obtain the services of technically qualified gentlemen, and I think it would be sufficient if these gentlemen possessed practical experience of the use of explosives, one of them at least having gained his experience in coal mining. In assigning their salaries, the fact that their work must of necessity be somewhat hazardous should not be lost sight of.

The responsibility of the chemical adviser to the department will be considerable, as in his hands will rest the recommendation for the acceptance or rejection of explosives. When it is remembered that the authorization of an explosive or otherwise, or the condemnation of a batch of explosive which has been issued from a factory may involve large financial interests, it is hardly necessary for me to point out that this gentleman should be possessed of the highest technical qualifications and integrity. The salary of the chemical advisers of the Home Office is entirely dependent on fees; but it would be far preferable if the chemist of the new department were paid an adequate salary so that his whole time should be at the disposal of the government.

It will be necessary to employ a mechanic at the Testing Station, who will be competent to carry out minor repairs to the apparatus, and who would assist in carrying out official tests and experiments. He should also be responsible for the care of explosives stored in the magazine and for apparatus and stores used in connexion with the Testing Station.

I have the authority of Major Cooper Key, His Majesty's Inspector of Explosives, for stating that he will be glad to afford facilities for any person who may be appointed as an Inspector to be attached to the Explosives Department of the Home Office, to enable him to get an insight into the administration of the Explosives Act, and the methods adopted for the testing of explosives for use in coal mines. Major Cooper Key also states that he would be glad to make arrangements for the chemical adviser of the new department to work in the laboratory of Messrs. Dupré, who are the chemical advisers of the explosives department. I would strongly urge that these facilities be taken advantage of.

If my proposal as to the regulation of the use of explosives be adopted, I would suggest that two or three gentlemen be appointed as assistant inpectors, whose duty would be confined to the administering of these regulations. Their principal functions would be to endeavour to educate the users of explosives by means of lectures and practical demonstrations to avoid the misuse of explosives, and also to investigate any accidents which might occur.

I have the honour to be,

Sir,

your obedient servant,

A. Desborough, Capt.,

H. M. Inspector of Explosives.

MEMORANDUM.

Magazine Construction Committee.

The Committee should consist of a member of the Mines Department, a representative of the Militia Department, a representative of the Public Works Department, and two members of the explosive trade.

The object of the Committee would be to test different natures of construction by exploding from a half to one ton of explosive inside each building, and noting the distance to which the débris is projected.

The Committee should satisfy themselves that each building is reasonably secure against unlawful entry.

I would suggest that the explosive be invariably stacked at one end of the building, so as to leave as great an air space as possible from the other end. This point is especially important where the construction is of concrete.

The types of construction which might be experimented with are as follows:—

1. Expanded metal and cement plaster.
2. German special re-enforced concrete.
3. Log magazine.
4. Any type which the Committee suggest.

I think the attention of the Committee might be directed to the possibility of the expanded metal being carried above the roof, and also being grounded to form an economical system of protecting from lightning.

Transportation of Liquid Nitro-glycerine by Road.

Mr. Lowry, at the recent conference, raised this point with regard to the use of liquid nitro-glycerine in opening oil wells.

When nitro-glycerine was first used on a commercial scale, it was invariably transported in the liquid state. In consequence of the large number of accidents which occurred, the practice was prohibited in all European countries. Alfred Nobel then absorbed the liquid in an infusorial earth, solely with the view of rendering its transportation reasonably safe, and with the intention of extracting the nitro-glycerine by a process of displacement by water when it had been transported to the place at which it was required to be used. He found, however, that for ordinary blasting purposes it was not necessary to use the nitro-glycerine as a liquid, and he called the plastic explosive dynamite. I have been told that it is essential to use liquid nitro-glycerine in opening oil wells, but I do not know if this practice is universal. If it is absolutely necessary to do so, I think that at any rate the nitro-glycerine should not be transported as a liquid but as dynamite. In Great Britain dynamite No. 1 is defined as a mixture of not more than 75 parts of nitro-glycerine absorbed in kieselgur.

A factory license could then be granted to allow of the nitro-glycerine being displaced in the immediate neighbourhood of where it was intended to be used; the operation to be effected in a definite building and to be under proper control and supervision.

Testing Station and Chemical Laboratory.

I attach to this paper a rough specification of the testing gallery which is being erected in England. The sketch drawings mentioned in the specification have been omitted, as there was not time to have copies made before I left England.

The ballistic pendulum is shown in detail on the plan furnished herewith. I may mention that the bob of the pendulum consists of a 13″ mortar, weighing 5 tons.

I have not yet received plans of the gun which it is proposed to use in England.

It will be necessary to erect an observation chamber at least 15 yards from the gallery. The front wall should be substantial, and fitted with narrow horizontal windows, suitably protected against the possible, but very remote, chance of a disruptive explosion in the gas gallery.

It will also be necessary to provide several sheds, or a shed divided into compartments, to be used as a safety lamp room, oil store, coal store, coal dust disintegration. Two small magazines should also be erected for the storage of explosives awaiting test, and for detonators.

Narrow gauge rails will have to be laid for use in connexion with the gas gallery and pendulum. It would be convenient if the rails were so arranged that the guns in use could be shifted from the gallery to the pendulum, or vice versa, as required.

At the station in England it is proposed to install a gallery for testing safety lamps, but the details have not yet been settled. The general idea is that the explosive atmosphere will be prepared in the explosives testing gallery, and that a branch gallery of small sectional area will lead from the big gallery through the lamp testing chamber back of the gallery.

The estimated cost in England of the above is £3,000, but I would suggest that a second gun be obtained (cost about £600). These guns are manufactured in the Royal Arsenal, Woolwich.

As far as the chemical laboratory is concerned, the only special feature to be attended to is the provision of a separate compartment, or a small detached building with a north light, in which stability tests will be carried out. It is essential that the atmosphere in which these tests are carried out should not be contaminated with acid fumes.

A very small detached shed of a few cubic feet capacity should be erected to store samples of explosive submitted for chemical examination. It is not advisable to store these samples in the testing gallery magazine, as they will doubtless often be of low chemical stability.

I attach a rough sketch of the disposition of the new apparatus in England.

(Signed) **A. Desborough,** Capt.

COLLECTION OF DATA ON EXPLOSIVES INDUSTRY, AND REPORTS ON ACCIDENTS IN MINES AND EXPLOSIVES FACTORIES, ETC.

I.

Joseph G. S. Hudson, M.E.

In compliance with instructions, I proceeded to collect and compile data and information necessary for the preparation of a draft Bill, as the basis of legislation for regulating the manufacture, importation, and testing of explosives in Canada.

This work necessitated visiting the principal explosives factories now in operation throughout the several provinces; interviewing the departments of the Provincial mining bureaus; and the explosives, mining, and transportation interests in the Dominion.

On July 22, 1910, Captain A. P. H. Desborough, one of His Majesty's Inspectors of explosives for Great Britain—who, at your request, was loaned by the British Government, to make a report on the explosives industry of Canada—arrived in Ottawa.

After several consultations, as to the general scope of the proposed legislation to regulate the use of explosives in Canada, I received instructions to accompany Captain Desborough on a tour of inspection: to visit the representative explosives factories and principal mining districts; so as to give him an opportunity of personally investigating conditions as they exist in Canada. This inspection was to terminate before the expiration of Captain Desborough's leave of absence, allowing time for a conference to be held in Ottawa, at which the representatives of the explosives and mining interests would have an opportunity of hearing, and discussing the recommendations which he proposed to submit in his official report.

With this object in view, the following explosives factories were visited in the Province of Quebec:—

The high explosives factory at Beloeil, and the black and sporting powder factory at Windsor Mills—both of these plants being operated by the Hamilton Powder Company; the high Explosives and black-powder factory at Isle Perrot, near Vaudreuil—owned by the Standard Explosives Company of Montreal; the dynamite factory at Lavigne—operated by the Northern Explosives Company; the rack-a-rock explosives factory at Sherbrooke; the fulminate of mercury at Capelton; and the Dominion Cartridge Company's factory at Brownsburg; where ammunition cartridges, and electric and explosive detonators are manufactured.

After inspecting the Quebec factories, magazines, and principal coal mining districts of British Columbia, we proceeded direct to Victoria, so that the Honourable, the Minister of Mines—W. Templeman, Esq., M. P.—might have an opportunity of discussing with Captain Desborough, the main features of the proposed Explosives Bill.

Interviews were obtained, while in Victoria, with the Honourable Richard McBride, Premier and Minister of Mines of British Columbia; Mr. Wm. Fleet Robinson, Provincial Mineralogist; and Mr. Francis Shepherd, Chief Inspector of Mines for that Province. At these interviews the proposed Federal legislation to regulate the manufacture, importation, and testing of explosives was discussed, and the co-operation of the Provincial Mining Bureau obtained.

We also inspected the following explosives factories, namely—the Hamilton Powder Company's plant at Northfleet bay, near Nanaimo: where they manufacture high explosives, black-powder, and Monabel powder; the last named explosive is on the "*Permitted List*" of Great Britain. The Hamilton Powder Company are manufacturing Monabel powder, under direct control of the Nobel Explosives Company, Glasgow, Scotland: for use in the gaseous and dusty coal mines of British Columbia.

The Grant Powder Company's factory—situated at Telegraph bay, near Victoria—was visited. This factory does not make any explosives other than dynamite in its several percentages.

The newly established explosives plant of the Western Explosives Company—a branch of the Standard Explosives Company—situated on Boon island, Howe sound, 16 miles from Vancouver, was also visited. At this factory, dynamite and black-powder are manufactured.

Under special instructions from the Honourable the Minister of Mines, representative coal mining districts were to be visited in British Columbia to allow Captain Desborough to have an opportunity of personally discussing the proposed Explosives Bill with the coal operators; particularly the regulations which would be framed, and the tests made, for powders to be placed under the "*Permitted List.*"

Consequently, Bankhead, near Banff, Alta., and Fernie, B. C., were selected for inspection, and the question of "*Permitted Explosives*" was thoroughly discussed with the mine inspectors and officials at these places. The large, distributing explosives magazine of the Hamilton Powder Company, situated at Kootenay lake, near Nelson, British Columbia, was also visited, and the question of distribution, storage, and transportation of explosives from central points was inquired into.

Cobalt was also visited: as being a representative hard rock mining district. While in this district several storage explosives magazines were inspected, and the subjects of storage, transportation, and testing of explosives were discussed with the president of the Timiskaming Mine Managers' Association.

On returning to Ottawa, we proceeded to the Province of Nova Scotia, and visited the coal mines at Glace Bay, Sydney Mines, and Stellarton, and had interviews with the management of the several coal companies, and representatives of the Provincial Workman's Association; who all expressed the opinion that, the proposed Federal legislation regulating the manufacture and importation of explosives was absolutely necessary, and that the establishment of an Explosives Testing Station at Ottawa, under the supervision of the Mines Branch of the Department of Mines, had become necessary, in order to safeguard the men employed in coal and metalliferous mines, and on railways, and other construction works in Canada.

On leaving the coal districts of Pictou and Cape Breton, it was deemed advisable to interview, at Halifax, the Deputy Commissioner of Mines, and Attorney-General of the Province, with regard to the proposed legislation.

The works of the Acadia Powder Company, situated at Waverley, near Halifax, Nova Scotia, were visited. At these works dynamite, black-powder, detonators—both fuse and electrical—are manufactured.

After leaving Halifax, we stopped over on our way back to Ottawa, at Montreal, to interview the heads of the railway departments of the Grand Trunk and Canadian Pacific railways, relative to the transportation of small quantities of explosives on regular trains. This question was taken up in order to safeguard the public; since it is a well-known fact that, in the mining districts where prospecting and assessment work is being performed, quantities of explosives are illegally carried in suit cases and dunnage bags. It is, therefore, proposed that the railway companies shall provide special boxes, of a pattern authorized by the Explosives Division of the Mines Branch, and the Board of Railway Commissioners for Canada: so that small quantities of explosives may be shipped by regular freight trains, and without excessive freight rates; and thus remedy the present dangerous method of carrying explosives clandestinely.

The railway officials acknowledged that this would be a move in the right direction, and promised hearty co-operation with the Explosives Division of the Mines Branch, in carrying this proposed rule into effect, when the Explosives Bill is passed.

Interviews were held at Toronto with the Deputy Minister of Mines for the Province of Ontario, with respect to the application of the proposed Federal legislation; who promised co-operation with the Federal Department of Mines in carrying out the proposed regulations within their jurisdiction.

The fireworks factory at Hamilton was also visited, and many matters discussed with the management relative to the application of the proposed Explosives Act; particularly to the class of fireworks used, and explosives imported, by the railway companies of Canada for *signalling purposes.*

At Kingston, we met by appointment the management of the Ontario Powder Company, and also visited the detonator factory at Arnprior.

Two explosions of explosives—attended with serious loss of life, occurred in close proximity to the city of Ottawa, during the year; and a very disastrous coal mining accident occurred on the 8th of December, 1910, at Bellevue mine, near Frank, in the Province of Alberta, which resulted in 31 men losing their lives. Pursuant to instructions, I attended the inquests in connexion with each of these disasters, and have made detailed reports thereon. (See pages 137, 140, and 144 respectively.)

"Virite" Explosion at Hull, Que.—View showing evidence of the force of the blast caused by explosion.

View showing disruptive force due to concussion.

Remains of magazine after explosion.

Plate XI.

View showing direction of projected stone through house.

Plate XII.

View showing direction of projected stone through house; which killed two persons sitting on door step.

View showing path of stone into slanting roof and out through gable end.

View showing where stone struck house and rebounded: killing one person and injuring another.

Plate XV.

House 1,500 feet from magazine: where two girls were killed.

Plate XVI.

Rear of house: showing stones which killed the two girls.

CANADA
DEPARTMENT OF MINES
MINES BRANCH

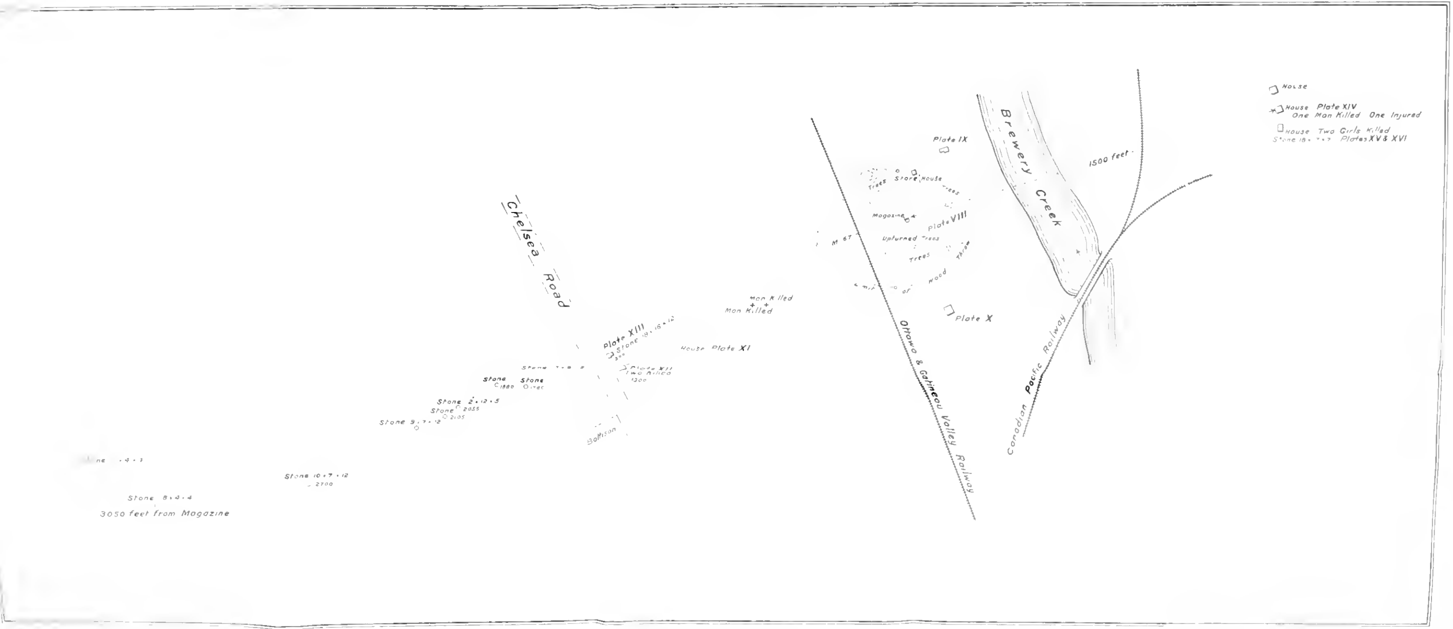


Fig. 1

[illegible] Explosion of a [illegible] Magazine at Hull Province of Quebec, on Sunday, May 8, 1910

II.

REPORT ON EXPLOSION OF "VIRITE" AT THE WORKS OF THE GENERAL EXPLOSIVES COMPANY, LIMITED, HULL, QUEBEC, MAY 8, 1910.

The General Explosives Company, Limited, was incorporated as a company in the Department of the Secretary of State for Canada, on the 4th day of July, 1905.

As stated in the letters of incorporation, the object of the Company is: "To carry on the business of manufacturing explosives of every description: gunpowder, nitro-glycerine, dynamite, gun-cotton, blasting-powder, or other like substances or things, and of purchasing, selling, and generally dealing in explosives and all materials, substances, and things, required for or incidental to, the manufacture, preparation, adoption, use, or making of explosives, or the packing, storing, firing, or disposition thereof."

On the 11th day of November, 1908, the following trade mark was registered in the Department of Agriculture, Ottawa:—

"I, Ernest Arthur LeSueur, a citizen of the Dominion of Canada, and resident of Ottawa in the county of Carleton and Province of Ontario, do hereby request you to register in the name of myself a specific trade mark to be used in connexion with the sale of explosives, which I verily believe is mine on account of having been the first to make use of the same.

"I hereby declare that the said specific trade mark was not in use to my knowledge by any other person than myself at the time of my adoption thereof. The said specific trade mark consists of the word 'VIRITE.' Trade mark No. 13203."

The plant of the General Explosives Company, Limited, was situated within the corporated limits of the city of Hull, in the Province of Quebec; being located on a strip of land 500 to 600 feet in width, lying between the main line of the Canadian Pacific railway, and the line of the Ottawa and Gatineau Valley railway (the magazine which exploded being within 250 feet of the last-named railway) on a back water of the Ottawa river known as Brewery creek, about one-half mile north of the Hull railway station.

The plant consisted of a watchman's shack, mixing and packing-house, office building (which was also used for storage purposes), soda dry house, chlorate of potash storehouse, and stone masonry magazine.

About 5 p.m. on Sunday, May 8, 1910, the shack occupied by the watchman (who was at the time absent) was observed to be on fire, and in a very short time the fire was communicated to other buildings.

About forty minutes after the first indications of fire were observed, a slight explosion occurred. As to the precise quantity of explosives exploded at this time it is uncertain, as no definite record could be obtained; but it was ascertained that a large quantity of detonators were stored within a few feet of the main magazine. A very short time after the first explosion was heard, a second explosion occurred, accompanied by great violence, and disruptive force: the stones from the magazine being propelled for a distance of 3,050 feet in one direction and over 1,500 feet in the opposite direction: killing ten persons, injuring twenty, and destroying valuable property.

It is stated that, at the time of the explosion, the magazine contained 9,500 pounds of manufactured "virite," packed in 50 pound boxes.

Late on the previous Friday, 20,000 pounds of this same explosive had been shipped, which was fortunate, for if this total quantity had exploded, the loss of life and damage to property would in all probability have been enormous.

The explosive named "virite," as manufactured by the General Explosives Company, Limited, is a chlorate of potash compound.

The magazine in which the explosion took place was of stone construction, the walls being nearly 2 feet in thickness.

The magazine was licensed by the Provincial Government of Quebec, and had been subject to inspection by Mr. Louis Guion, Chief Inspector of Industrial Establishments and Public Buildings, to the city of Montreal, who verified the fact in his evidence before the Coroner at the inquest held on the bodies of the people killed by the explosion:—

"The magazine undoubtedly was built according to regulations under the statutes, there is no doubt about that. It has been described, and there was nothing wrong about the magazine under the existing statutes; but the storing of these detonators, in my estimation, near the powder magazine, readily opens a theory as to what caused the explosion in the magazine."

That the great loss of life was due to the magazine being of stone construction is, without doubt, absolutely true, as the stones used in its construction were hurled as though they were projectiles.

No written description can represent the force with which they were propelled as can the accompaning illustrative Plates I to IX—showing the destruction to the contingent buildings; and the diagram, page 136, which shows the distances to which they were hurled.

The plant where the explosive "virite" was manufactured was surrounded by a growth of cedar scrub trees and underbrush; the surface formation having little or no soil. The magazine was built on practically solid bed-rock.

The ground was comparatively level and about the same elevation as the surrounding country; except towards the west, in which direction the surface rises gradually up to, and over the Chelsea road, having a possible elevation of 75 to 100 feet in a distance of 1,000 feet.

The disruptive force, and the projectiles from the explosion, did a large amount of damage to outside property. One noticeable feature (see diagram) was the short distances any wood used in the construction of the buildings was thrown; in comparison to the greater distances to which stones used in the construction of the magazine were propelled: indicating the necessity of having well defined rules and regulations laid down, governing all explosive magazines built in the future.

DAMAGE TO OUTSIDE PROPERTY.

The nearest tenement to the seat of the explosion was a frame building, very fortunately unoccupied at the time (see Plate IX). As indicated by the illustration, it was completely wrecked. Seventy-five feet in a northerly direction was a frame stable, the sides and roof of which were badly damaged. A distance of 400 feet from the seat of the explosion, and located on the edge of the creek, but partly protected by a bank about 18 feet high, was a frame building 50 × 60 feet, occupied by the Hull Fertilizer Company. The end of this building facing the direction of the explosion had part of the roof damaged, the sides torn off, and rafters and beams broken.

Directly south of the plant was a frame structure, with brick smoke stack, and containing machinery: located about 400 feet from the "virite" magazine. This building was badly shattered, and two small adjoining sheds built of wood were wrecked. Between a distance of 400 and 900 feet from the magazine there were no buildings; but, at a distance of from 1,000 to 2,000 feet there were quite a number of buildings which had extended from the main part of Hull towards the plant of the General Explosives Company. Damage to these buildings was altogether due to the stones—with which the magazine walls had been constructed—being hurled with terrific force. Stones weighing 30, 40, and even up to 100 pounds in weight, smashed like cannon balls through the frame houses. In many instances, portions of fields were ploughed up, and the stones completely buried by the force with which they had been propelled.

The ten fatalities were due to stones, which were blown from the magazine, and were found about the following distances from the base of the explosion:—

Boy in field to west of the magazine...............	650 feet.
Man on the railway track.........................	1,000 "
Three men near railway bridge on creek...........	1,050 "
Man at corner Eugene street, Chelsea road.........	1,500 "
Two girls in house, Chaudière street, Hull.........	1,500 "
Man on the street..................................	1,500 "
Small boy in field east of the plant................	1,600 "

PEOPLE INJURED.

It was ascertained that 20 people were injured, many very seriously; and the effects of shock were felt by a great number. It was marvellous that so many escaped; for when the alarm was given that the factory was on fire, a large crowd of people from a nearby baseball game gathered about the factory. Apparently, when the explosion took place, the heavy stones and timbers were hurled right over the heads of the crowd, without injury; while the people killed were at greater distances away, and not in the immediate vicinity of the magazine.

In conclusion, I may say that, it is a difficult matter to advance any positive theory as to the direct cause of the explosion, since not a vestige of the plant remained: (see Plate X). What is known with certainty is, that a fire started, and was transmitted from one building to another, until the explosion occurred. The jury empanelled by the Coroner to inquire into the cause of death resulting from this explosion, rendered the following verdict:—

"That the deceased, Antoine Servant, came to his death on the 8th day of May, 1910, at 5.45 p.m., as a result of being struck by a stone hurled against him by the explosion of 'Virite' at the magazine of the General Explosives Company, of Montreal, Limited, at Hull, and without holding said Company criminally responsible, we consider it guilty of certain imprudence in storing a quantity of detonators in close proximity to their magazine, and also in not keeping a regular watchman constantly upon the premises; and we recommend to the Government of this Province such amendments to the laws and regulations concerning the manufacture and storing of explosives as will secure the greatest safety to the public, and that in no case shall factories or store houses be allowed in the limits of cities, towns, or villages, and that this verdict applies to Ferdinand Lauren, Theodore Gagne, William Sabourin, Louis McCann, Donat Fabin, Rosalie Carriere and Emelia Carriere."

It may be stated that the directors of the General Explosives Company, Limited, paid, voluntarily, all damages to buildings and property caused by the explosion; and, moreover, fully compensated, by money, the people who were dependent upon those who were killed, also provided for those who were seriously injured, without a single action-at-law, for damages, being taken against the Company.

On the extent of the disaster becoming known, the Mayor of the city of Hull started a fund for the relief of the sufferers, which was liberally subscribed to by the general public; but on the settlement of the claims, the directors of the Company returned to the subscribers the amounts of their subscription.

III.

REPORT ON EXPLOSION OF "BLASTERS' FRIEND" AT THE WORKS OF THE DOMINION EXPLOSIVES COMPANY, LIMITED, SAND POINT, NEAR ARNPRIOR, RENFREW COUNTY, ONTARIO, JULY 11, 1910.

Investigation of the disaster attending the explosion which occurred in an explosives factory operated by the Dominion Explosives Company, Limited, at Sand Point, a small village on the Ottawa river, 6 miles above Arnprior, in the county of Renfrew, Province of Ontario, on July 11, 1910; whereby, three men were killed on the spot, namely: Frank Pittner, John Hewart, Earl Murphy; one seriously injured: Edward Lynn; and seven slightly hurt: Charles Thomas, Thomas Mullet, John Chalterton, W. Bradley, Supt. Matchette, David Lynn, Donald McLean; all as a result of the explosion.

The Dominion Explosives Company, Limited, was incorporated under the Dominion Government, and received a charter from the Department of the Secretary of State, on the 3rd day of March, 1910. A patent, No. 116625, was granted to Henry G. Nicoll, by the Department of Agriculture on the 9th day of February, 1909, for an explosive compound, and process of making the same: also patent No. 125632, on the 10th day of May, 1910, granted to Henry Garwin Nicoll, for a mixer for a process of part of the manufacture of explosives. These patents were transferred to the Dominion Explosives Company, who own and operate the factory at Sand Point. The explosive is manufactured and supplied to the trade under the name of "Blasters' Friend;" and is described, as "an improvement in explosives compounds." The object of the invention is, to produce a non-freezing powder, which may be used as a substitute for any nitro-glycerine dynamite; having equal disruptive power with the same, and greater stability for the same grade, weight, and bulk.

The base of the explosive is the product known as Cassava flour; it being claimed by the patentee that, better results and more efficient nitration are secured by the use of Cassava flour in comparison with other forms of nitrated starch.

(This Cassava flour is really the by-product of the tapioca factory, as from Cassava the tapioca of commerce is obtained.)

The manufacture of the explosive known as the "Blasters' Friend," may be briefly described as follows:—

The Cassava flour as it is received at the works is in a dry form, but, if it has absorbed any moisture, it is dried by being heated with hot air at a temperature of nearly 260° F. After drying, the Cassava flour is allowed to cool to a temperature of 60° F., before being subjected to the process of nitration.

The nitration of the Cassava flour is effected by gradually sifting the flour into a mixture of nitric and sulphuric acids, prepared ready for use in accordance with the following formulæ:—

	Per cent.
H_2SO_4	63·30
HNO_3	34·50
H_2O	2·20
	100·00

It is claimed by the officials of the Company that the best nitration is obtained by using four parts by weight of the mixed acids to one part of the Cassava flour.

The Cassava flour is introduced into the mixed acids by sifting the flour into the surface of the acid, and by mechanical agitators, giving a thorough precipitation, the temperature being maintained between 60° and 70° F., and not allowed to approach 90° F.; the cooling process being facilitated by water circulating around the tank, in which the nitration is being carried on.

The usual time required for the process of nitration is 55 to 60 minutes, to as long as 1½ hours; the determination of the proper degree of nitration being regulated by the condition and appearance of the mixed nitrated liquid and Cassava pulp.

When the process of nitration has been satisfactorily performed, the mixture is withdrawn from the nitrator, and is allowed to run down by gravity, and shovelling through a flow of water, by three separate oval bottomed shaped tanks, each tank being 12 feet in length and having a drop of about 20″ from one tank to another. During this process, the acids in the nitrated Cassava flour are washed out, but in the event of any portion of the mixed acid remaining, a tank similar in construction and design to those above mentioned is placed at right angles to the three down flow tanks, in which is held an ammonia solution of about 26 per cent, the object of which is to neutralize any acids left in the Cassava flour.

The next operation is to lift the nitrated Cassava flour sludge, and put it into a centrifugal spinner, to drive off as much water as possible, and to recover the spent acids. The nitrated flour is then conveyed to the drying house, which is fitted up with drying closets, where the nitrated sludge is placed in nine pound lots, on wood frames, and covered with fine canvas or cloth. Into these drying closets a forced draft of hot air at a temperature of from 90° to 100° F., is circulated.

When the nitrated Cassava flour is dried, it is in the form of a very fine powder, varying in colour from a light to a dark yellow, forming the base of the non-freezing powder, and is in a condition for its final mixing.

An analysis of this powder, at the stage just described, gives from 13 to 14 per cent of nitrogen.

The dried nitrated Cassava flour is now mixed with a fixed percentage of sodium bicarbonate, which is claimed by the officials of the Company to give an extremely stable explosive, non-freezing, and readily detonated by a standard fulminate cap.

To give this powder body for saleable and resultant purposes, a small percentage of powdered charcoal, mineral and vegetable oils is introduced.

When the above-mentioned compound is thoroughly mixed, it has the consistency of a dry, but plastic, finely divided, slate-coloured powder, which readily adapts itself to packing in the ordinary explosive waterproof paper cartoons; graduated in diameter to meet the requirements of the trade.

So far as I am aware, the manufactured explosive known as "The Blasters' Friend" has not been "tested," except in the chemical laboratory of the Bureau of Safe Transportation of Explosives, New York; for transportation over the railway lines of the companies subscribing to this bureau.

The chemist of this bureau gives the following information:—

"Temperature of ignition, 155° C.

Impact test 8 pounds weight, fall 5 inches.

Friction test 8 pounds weight, 6 inches.

Powder did not ignite nor explode when shot into with a 30 calibre military rifle bullet. It is detonated with a single strength cap.

When unconfined, it is readily ignited by a spark or flame, and burns rapidly, but quietly. It is classed as a high explosive, and is considered sufficiently safe for transportation. The probable efficiency of this explosive is not considered in this report."

The disaster under investigation occurred in the drying house of the plant, and such was the force of the explosion that not a building remained standing; being destroyed either by the disruptive force of the explosion, or by fire.

This was in some measure due to the fact that many of the buildings had originally been erected for purposes other than for an explosives factory and were closely grouped together, and inasmuch as we have not, at the present time, an Explosives Act in force in Canada—whereby specific distances are maintained between danger buildings—the whole plant was annihilated; the wood used in the construction of the buildings being torn and splintered into very minute fragments.

The inquest on the bodies of the men killed was held at Sand Point on the 18th of July, 1911, and in compliance with your instructions, I was in attendance. Dr. Armstrong, of Arnprior, was coroner, and Mr. Metcalf—the Crown Attorney for the county of Renfrew—conducted the inquiry.

The principal witness was Mr. I. D. Matchette, superintendent of the Explosives works, who in his evidence stated that he had had two years' experience in the manufacture of an explosive similar in composition to that known as the "Blasters' Friend," and that he had been employed nearly all his life in powder factories. He stated that the Dominion Explosives Company had been making the explosive known as the "Blasters' Friend," for a period of six weeks.

Frank Pittner and John Hewart—two of the men killed—had been brought as specialists to the works of this Company at Sand Point on account of their experience in the United States in the manufacture of the class of explosives such as was being made at the plant of the Dominion Explosives Company.

He (the superintendent) knew of his own personal knowledge that they were capable, careful men; one being employed at the nitrator, and the other in the drying room.

Superintendent Matchette stated in his evidence that he was in the drying-room two minutes before the explosion occurred, and to the best of his knowledge, conditions were as usual, the thermometer indicating the heat was normal.

The workmen who were employed in the drying-room and other danger buildings were provided by the Company with special clothes: such clothes as are usually worn in explosives factories, without metallic buttons, or pockets; felt and rubber soled boots being provided; and the men are periodically subjected to a search to prevent matches or other dangerous articles from being taken into the works. In the construction of the drying-house and other danger buildings, the nails in the boards were counter sunk and putty inserted over the heads; copper nails being used where any exposure was unavoidable.

The superintendent stated that he had no idea how or in what manner the fire originated, or how the explosion occurred, every precaution within his knowledge having been used. The employes were personally warned, also by means of printed notices, to be careful; and that disregard of instructions meant injury to themselves and to their fellow workmen.

There were about 100 cases stored—each case containing 50 pounds of explosive—in the packing house, which was about 150 feet distant from the drying-house. It is claimed that this explosive did not explode, but was burnt.

After an exhaustive examination of all available witnesses, the jury retired to consider their verdict which was rendered as follows:—

> "We the jury empanelled to investigate the cause of the death of the late Frank Pittner, killed in the Dominion Explosives Limited factory, near Sand Point, on July 11, 1910, find:" "That his death was caused by an explosion, originating in the drying-room from causes which we are unable to determine, and after full and exhaustive examination find that no blame can be attached to any of the officials or managers of the Company, who in our judgment used all due precautions in the erection of their buildings and manufacture of their product."

IV.

INVESTIGATION OF THE COAL MINE DISASTER AT BELLEVUE MINE, NEAR FRANK, ALBERTA.

Joseph G. S. Hudson.

Letter of Instruction.

OTTAWA, December 12, 1910.

DEAR SIR:—

You are instructed to proceed at once to Bellevue, near Frank, Alberta, for the purpose of investigating the recent accident from an explosion, which occurred at the coal mine at that place.

1. It will be your duty to obtain a full description of the disaster.

2. You will endeavour to ascertain, if possible, the cause of the disaster.

3. And ascertain whether the method of mining is defective, in that it prevented the escape of the miners after the explosion.

4. To make such suggestions as will in future avoid at that mine or mines with similar lay-out loss of life from the probable cause mentioned under No. 3.

You are to be present at the inquest and take notes of all that is said in evidence.

To report on any other essentials which may be necessary for a comprehension of the causes of the disaster, and its possible prevention in future from similar causes.

Yours truly,

(Signed) **Eugene Haanel,**
Director of Mines.

JOSEPH G. S. HUDSON, Esq.,
Mines Branch,
Department of Mines.

REPORT ON BELLEVUE MINE DISASTER.

DESCRIPTION OF MINE.

The Bellevue mine is one of three mines operated by the West Canadian Collieries Company, Limited, and is situated near Hillcrest station, Alberta, on the main line of the Crows Nest Pass division of the Canadian Pacific railway, and is in close proximity to the divisional line between the Provinces of Alberta and British Columbia.

No. 1 Mine: The underground Working in Which the Disaster Occurred.

This mine is opened from the surface by a stone drift until it reaches the coal, when a gangway and counter gangway are driven on a course having sufficient angle of inclination to allow water to flow from inby to the mine entrance.

From the main gangway chutes are driven on the full pitch of the seam, the chutes having 50 ft. centres. From the chutes, rooms are driven from one gangway to another, and the coal is run down the chutes, where it is loaded into mine cars on the main gangway, and hauled out to the surface by means of compressed air locomotives.

The main gangway has been driven in, a distance of 8,200 feet from the slope opening.

There are two openings designated on the plan as No. 1 and No. 2 mine.

From No. 1 mine, gangway 129, chutes have been driven north, and 35 south the south gangway is not now in use; while from No. 2 mine 24 chutes have been driven.

The geological features are peculiar, in that what may appear as two seams, probably may be proven to be but one, as an anticlinal has been discovered in the workings, which shows a complete fold over in the coal seam.

Between chutes 61 and 62 in No. 1 mine, a rock tunnel is being driven through the intervening strata, to connect the underground workings of both seams.

For the purpose of ventilation and exit from the underground workings of No. 1 mine, the following chutes have been driven to the surface:—

No. 26 chute, not now used,

No. 45 chute (first chute to surface),

No. 81 chute on this chute is the return airway from the mine workings of No. 1 seam.

No. 110 chute is being driven to the surface, the work has just been started, and it has to be driven 180 feet through very hard rock to the surface to complete the exit.

The ventilation fan is of the Sorocco type and is placed 400 feet from the mine entrance on the Main Rock tunnel, and forces the air along No. 2 seam main level to 53 chute, where a rock tunnel connects with No. 1 seam, at No. 1 chute north, and is carried along the main gangway to the working faces.

The official record as to the total quantity of air circulating in the mine on November 30, 1910, is as follows:—

No. 1 rock tunnel	62,720	cubic feet per minute.
Inside of 46 chute	25,900	included in
Inside of 82 chute	20,160	total quantity.

The seam of coal worked varies from 11 feet to 12 feet in height, having a hard rock roof, and lies at an angle of inclination varying from 45 to 80 degrees.

HISTORY OF ACCIDENT.

On October 31, 1910, the Bellevue mine was idle on account of a general holiday, "Thanksgiving Day," and in consequence there were not any men working in the mine underground.

While some men were engaged in erecting a power transmission line over the surface of the ground, under which were situated the underground workings, they were much surprised to see a cloud of dust and debris issuing with considerable force from the mouth of the chutes into the open air.

On an investigation being made by the mine officials it was found that the escapement doors of the ventilating fan had been blown open, and at the surface openings debris was strewn all around.

Knowing that no men or lights (even safety lamps) were at the time in the mine, it seemed an unusual occurrence that a mine explosion had taken place, and considerable anxiety was felt as to the probabilities of a second explosion following the first.

After a consultation held between the mine officials and Mr. James Ashworth, the General Manager of the Crowsnest Pass Coal Co., and Mr. Heathcote, the District Inspector of Mines, it was decided to test the air from the mine at the bottom of the fan and other openings, and if the return air from the mine did not show a large amount of CO, CO_2; or CH_4 gas, or that it did not show a temperature above normal, that an exploration party should enter and examine the mine to ascertain to what extent the explosion had wrecked the underground workings, or if any fire remained in the mine unextinguished after the explosion, and if possible, to arrive at some conclusion as to what had caused the explosion.

Mr. James Ashworth, in his evidence at the coroner's inquest, connected the explosion on "Thanksgiving Day" with the disaster which occurred on the 9th of December. He was asked by the General Manager of the West Canadian Collieries Company to come to Bellevue for consultation as to whether a fire existed in the mine or not: due to the explosion on "Thanksgiving Day."

After making several tests on the surface it was decided that no fire did exist in the mine, and that an exploration party would go into the mine and make an examination of the underground workings.

On entering the mine, it was clearly demonstrated that an explosion of considerable force had occurred, from 75 chute inwards: the effects of force being clearly indicated by the way the air stoppings were blown out; and along the gangway, mine cars, etc., were covered with mud showing the evidence of considerable force. On going up No. 81 chute, coal was found perceptibly warm. On the way back they went up No. 71 chute, and perceived that a large section of the roof of the mine had caved in. On the previous Friday a miss-shot had been left in the coal, and not fired in the section where the cave-in had occurred. No decision was arrived at as to whether this shot had exploded or not; but it was thought that the percussion from the caving in of the roof of the mine was sufficient to cause the damage which was in evidence in the mine, hence it was concluded that no fire existed in the underground workings of the mine.

One of the fire bosses who accompanied this party has given me the following account of his own observations which he had carefully written down on his inspection, and which I think is important:—

"On the counter (gangway) at 99 chute, the force left 3 distinct trails:

1. Inby to No. 105 chute;
2. Outby towards No. 82 chute;
3. Down the chute to the gangway.

"At this point, a trip of mine cars was standing on the parting.

"The first was an empty car, with a defective door, which was being sent out for repairs. The second car was filled with rock, as also was the third car. The force of the explosion struck the trip, (connected series of cars), and separated the first two cars from the rest of the trip, and carried them forward for about 12 feet and over on to the empty track, reversing their position; the empty car now being inby (the car of rock would weigh approximately 6 tons) the third car was thrown off the track and towards the other cars. The coupling which connected the second and third car remained on the front end of the third car and the clevis and pin which had connected them to the third car was drawn out nearly straight. The force of the explosion went inby on the main gangway as far as 118 chute when it became expended, as evidenced by the mud on the outby side of the chutes, props, etc., and by the fact of the props inclining inby in the tops. Most of the chutes were damaged in to No. 106. Past that point none were damaged. On the counter gangway all the air stoppings were blown out as far as 106 chute, the wheel valve of No. 104 chute charging station (where the compressed air locomotives receive their pressure of air) was carried inby for about 18 feet, and the charging station itself, weighing about 80 pounds, was blown inby for a distance of 50 feet.

"No. 99 chute shows evidence of the force having come down there from the counter gangway. This seems to have been the main trail of that branch of the force although 98, 97, 96, and 95 chutes show evidence of the force having also gone down from the counter to the main gangway.

"From 109 to 94 chutes, the inby sides of the posts show evidence of a slight recoil, and from 94 chute outby the recoil has been much stronger.

"The boards and canvas opposite the 6th X cut 98 room were burned, and traces of coking were observed between 98 and 81 chutes. Gas (CH_4) was in 98 and 96 (40 feet), the dust (coal) was very thick in 82, 83, 84 chutes. Heathcote (District Inspector of Mines), Emmerson (Mine Manager), Green (Superintendent of Mines), Hallworth (fire boss), and myself (Brownrigg) went along counter gangway from 52 chute to 106 chute and found all stoppings blown out. We went up 75 chute to 4th X pitch and crossed to 70 chute (roof), still weighting, seemed about 10 feet of rock caved. No gas at this point, but very dusty. Force seems to have come down chutes 70 and 75 and spread north and south along both counter and main gangway. Coal coked on ribs and props."

Note.—Brownrigg informs me that where a piece of the roof falls on the wrought iron sheets in the chutes, a continuous streak of vivid sparks can be seen, and also that when a chute is abandoned, the sheet iron is left in the chutes.

Elijah Heathcote, District Inspector of Mines, McLeod, Alberta, in whose district the Bellevue mine is located, gave evidence in substance as follows:—

On November 2—two days after the explosion—he inspected the underground workings of the Bellevue mine. Travelled right up to the face of the mine gangway: found a thick coating of coal dust on the electric light globes at No. 27 chute (light wires stop here), and mud on mine cars from No. 27 chute: props blown down, coal and debris being strewn along the track outward at 58 chute.

Going up 65 chute and along the counter gangway to 67 chute, we found coking on the inside of the props, showing that the flame travelled outwards against the air current. From 67 to 71 chutes, the coking was on the outward side of the props, while dust and a trace of coke were on the inside, showing that from 67 to 71 chutes the flame must have kicked back, proceeding up 71 chute to a big cave-in of rock—the rocks being of immense size. Although the pillars from chutes 61 to 70 had been extracted, the pit records show that up to October 29, no cave-in had taken place. It was evident, therefore, that the cave-in which he now saw occurred since the date mentioned. On the outside of the cave-in rooms 52 and 57 and pillars 59 and 60 are in working, getting round the cave at 75 chute to the face of the pillar 250 feet up the gangway.

From 71 to 75 chutes the stoppings in the counter gangway are blown inwards towards the face of the main entry, and from 75 to 85 the stoppings are blown outwards towards the mouth of the mine, showing that the blast must have split at 81 chute: one portion travelling up 31 chute manway to the surface, blowing out the dust; while another portion must have travelled through the cross-cuts off 81 chute, returning down 85 chute, and blowing the stoppings outwards. At 85 chute, the stopping in the counter gangway has a large hole in the middle, but remains intact; while from 99 to 103 chutes the stoppings are blown inwards; the sheet iron in the rooms are twisted and bent inwards from the counter gangway. At 103 chute, the stoppings are intact, but at 110 chute the force of the explosion was manifestly spent, owing to the damp and wet state of the mine. From 96 to 104, in the main gangway, is a large parting, and empty cars standing. The first two empty cars were blown from the empty track to the full track, and mud was on the corners of the inward and outward ends of the cars, showing that two forces of the blast must have met at this point.

The witness also stated that he had had a conversation with Mr. Couthard, General Manager of the West Canadian Collieries, as to the cause of the explosion, and what remedies should be taken to put the mine into better condition. After the explosion of October 31, the mine was put into condition by restoring the ventilation and cleaning the main gangway from broken timbers, etc.

The next stage to be noted is that the Secretary of the United Mine Workers of America, Bellevue division of No. 18 district, telegraphed to Mr. John T. Sterling, Provincial Inspector, at Edmonton, that the men working in the Bellevue mine desired an inspection of the mine. Mr. Sterling wired back asking for a reason why the mine should be inspected outside of the regular visit of district inspector; the Secretary of the Union replied that large quantities of gas were reported in the Bellevue mine. Mr. Sterling then wired to Mr. Heathcote, District Inspector at McLeod, to proceed to Bellevue mine and make inspection, who received this telegram on December 4, late on Sunday night. He stated that on Monday, December 5, he had too much work in his office to go to Bellevue mine. (This is an unfortunate state of things. Inspectors should have ample office and clerical help, so that they can leave immediately for urgent inspection duties; for the inspection of underground workings is of greater importance than attention to mere office routine).

On Tuesday, December 6, Mr. Heathcote arrived at Bellevue at 11 a.m. He went to the mines office at 2 p.m. and saw Mr. Powell the manager (who had only taken over the supervision of the mine on December 1; Mr. Emmerson the manager of the mine when the explosion occurred on October 31 having resigned to accept a more important position in South America, hence was not available for any information as to the cause of the first accident). He told the mine manager that it was asserted that a considerable quantity of gas was reported to be in the mine, and said that he would make an inspection of the mine on the following morning. Accordingly, on December 7, he went into the mine at 8.30 a.m. with John Anderson the pit boss, and proceeded up to the face of the main gangway at 129 chute, travelled back to 123 room, asking men if they had seen any gas, and also testing the working places for gas, but did not find any. The miner working in 123 room said that he had seen gas about 3 feet back from the face, but brattice was 12 feet back. This room was stopped working until the gas was cleared out. In 121 and 120 chutes, at the faces, gas had been seen. Travelled from 129 to 119 chutes, the places where gas most likely would be found, it being the farthest place from the entrance to the mine and in the higher workings.

In this inspection, he was accompanied by John Anderson, the pit-boss, and on arriving at 27 chute asked Anderson if he knew where there was any gas in the mine; he said no.

On arriving at surface he posted notice according to Mines Regulation Act, Chap. 25, section 46, subsection 3, (1906, C. 25, 546; 1908 C. 20, S. 16.)

It is here necessary to note the conduct of Anderson, the pit-boss, who accompanied the District Inspector in his rounds through a section of the underground workings.

Although at the time they (the District Inspector of Mines and pit-boss) were going around the working faces, he (Anderson) had sent two men to make a special inspection and examination of the section of the mine where the big cave-in from the roof eventually occurred, he did not inform the Inspector of what he was doing. He (Anderson) was told by one of the fire-bosses, that the two men above mentioned had reported having found gas, yet he (Anderson) did not place himself in a position to verify the report of Crandel and Boveio until the following morning, when they reported directly to Anderson that they had found gas. In the face of all this, he actually allowed Heathcote, the District Inspector, to post a notice at the entrance of the mine, that there was no gas in the mine. He knew where the Inspector was staying, and could easily have informed him—even on the following morning—that the men whom he (Anderson) had sent to inspect the section of the mine where pillars had been extracted, reported having found gas in considerable quantities, nor did he report to the Inspector that he had put in a new regulator, on the top room between 79 and 80 chute, which would have a very material effect on the whole volume of the air circulating in the mine.

After the effects of the first explosion had been remedied, as far as repairing the damage done in the underground workings of the mine was concerned, and restoring the ventilation of the mine by renewing the air stoppings, etc., the mine resumed work, and apparently on the part of the management work went on as under normal conditions, although the workmen were evidently not satisfied, as shown by their action in asking the Provincial Inspector for a further examination; and also asking that the Pit Committee of the Bellevue Local Lodge of the United Mine Workers of America make an inspection of the underground workings (this latter inspection did not take place), though Rule 32, Chap. 25, 1906, Coal Mines Act of the Statutes of Alberta, states: —

"The persons employed in a mine may from time to time appoint two of their number to inspect the mine at their own cost and the persons so appointed shall be allowed once at least in every month, accompanied, if the owner, agent or manager of the mine thinks fit, by himself or one or more of the officers of the mine, to go to every part of the mine and to inspect the shafts, levels, planes, working places, return airways, ventilating apparatus, old workings and machinery, and shall be afforded by the owner, agent, or manager and all persons in the mine every facility for the purpose of such an inspection and shall make a true report of the result of such inspection, and such report shall be recorded in a book, to be kept at the mine for the purpose, and shall be signed by the persons making the same, and if the report states the existence or apprehends the existence of any danger, the owner, agent, or manager shall forthwith cause a true copy of the report to be sent to the inspector of the district."

What really happened on the night of the explosion may be taken from the evidence of Mr. John Powell, the manager of the mine:—

Mr. Powell's Evidence.

The manager assumed charge of the Bellevue mine on the 1st of December, 1910 (after the date of the first explosion). On Friday evening, December 9, 1910, at about 7.30 p. m., a man came to his residence, and said that there was something wrong at the mine; he asked him of what nature, and he said he thought an explosion. He went immediately for Frank Lewis, the driver boss, and John Anderson, the pit-boss, and with these men, procured safety lamps at the lamp house, and with other men entered the mine. They went in as far as 43 chute on the main gangway, up to which point no indications were observed as to damage to any extent in the underground workings of the mine. At that point, however, a large cave-in of rock from the roof was encountered. At 45 chute 3 men were found, suffering from the effects of after-damp. These men were gotten out, and sent to the surface. They next proceeded along the main gangway to 61 chute, where a large volume of after-damp was found. At 76 or 78 chute, they found 3 men, who were pulled out; one dead, one breathing, and one badly overcome with gas. He gave orders to close 45 air chute, and to get brattice and repair stoppings to force the ventilation into the inside workings and along the main gangway; after this was done, he got as far as No. 80 chute, where he saw lights (safety lamps) and could hear air blowing off. (This point is a re-charging station for the haulage motor.) At 84 chute there were 21 men found dead, all clustered around the compressed air pipe line. (Note the fact that, safety-lamps were burning, although men were dead). The men kept on working at stoppings, until he reached 86 chute; when Stratton came to this point with the Drager oxygen breathing apparatus. Anderson the fire-boss from Hosmer was with him. (This man in trying to save another afterwards lost his life).

Witness explained the circumstances of getting out the bodies of all the men killed in the main gangway, together with the 16 men who were in the mine at the time of the explosion but who were rescued and brought out alive; only four men were unaccounted for, and these were eventually found between 53 and 54 chutes. They were employed as timber packers, and were brought out of the mine on

Sunday. The finding of these bodies was important since they showed distinct evidence of having been burned. The evidence of George O'Brien, fire boss, from Coleman, who came with the rescue party and assisted at the washing of the bodies, says: that of three bodies, one was burned on the right side of his face; one burnt on both sides, and one had his hands badly burnt (from the clothes of this man whose hands were burnt, a dozen or twenty matches were taken). This witness was asked the direct question. (Q.) What were the burns like? (A.) Fire burns. (Q.) This on your oath? (A.) Yes, I picked the flesh off the bones, flesh looked cooked. This witness was corroborated by several other witnesses as to the burns on the men found at the top of 53 and 54 chutes.

After all the bodies of the men killed had been removed the underground workings were inspected by the Provincial and District Inspectors of Mines, also by the collieries officials; information was gathered and noted, and the same was used at the Coroner's inquest.

It is proposed by the officials of the Company that another airway should be driven to the surface, and the ventilating fan moved to a point near the working faces. After consultation the Provincial Inspector of Mines—Mr. Sterling—decided that the mine be closed, and no one allowed to enter it until after the Company had carried out some of the proposed alterations.

The Coroner's jury after viewing the bodies of the men killed adjourned the inquest until the 19th day of December, 1910, at which date the inquest opened at Bellevue, Alberta. After the opening formalities were gone through, Dr. Malcomson, the medical practioner of the district, was called, and explained the cause of death, namely that the men came to their deaths by carbon monoxide gas poisoning. At this point the foreman of the jury announced that he considered the duty of the jurymen at an end, when the cause of death was known; that the jury were not technical experts to find out why or by what means the carbon monoxide gas was produced; and that as far as he was personally concerned the case to go before the jury ended at this point.

Mr. Campbell, who represented the Attorney-General's Department, for the Province of Alberta, endeavoured to instruct the jury as to their duty, but without avail, and the whole matter was laid (by phone) before the Attorney-General at Edmonton, who gave instructions that the first jury were to be discharged, and a new jury to be empanelled for January 3, 1911.

In accordance with this arrangement, the Coroner's inquest was resumed at Bellveue, on January 3, 1911. After a very long and exhaustive examination of witnesses, which continued until 8·30 p.m. on Friday evening January 13, 1911, the inquest was adjourned to enable the jury to consider their verdict. After four hours' deliberation the verdict rendered was as follows:—

"We do, upon our oath, say that 30 men came to their deaths by carbon monoxide poisoning, and one by a combination of carbon monoxide poisoning and fractured skull, the said carbon monoxide and fractured skull being caused by a cave of rock over chutes 76 to 78."

The jury respectfully submit the following riders to their verdict:—

(1) That more mine inspectors be appointed.

(2) That a "Drager" apparatus station be provided in this district.

(3) That telephones be installed under the supervision of the chief inspector of mines, where practicable in the underground workings of coal mines.

(4) That a thorough investigation be made of the means of preventing loss of life by caves-in in coal mines.

(5) "We consider that negligence is in evidence on the part of both operators and miners on the carrying out of the provisions of the Coal Mines Act, and we must strongly recommend a stricter adherence to the intent of this Act."

CAUSE OF THE DISASTER.

The coal mines of this district, which are locally known as the Pass mines, derive this distinction as being situated in the Crowsnest pass, in the southern part of the Province of Alberta, and adjoining part of the Province of British Columbia. The seams of coal have several characteristics which require special consideration, in reference to the method of extracting the coal in the underground workings.

(1) The seams of coal are all located in mountainous districts, hence are subject to very heavy pressure from the strata overlying the coal worked; (2) they have a great thickness between the roof and pavement, and (3) lie at high angles of inclination. These three characteristics constitute dangerous conditions in mining, which have to be guarded against not only at the present time, but more particularly in the future, as the underground workings go deeper from the surface; as the area of the workings become wider in extent, and the trade demands necessitate increasingly greater outputs of coal from the existing mines.

Explosions in coal mines may be classed under three general heads:—

(1) Explosions of gas;
(2) Explosions of coal dust; and
(3) Explosions of gas and coal dust combined.

It was brought out in evidence at the inquest, that two of the above-mentioned factors were involved in the explosion at the Bellevue mine: namely, explosive gas, which had been detected on the safety lamps of Cardel and Boveio, the men who had been sent by pit-boss Anderson to make an examination of the old workings after the first explosion; or, coal dust. The main point that had to be determined by the jury was: what caused the ignition of either the inflammable gas, or the coal dust, or a combination of these two factors. Two possible causes might be assigned: (1) A shot fired in the working faces; but this can be set aside, because all the men who were in the working faces gave evidence that the explosion came from the older section of the workings, where the force of the explosion was concentrated in the district from 50 to 80 chutes. (2) That a defective safety lamp might have ignited a body of explosive gas; but there was no evidence from which to draw the deduction that any of the lamps found had been tampered with or injured.

It is clearly demonstrated that the destructive zone of the explosion was at 75 or 76 chute. That an explosion of gas had occurred was demonstrated by the large amount of carbon monoxide gas and after-damp, encountered by the exploration party, at this section of the main gangway, and also that 3 of the 4 bodies recovered between 53 and 54 were burnt.

One important point that did not come out in the evidence was, that a strata of rock situated in the roof immediately over the coal is composed of a coarse-grained sandstone, highly impregnated with ironstone, so that when two small pieces are struck together vivid sparks are emitted at an intense heat.

It is affirmed that matches, pipes, and tobacco were found on one of the bodies recovered from between 53-54 chute, but this allegation was, by common consent, declared to have no bearing on the explosion.

The theory that I would suggest as being the probable cause of the disaster, is as follows:—

It is known that a very large cave-in of rock from the roof occurred in the vicinity of 70 to 78 chutes. The rubbing and grinding of the rocks, as they fell, emitted sparks at a high temperature. The heat generated by the friction and concussion of rocks raised the temperature of the air and gas to a high point, so that it would require only a spark of comparatively low thermal intensity to reach the ignition point of a small volume of hot explosive gas.[1] That the defective state of ventilation in the old workings was favourable to explosive conditions was manifest: for the ventilation was by scales of air through the board stoppings on the main gangway, and not by direct current, hence the air was in a sluggish condition, consequently when the explosion occurred, would give out a large volume of carbon monoxide gas without a large demonstration of explosive force. The force of the explosion travelled along the upper section of the workings, killing the 4 men working at the top of Nos. 52 and 53 chute; and the volume of carbon monoxide being forced down on the main gangway by the blowing out of the air stoppings evidently caused the death, by carbon monoxide poisoning, of the men who were on the main gangway.

If this deduction from the evidence, as submitted at the inquest is correct, then the finding of the corner's jury, that the 31 deaths were "caused by a cave-in of rock," is manifestly erroneous.

---

[1]The following extract from evidence taken before the Royal British Commission on Electricity in Mines, bears out the above theory:—

Evidence given before the Departmental Committee, by Mr. Afred Onions, miners' agent and general treasurer, South Wales Federation:—

> Witness gave two instances where there had actually been explosions with nobody in the pit.
> One was at the Maindy colliery in the Rhondda valley.
> It was proved that there was absolutely no one in the pit. But when they went in on Monday morning, or Sunday night, they found evidence of a very violent explosion. The theory was that there had been a fall of roof, and then a further fall took place, the right composition of gas having accumulated in the meantime, and this other fall which was a fall of stone, brought down gas, and due to the fall there was sparking. This sparking ignited the gas. There was evidence of burning. There was another instance of an explosion occurring in a disused level at Pentre, in the Rhondda valley. There was no one in the place, and there was evidence of violent explosion. If his memory served him rightly, some of the stone that fell from the roof of the Maindy colliery was taken out and experimented upon by Mr. Heppell, of Cwmammau, in the Aberdare valley, and by some mechanical means he produced explosions by the sparking of this very stone.

Then there was another instance of a man—he thought it was at the National Colliery—who was in a cutting, who struck his pick, or mandrel, as they call it in South Wales, against one of the stones in the coal, and sparking took place, and there was an explosion, because gas was present.

So there was no doubt about it, if they had the right ingredients present, and the righ intensity of sparking. The cases were well authenticated. (The Colliery Guardian, June 16, 1911, page 1,206).

METHOD OF MINING.

The coal seams in this district lie at a high angle of inclination, and in the majority of cases the mines are slope or gangway openings, these openings having been commenced from a point where the seam outcrops to the surface.

The general practice is to drive a gangway and counter gangway on a slight rise, giving a sufficient inclination to allow water to flow outwards to the mine mouth.

The system of working the coal is to drive chutes (having 50 or 60 ft. centres) on the full pitch of the seam, and to run the coal down on the chutes to the main gangway, where it is loaded on the mine cars. All mining laws specify that there shall be two distinct exits from the mine; but in the case of the Bellevue Mine lay-out, there is only one way of exit, namely, along the main haulage gangway. Practically, the counter gangway is stopped by the coal chutes coming down, and through them at right angles, hence is not available for a travelling way out of the mine. Although from the main gangway Nos. 26, 45, and 81 chutes are put through to the surface, there was not any evidence submitted at the inquest to show that any of the men who survived the shock of the explosion, and they were by far the greater number, made the slightest attempt to escape from the mine by travelling up the exceedingly steep chutes to the surface—the rise being from 45 to 80 degrees. It is manifest, therefore, that some provision should be made for maintaining an upper level at the top of the chutes, which would serve a double purpose, namely, as a return air-way, and at the same time a travelling way in case of accident. This way of getting out of the mine in case of emergency, instead of by the main haulage gangway, would undoubtedly be a great advantage.

GENERAL DEDUCTIONS.

More Mine Inspectors Needed.

The first rider attached to the jury's verdict, viz., "That more mine inspectors should be appointed," is a wise suggestion, for there is sufficient work for a resident mine inspector in the pass inasmuch as the mines of this district can be classed as dangerous. Their future development will add many complex conditions to mining, and consequently will affect the safety of underground workers employed in the mines.

On the Establishment of Oxygen Breathing Apparatus Stations in Coal Mining Districts.

Unfortunately, the general public have conceived a very erroneous idea as to this class of apparatus. In the first place, by applying the word "rescue" as a prefix; the prevailing notion being, that any person can put himself into an oxygen breathing helmet to enter a mine after an explosion, and bring out the men. Such is not the case. The value of oxygen breathing, and the success of the apparatus, depends wholly on the physical organization of the men who go into a mine after an explosion, equipped with oxygen breathing apparatus.

Unless they are physically fit, and properly trained they only endanger their own lives, and do not accomplish any good purpose.

Mr. W. E. Garforth, Past-President of the Mining Association of Great Britain—a mining engineer with wide experience in the recovery of mines after explosion—says:—

"That unless the wearer of the apparatus has systematically and regularly practised for three months in a gallery on the surface made like the damaged roadway of a mine, with confined spaces, etc., and has been surrounded with an irrespirable, hot, and occasionally humid atmosphere, for at least two consecutive hours, then such an apparatus, instead of being a help to the wearer, may prove to be a 'Death Trap.'"

With regard to the establishment of oxygen-breathing rescue stations, the general opinion seems to be that, either the Dominion or Provincial Governments should be responsible for their instruction and maintenance. Perhaps the most satisfactory results will be obtained by the different coal companies in mining districts in the establishment of a series of strategic stations, co-operating and maintaining these stations, as a first-class insurance asset.

In order to make such a system efficient and effective, a committee should be formed, comprising inspector of mines, and representatives of both coal operators and mines employes, who will determine the most suitable location for a central station in the district, and sub-station at each separate mine. A competent officer in charge would be held responsible for the training of the men; keeping the apparatus in good condition, and maintaining a sufficient quantity of oxygen at the station and sub-station.

Each mine to have a specified number of trained men, based on the total number of men employed underground.

The respective coal companies to contribute to a general fund, assessed on the number of tons of coal mined. From this fund the apparatus will be purchased, installed, and maintained.

The various Provincial Governments to issue certificates of competency, and provide a distinctive badge for qualified men.

PROPOSED TELEPHONE SYSTEM.

Telephone communication should be established in all underground workings: not only facilitating communication in case of accident, but for the more efficient carrying out of the daily work.

EMERGENCY ACCESS TO MINE PLANS.

At the Bellevue mine the plans showing the underground workings were not up to standard which should be maintained in good mining practice. The blue-prints of the plans produced at the Coroner's inquest were not only lacking in many technical essentials but were proved to be inaccurate. They did not show any definite system of ventilation, nor were they available to the mine managers from surrounding collieries, who had rushed to the mine to render assistance and advice.

These mine plans should be available for inspection at the mine office, in the event of an accident such as occurred at the Bellevue mine. They should be kept up, and corrected to periods of every three months; show distinctly all roads then open, ventilation intakes, and return air-ways, in separate colours; and have marked thereon in plain lettering all main roads and chutes or gate roads; the position of overcasts, ventilating doors, the air splits, also the quantity and direction of the air currents with the position of the ventilating fan. In cases where the ventilating fan has been reversed, there should be provided, if possible, a duplicate plan showing the above details. On the plan should be carefully indicated the position of the sections where men are at the working faces; these plans should be kept in an emergency drawer, conspicuously marked.

MINES REGULATION ACT.

The last rider attached to the verdict of the Coroner's jury has a very important bearing on this special disaster since it attached blame on all concerned. "It declares that negligence is in evidence on the part of the operators and miners in the carrying out of the Coal Mines Act, and we would most strongly recommend a stricter adherence to the intent of the Act."

The coal mining industry of the Province of Alberta is passing through the same experience in relation to coal mining, as other countries; sacrificing life and limb to the exigencies of output.

The coal-fields of Alberta have been developed very rapidly. In the year 1900, the annual production of coal was 311,450 tons; for the year 1909, the output was 1,994,741, and the estimated production for the year 1910 is 3,000,000. This large increase of tonnage has naturally made a heavy demand for miners, and other mine workers, generally. There has been a great striving by the mine operators to meet tonnage demands.

A large number of new mines have been opened, and in existing mines extended areas have been developed. These strenuous conditions have doubtless had not a little to do with the increasing number of mining accidents, as the following tabulated statistics will show:—

Comparative Statement of Accidents in Coal Mines, 1905-1910.

Year.	Alberta: number of men employed.	Alberta: Accidents.			Alberta: Ratio per 1,000 men employed.			British Columbia: number of men employed.	British Columbia: Accidents.			British Columbia: Ratio per 1,000 men employed.			Nova Scotia: number of men employed.	Nova Scotia: Accidents.			Nova Scotia: Ratio per 1,000 men employed.			Great Britain: fatal accidents, per 1,000 men employed.	United States: fatal accidents, per 1,000 men employed.
		Fatal.	Serious.	Slight.	Fatal.	Serious.	Slight.		Fatal.	Serious.	Slight.	Fatal.	Serious.	Slight.		Fatal.	Serious.	Slight.	Fatal.	Serious.	Slight.		
1905....	2,800	15	18	*	5·35	6·43		4,407	12	30	26	2·72	7·03	5·90	10,780	20	55	19	1·85	5·10	1·76	1·38	3·53
1906....	2,800	10	31	*	3·57	11·07		4,805	15	36	32	3·12	7·49	6·66	12,123	29	58	16	2·30	4·79	1·32	1·29	3·10
1907....	3,600	19	86	*	5·27	23·88		6,059	31	61	62	5·11	10·06	10·23	12,107	37	59	22	3·05	4·87	1·81	1·32	4·86
1908....	3,780	11	51	*	2·91	16·14		6,095	18	50	52	2·95	8·20	8·53	12,933	45	97	82	3·18	7·50	6·34	1·32	3·55
1909....	5,207	9	60	*	1·72	11·52		6,418	57	17	59	8·88	7·32	9·19	12,083	35	68	8	3·89	5·62	0·66	1·43	3·76
1910....	5,818	61	11	58	10·18	7·04	9·97	7,758	28	95	66	3·61	12·24	8·51	10,970	31	80	75	2·82	7·20	6·83	1·69	
	24,005	125	287	58	5·20	13·52	9·97	35,512	161	319	297	4·53	8·97	8·35	70,996	197	417	222	2·77	5·87	3·12	1·40	3·82

In the year 1910 there were 61 fatal accidents in the coal mines, Province of Alberta: 59 inside and 2 outside of the mines; as against a total of 9 for the year 1907. The Bellevue Mine disaster on the 9th of December, 1910, contributed 31 deaths of the 61 total.

In the year 1909 the death rate of 8·88 per 1,000 men employed in the coal mines of British Columbia was the highest rate for Canada, or the United States. For the year 1910, the high death rate of 10·18 per 1,000 men employed in the coal mines of Alberta, will probably place this Province in that position.

*Accidents serious and slight not separated in Government returns.

J. G. S. Hudson.

MAPPING AND DRAUGHTING DIVISION.

Maps and Drawings.

MAGNETOMETRIC SURVEY MAPS:—

Bristol Mine.—Prepared by E. Lindeman; completed and traced for reproduction, by L. H. S. Pereira.

Northeast Arm Timagami Lake.—Drawn by E. Lindeman; traced for reproduction by L. H. S. Pereira.

Maps for Dr. A. W. G. Wilson's Report on the Copper Mining Industry of Canada:—

Route map of Eastern Canada and United States.
Map of Quebec district.
Map of British Columbia.
Map of Nova Scotia.
Map of Parry Sound district.
Prepared and traced for reproduction by A. Pereira.
Map of Eustis Mine, Province of Quebec.
Prepared and plotted by Howells Fréchette, assisted by A. Pereira.

Diagram of Hull Explosion for J. G. S. Hudson's Report:—
Prepared by H. Fréchette; redrawn by L. H. S. Pereira.

Plan of Dominion Coal Company's Coal Areas:—
Making corrections and additions on original tracing of same. Also colouring three copies of black and white prints, by A. Pereira.

Illustrations for Bulletin No. 3, Recent Advances in the Construction of Electric Furnaces, by Eugene Haanel, Ph.D.:—

Fifteen drawings of Experimental Furnace; traced for reproduction by L. H. S. Pereira.

Working Drawings for Ore Dressing and Concentrating Laboratory — G. C. Mackenzie:—

Working drawings for Box Feeder; and
Working drawings for Separating Tanks for Fuel Testing Plant, Ottawa, by L. H. S. Pereira.

Drawings to Accompany Peat Bulletin No. 4, by A. Anrep, Jr.:—
Map of Brunner Peat Bog, Ontario.
Map of Komoka Peat Bog, Ontario.
Map of Rondeau Peat Bog, Ontario.
Map of Brockville Peat Bog, Ontario.

Plan of Government Peat Bog, Alfred, Ontario: showing contours.
Plan of Government Peat Bog, Alfred, Ontario: showing layout.
Plan of Government Peat Plant, Alfred, Ontario.
Profile of Main Ditch.

Working Drawings:—
Drawings of Peat Sheds, Front and Side Elevations.
Drawings of Four Buildings at Alfred Peat Bog.
Drawings of Side Dump Car for Dried Peat.
Diagram of Wet-Carbonizing Oven.
Drawing of Rail Section.

All prepared in the rough by A. Anrep, jr., finished and traced for reproduction by L. H. S. Pereira.

Reproduction of Drawings for Report on the Gypsum Deposits of the Maritime Provinces, by W. F. Jennison, M.E.:—

Map of Magdalen Islands, showing Gypsum Deposits.
Map of Nova Scotia, " " "
Map of New Brunswick, " " "
Plan for 32" × 96" Kettle Plaster Mill.
Plan and Section for 32"×96" Kettle Plaster Mill.
Plan for 32"×120" " " "
Sections for 32"×120" " " "
Sections for 32"×96" " " "
Plan and Section for 32"×120" " " "
" " 18"×72" " " "
Elevations and Sections 18"×72" " " "
Side Elevation of Cummer Calcining Plant.
End Elevation " " " "
Plan " " " "
General Layout of Great Northern Mining Company's Gypsum Mill.
Elevation of Plaster Mill, Great Northern Mining Co.
Section through Gypsum Deposit, Great Northern Mining Co.
Section of Borehole in Cheverie Gypsiferous Area.
Construction of Fireproof Walls, U. S. Gypsum Co., Ltd.
Plan and Section of Olson Land Plaster Distributor.
Bottom and Inside View " " "

REPORT OF EDITORIAL OFFICE.

Reports, Bulletins, Etc., Published Since January 1, 1910.

47. Iron Ore Deposits of Vancouver and Texada Islands—by E. Lindeman, M.E. Published March 14, 1910.
55. Report on the Bituminous or Oil-shales of New Brunswick and Nova Scotia; also on the Oil-shale Industry of Scotland—by Dr. R. W. Ells. Published February 24, 1910.
58. Annual Report of Division of Mineral Resources and Statistics on the Mineral Production of Canada during the calendar years 1907 and 1908—by J. McLeish, B.A. Published May 16, 1910.
59. Report on Chemical Analyses made in the Mines Branch Laboratories during the years 1906, 1907, and 1908. (Appendix—Commercial Methods and Apparatus for the Analysis of Oil-shales—by H. A. Leverin). By F. G. Wait. Published August 27, 1910.
62. Preliminary Report on the Mineral Production of Canada during the Calendar year, 1909—by J. McLeish, B.A. Published March 1, 1910.
63. Summary Report, 1909. Published July 31, 1910.
67. Bulletin No. 2: Iron Ore Deposits of the Bristol Mine, Pontiac county, Que.—by E. Lindeman, M.E., and G. C. Mackenzie, B.Sc. Published June 29, 1910.
68. Bulletin No. 3: Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc—by Eugene Haanel, Ph.D. Published September 13, 1910.
69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses (Second Edition)—by Fritz Cirkel, M.E. Published March 30, 1911.
71. Bulletin No. 4: Investigation of the Peat Bogs, and Peat Industry of Canada, 1909-10, by Aleph Anrep: to which is appended Mr. Alf. Larson's paper on Dr. M. Ekenberg's Wet-Carbonizing Process, from Teknisk Tidskrift, No. 12, December 26, 1908. Translation by Mr. A. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet, entitled "A Solution of the Peat Problem," 1909, describing the Ekelund Process for the Manufacture of Peat Powder—by Harold A Leverin, Ch.E. (Second Edition enlarged). Published December 7, 1910.
79. Production of Iron and Steel in Canada during the calendar year 1909—by J. McLeish, B.A. Published December 12, 1910.
80. Production of Coal and Coke in Canada during the calendar year 1909—by J. McLeish, B.A. Published December 14, 1910.
82. Bulletin No. 5: Magnetic Concentration Experiments with Iron Ores of the Bristol Mines, Que.; Iron Ores of the Bathurst Mines, N.B.; a Copper Nickel Ore, from Nairn, Ont.—by G. C. Mackenzie, B.Sc. Published February 10, 1910.

85. Production of Cement, Lime, Clay Products, Stone, and Other Structural Materials, in Canada, during the calendar year 1909—by J. McLeish, B.A. Published December 24, 1910.
88. Annual Report of the Division of Mineral Resources and Statistics on the Mineral Production of Canada, during the calendar year 1909—by John McLeish, B.A. Published July 18, 1911.
89. Proceedings of Conference on Proposed Legislation on the Manufacture, Importation, and Testing of Explosives: Held House of Commons, Sept. 23, 1910—by Eugene Haanel, Ph.D. First Edition published September 28, Second Edition published January 31, 1910.
92. Investigation of the Explosives Industry in the Dominion of Canada, 1910—by Capt. Arthur Desborough. First Edition published February 10, 1911, Second Edition published June 14, 1911.
102. Preliminary Report on the Mineral Production of Canada for the calendar year 1910—by J. McLeish, B. A. Published February 28, 1911.

ACCOUNTANT'S STATEMENT.

MINES BRANCH.

Statement of Appropriation and Expenditure by Mines Branch for the year ending March 31, 1910:—

	Appropriation.	Expenditure.
	$ cts.	$ cts.
Amount voted by Parliament	112,937 50	
Amount received for assays and analyses	366 15	
Civil list salaries		27,618 51
Machinery, labour, etc., Peat bog, Alfred		11,529 17
Publication of reports and maps		8,686 60
Coal tests		6,000 00
Fuel testing plant, Ottawa		5,640 04
Investigations, etc., peat and coals		5,151 49
Monograph on gypsum		4,429 76
Investigations *re* iron ores		3,940 70
Printing, stationery, and mapping materials		3,007 02
Monograph on asbestos		2,850 02
Laboratory		2,144 08
Wages		1,720 34
Mining and metallurgical industries		1,611 54
Investigations of copper deposits		1,218 13
Instruments		899 49
Postages and telegrams		559 22
Travelling expenses		333 50
Miscellaneous		290 96
Books and periodicals		211 17
J. E. Woodman, advance unaccounted for		100 00
Balance unexpended and lapsed		25,361 91
	113,303 65	113,303 65

(Signed) **John Marshall,**

Accountant Department of Mines.

APPENDIX I.

PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA, DURING THE CALENDAR YEAR 1910: WITH REVISED STATISTICS FOR 1909.[1]

EUGENE HAANEL, Ph.D.,
Director of Mines.

SIR:—I beg to submit herewith, the annual preliminary report on the mineral production of Canada in 1910, including a table showing the revised statistics of production in 1909.

The figures of production given for 1910 are, of necessity, subject to revision, since at this time, in many instances, producers of metallic ores have not themselves received complete returns from smelters. For these and other reasons, estimates have to be made. It is hoped, however, that this preliminary statement may serve to give a general idea of the gross output of the mineral industry during the year.

I am, Sir, your obedient servant,
(Signed) **John McLeish.**

Division of Mineral Resources and Statistics,
February 23, 1911.

THE MINERAL PRODUCTION OF CANADA, 1910

(Statistics subject to revision.)

Although complete statistics are not yet available, sufficient information is at hand to indicate that the total value of the mineral production of Canada during the past year exceeded $105,000,000. This production is made up from such a great variety of well established mining industries that the record should be particularly gratifying not only to those who are directly interested in the development of the mineral resources of the country, but also to the public at large who indirectly profit thereby.

Not only is the increase over the production of the previous year a large one, having amounted to $13,209,517, or over 14 per cent, but an examination of the details of production shows that the increase has been fairly well distributed amongst the more important ores and minerals produced in Canada.

The production of the more important metals and minerals is shown in the following tabulated statement in which the figures are given for the two years, 1909 and 1910, in comparative form, and the increase or decrease in value shown. Tabulated statements for both years, in greater detail, will be found on subsequent pages of this pamphlet:—

	1909.		1910.		Increase (+) or decrease (−) in value.
	Quantity.	Value.	Quantity.	Value.	
		$		$	$
Copper............Lbs.	52,493,863	6,814,754	56,598,074	7,209,463	+ 394,709
Gold..............Ozs.	453,865	9,382,230	....	10,224,910	+ 842,680
Pig iron............Tons.	757,162	9,581,864	800,797	11,245,630	+ 1,663,766
Lead..............Lbs.	45,857,424	1,692,139	32,987,508	1,237,032	— 455,107
Nickel............ "	26,282,991	9,461,877	37,271,033	11,181,310	+ 1,719,433
Silver..............Ozs.	27,529,473	14,178,504	31,983,328	17,106,604	+ 2,928,100
Other metallic products....	....	405,122	....	559,186	+ 154,064
Total................	....	51,516,490	....	58,764,135	+ 7,247,645
Less pig iron credited to imported ores.........	607,718	7,359,649	695,891	9,594,309	+ 2,234,660
Total metallic.........	....	44,156,841	....	49,169,826	+ 5,012,985
Asbestos and asbestic.Tons.	87,300	2,201,775	100,385	2,476,558	+ 274,783
Coal.............. "	10,501,475	24,781,236	12,796,512	29,811,750	+ 5,030,514
Gypsum........... "	439,129	809,632	531,313	939,838	+ 130,206
Natural gas...............	....	1,207,029	....	1,312,614	+ 105,585
Petroleum.........Bls.	420,755	559,604	315,895	388,550	— 171,054
Salt...............Tons.	84,037	415,219	84,029	409,624	— 5,595
Cement...........Bls.	4,067,709	5,345,802	4,753,975	6,414,315	+ 1,068,513
Clay products.............	....	6,450,810	....	7,600,000	+ 1,149,190
Lime.............Bus.	5,592,924	1,132,756	5,721,285	1,131,407	— 1,349
Stone.....................	....	3,127,135	....	3,499,772	+ 372,637
Miscellaneous non-metallic.	....	1,642,602	....	1,886,704	+ 244,102
Total non-metallic.....	....	47,674,600	....	55,871,132	+ 8,196,532
Grand total...........	....	91,831,441	....	105,040,958	+13,209,517

The subdivision of the mineral production in 1909 and 1910 by provinces was approximately as follows:—

Province.	1909. Value.	1909. Per cent of total.	1910. Value.	1910. Per cent of total.
	$		$	
Nova Scotia	12,504,810	13·62	14,054,534	13·38
New Brunswick	657,035	0·71	585,891	0·56
Quebec	7,086,265	7·72	8,193,275	7·80
Ontario	37,374,577	40·70	43,017,026	40·95
Manitoba	1,193,377	1·30	1,470,776	1·40
Saskatchewan	456,246	0·50	557,806	0·53
Alberta	6,047,447	6·58	7,876,458	7·50
British Columbia	22,479,006	24·48	24,547,817	23·37
Yukon	4,032,678	4·39	4,737,375	4·51
	91,831,441	100·00	105,040,958	100·00

It will be observed that there has been an increased production in nearly every province, the only falling off being shown by New Brunswick, in which the gypsum production, and some of the structural products, showed a slight decrease.

In Nova Scotia there was a largely increased production of coal and gypsum. In Quebec the principal increases were in cement and asbestos. Ontario's increases are principally in the metals, copper, nickel, and silver.

Manitoba shows an increased production of gypsum and clay products; while in Alberta clay products, cement, and particularly coal, contribute the chief gains. In British Columbia the increase is mainly due to the coal industry, while the Yukon not only shows a gratifying gain in gold production but a growing shipment of copper and silver ores.

Of the total production in 1910, $49,169,826 or 46·8 per cent is credited to the metals, and $55,871,132 or 53·2 per cent to the non-metallic products. Amongst the individual products, coal still contributes the greatest value, constituting 28·4 per cent of the total. Silver is next with about 16·3 per cent; nickel, third with 10·6 per cent; gold, 9·7 per cent; clay products, 7·2 per cent; copper, 6·8 per cent, and cement, 6·1 per cent.

In valuing the metallic production, the same general practice has been followed as in past years, with one or two slight modifications. Instead of valuing lead at the New York price, the average price at Toronto has been used. This is somewhat lower than the New York price, but higher than that in London.

Nickel has been valued at an average price of 30 cents per pound, although the minimum quotation for the metal in large lots was 40 cents. Considerable quantities of monel metal are now made, the production of which does not require the separation of the nickel metal, and the price of 30 cents is equivalent to valuing two-thirds of the production at 37½ cents, and one-third at 15 cents.

THE MINERAL PRODUCTION OF CANADA IN 1910.

(Subject to revision).

Product.		Quantity.	Value.
METALLIC.			$
Copper, value at 12·738 cents per pound	Lbs.	56,598,074	7,209,463
Gold		....	10,224,910
Pig iron from Canadian ore	Tons.	104,906	1,651,321
Iron ore (exports)	"	114,449	324,186
Lead, value at 3·75 cents per pound	Lbs.	32,987,508	1,237,032
Nickel, value at 30 cents per pound	"	37,271,033	11,181,310
Silver, value at 53·486 cents per ounce	Ozs.	31,983,328	17,106,604
Zinc ore and other products		....	235,000
Total		....	49,169,826
NON-METALLIC.			
Arsenic, white	Tons.	1,502	75,328
Asbestos	"	75,678	2,458,929
Asbestic	"	24,707	17,629
Coal	"	12,796,512	29,811,750
Corundum	"	1,870	198,680
Feldspar	"	15,719	47,867
Fluorspar	"	2	15
Graphite	"	1,243	59,087
Grindstones	"	3,847	43,936
Gypsum	"	513,313	939,838
Magnesite (railway shipments)	"	328	2,493
Mica	"	....	143,409
Ochres	"	4,813	33,185
Mineral water		....	175,173
Natural gas		....	1,312,614
Peat	Tons.	771	1,735
Petroleum, value at $1·23 per barrel	Bls.	315,895	388,550
Phosphate	Tons.	1,319	11,780
Pyrites	"	55,925	192,263
Quartz	"	88,205	91,951
Salt	"	84,092	409,624
Talc	"	7,112	22,308
Tripolite	"	22	134
Total		....	36,438,278
STRUCTURAL MATERIAL AND CLAY PRODUCTS.			
Cement, Portland	Bls.	4,753,975	6,414,315
Clay products—			
Brick		....	5,930,630
Sewer-pipe, fireclay, drain tile, pottery, etc		....	1,669,370
Lime	Bus.	5,721,285	1,131,407
Sand and gravel (exports)	Tons.	624,824	407,974
Sand-lime brick		....	360,894
Slate		....	18,492
Stone—			
Granite		....	634,783
Limestone		....	2,303,804
Marble		....	158,779
Sandstone		....	402,406
Total structural materials and clay products		....	19,432,854
All other non-metallic		....	36,438,278
Total value, metallic		....	49,169,826
Total value, 1910		....	105,040,958

The average monthly prices [1] of the metals in cents per pound for several years past are shown herewith:—

—	1906.	1907.	1908.	1909.	1910.
	Cts.	Cts.	Cts.	Cts.	Cts.
Copper, New York	19·278	20·004	13·208	12·982	12·738
Lead, "	5·657	5·325	4·200	4·273	4·446
" Toronto	4·727	5·429	3·894	3·692	3·750
Nickel, New York	41·64	45·000	43·000	40·000	40·000
Silver, "	66·791	65·327	52·864	51·503	53·486
Spelter, "	6·198	5·962	4·720	5·503	5·520
Tin, "	39·819	38·166	29·465	29·725	34·123

[1] Quotations from *Hardware and Metal* and *Engineering and Mining Journal.*

Smelter Production.

General statistics of smelter production were collected by this branch for the first time in 1908, and the aggregate results of these operations during the years 1908 and 1909 are shown in the accompanying table. Unfortunately, complete returns have not yet been received for the year 1910. It should be explained also that the figures include the results of the treatment of a small quantity of imported ores. The results of the operations at the smelter at Northport, Wash., treating chiefly Canadian ores, have also been included:—

SMELTER AND REFINERY PRODUCTION IN CANADA, 1908 AND 1909.

—		1908.		1909.	
		Refined products.	Metals contained in matte, blister, base bullion, and speiss.	Refined products.	Metals contained in matte, blister, base bullion, and speiss.
Antimony	Lbs.			61,207	
Gold	Ozs.	15,436	203,300	18,241	200,129
Silver	"	11,168,689	3,271,899	14,242,545	4,845,920
Lead	Lbs.	36,549,274	1,116,792	41,883,614	3,973,810
Copper	"		51,965,289		53,328,583
Copper sulphate	"	203,379		51,405	
Nickel	"		19,506,251		27,041,957
Cobalt	"		692,170		1,321,083
White arsenic	"	1,431,052		2,258,087	
Arsenic	"		436,787		1,074,516

The total ore charged to the furnaces during each of the past three years is shown as under:—

—	1908.	1909.	1910.
Nickel-copper ores	360,180	462,336	628,947
Silver-cobalt-nickel-arsenic ores	7,182	8,384	9,466
Lead and other ores treated in lead furnaces	53,545	53,006	57,547
Copper-gold-silver ores	1,797,488	1,850,889	*2,000,000
Total	2,218,395	2,374,615	2,695,960

*Returns incomplete but tonnage probably exceeded the figure given.

Gold.

While statistics of gold production are as yet incomplete, a preliminary estimate shows a production of approximately $10,224,910, an increase of about 9 per cent over the 1909 production. The production of the Yukon is valued at $4,550,000, the total exports on which royalty was paid during the calendar year according to the records of the Interior Department being 275,472·51 ounces. The Yukon production in 1909 was $3,960,000, the exports being 239,766·35 ounces. The British Columbia production in 1909 was: placer gold $477,000; bullion from free milling ores $329,655; smelter recoveries $4,367,924. In 1910 the placer production is estimated by the Provincial Mineralogist as $482,000. An estimate of free milling bullion shipments and smelter recoveries is made of $4,950,000, or a total production for the Province of $5,432,000. The Nova Scotia production shows a falling off of about $20,000, while Ontario will probably show a slight increase on account of the gold recovered in development work at Porcupine, of which a re ord has not yet been received.

Silver.

The silver production of Canada in 1909 showed an increase of 24·5 per cent over that of 1908 following a series of large increases during the three preceding years. It is very satisfactory, therefore, to be able to report a further increase in 1910 of about 16 per cent. The total production last year, including that produced as bullion and the metal estimated as recovered from ores sent to smelters or otherwise treated, was approximately 31,983,328 ounces, as compared with a production of 27,529,473 ounces in 1909.

The increase is again chiefly credited to Cobalt and adjacent mining districts of Ontario.

There was a slight falling off in the silver production of British Columbia as a result of the decreased production from the silver lead ores of the Province.

For the Province of Ontario, complete returns have been received from all the larger operators, while estimates based on railway shpiments have been made for two or three of the smaller mines. The net production of recoverable silver is estimated at 29,375,000 ounces, that is after deducting 5 per cent from the settlement assays of ores sent to smelters to allow for smelting losses. At the average price of silver for the year this has a value of $15,711,513.

The production similarly estimated for 1909 was 24,822,099 ounces, thus showing an increase in 1910 of about 4,552,901 ounces, or over 18 per cent.

The total shipments of ore and concentrates were about 34,580 tons, containing approximately 29,931,678 ounces of silver, in addition to which somewhat over 940,000 ounces were shipped as bullion. The average silver content of ore and concentrates shipped was thus about 865·57 ounces, or $462.96 per ton, as compared with an average of 840 ounces in 1909.

The shipments during 1909 were 27,835 tons of ore, containing 22,349,717 ounces of silver, or an average of 803 ounces per ton; 3,059 tons of concentrates containing 3,627,819 ounces, or an average of 1,186 ounces per ton, and bullion containing 143,440 fine ounces.

The exports of silver in ore, etc., as reported by the Customs Department, were 30,699,770 ounces, valued at $15,649,537.

The price of refined silver in New York varied between a minimum of 50½ cents per ounce on March 2, and a maximum of 56¾ cents on October 19, the average monthly price being 53·486, as compared with an average monthly price of 51·503 cents in 1909.

Copper.

No refined copper is produced in Canada, but the copper ores are mostly reduced to a matte or blister copper carrying values in the precious metals. In Quebec, where the copper is recovered subsequently to the extraction of the sulphur from pyritic ores, there was increased activity during the year. A small quantity of ore was exported from British Columbia coast mines and the Yukon to United States smelters for treatment. In Ontario, where the copper is chiefly recovered from the nickel-copper ores of the Sudbury district, there is a very large increase in production. In British Columbia the most important events during the year were the acquisition of a controlling interest in the Dominion Copper Company by the British Columbia Copper Company, with the subsequent re-opening of several of the properties, and the destruction by fire of part of the head works of the Granby mines at Phœnix, B.C., which noticeably affected the output, although the Boundary district as a whole shows an increased production.

Statistics are not available at the present time to show the total quantity of copper contained in ores shipped from the mines. The total production of copper, however, contained in blister and matte produced and estimated as recoverable from ores exported, was in 1910 approximately 56,598,074 pounds. In 1909 the production of copper estimated on the same basis was 52,493,863 pounds, an increased production of about 7·8 per cent being, therefore, shown in 1910.

Of the production in 1910, Quebec is credited with 957,178 pounds; the production in Ontario was 19,259,016 pounds; and in British Columbia the production is estimated at about 36,000,000 pounds. Ontario shows an increased production of about 3,512,317 pounds, or 22·3 per cent, while British Columbia shows a slight increase, the production in 1909 being estimated at 35,658,952 pounds.

The New York price of electrolytic copper during the year varied between the limits of 12 cents and 13¾ cents per pound, the average being 12·738, as compared with an average of 12·982 cents in 1909.

The total exports of copper contained in ore, matte, and blister, according to Customs Department returns, were 56,964,127 pounds, valued at $5,840,553. It will be noted that the exports agree very closely in number of pounds with the record of the production which would be expected since practically all the copper is exported.

Lead.

The total production in 1910 of pig and manufactured lead was 32,987,508 pounds, valued at the average price of refined lead in Toronto at $1,237,032.

The production of refined lead and lead contained in base bullion exported in 1909 was 45,857,424 pounds. A decreased production in 1910 is, therefore, shown of 12,869,916 pounds.

The production of both years was entirely from British Columbia. The falling off in the output of that Province is due largely to the curtailment of production by several of the important Slocan mines, resulting from the destruction of railway facilities and of several mines buildings by forest fires.

The Blue Bell mine also, one of the leading shippers of lead in 1909, suspended operations early in 1910. Against these decreases may be placed the advent of the Sullivan mine, East Kootenay, into the list of shippers.

The exports of lead in ore during the year were 23 tons, and of pig lead 3,856 tons, or a total of 3,879.

About 12,614 tons of domestic production were, therefore, available for home consumption.

The imports of lead in 1910 were 8,305 tons, valued at $525,265; in addition to which were manufactures valued at $107,688, and litharge, white and red lead, etc., $200,790, or a total value of $833,743.

The price of lead in Toronto during 1910 averaged about 3·750 cents per pound, in New York 4·446 cents per pound, and in London £12·920 per long ton.

The amount of bounty paid during the twelve months ending December 31, 1910, on account of lead production, was $318,308·28, as compared with a payment of $346,527·98 in 1909.

Nickel.

There has been a very large increase in the production of nickel-copper ores in Ontario during the past two years, and it is perhaps not generally realized that the production of nickel in this Province is now almost as large, pound for pound, as the production of copper in British Columbia, while the market price of the metal is from two to three times that of copper. A portion of the production is, however, now recovered with copper as monel metal and sold at a much lower price than fine nickel. Active operations are being carried on by the same companies as formerly, viz.: the Mond Nickel Company, at Victoria Mines, and the Canadian Copper Company, at Copper Cliff.

The ore is first roasted and then smelted and converted to a Bessemer matte containing from 77 to 82 per cent of the combined metals, copper and nickel; the matte being shipped to the United States and Great Britain for refining.

The total production of matte in 1910 was 35,033 tons, valued at the furnace at $5,380,064, an increase of 9,188 tons, or 31·6 per cent over the production of 1909. The metallic contents were copper, 19,259,016 pounds, and nickel, 37,271,033 pounds.

The aggregate results of the operations on the Sudbury District nickel-copper ores during the past four years were as follows in tons of 2,000 pounds:—

—	1907.	1908.	1909.	1910.
Ore mined	351,916	409,551	451,892	652,392
Ore smelted	359,076	360,180	462,336	628,947
Bessemer matte produced	22,041	21,197	25,845	35,033
" shipped	22,025	21,210		
Copper content of matte shipped	6,996	7,503	7,873	9,630
Nickel " "	10,595	9,572	13,141	18,625
Spot value of matte shipped	$3,289,382	$2,930,989	$3,913,017	$5,380,064
Wages paid	$1,278,694	$1,286,265	$1,234,904	$1,748,153
Men employed	1,660	1,690	1,735	

Exports of nickel contained in ore, matte, etc., as compiled from Customs reports, have been, for the twelve months ending December 31, as follows:—

—	1906.	1907.	1908.	1909.	1910.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
To Great Britain	2,716,892	2,518,338	2,554,486	3,843,763	5,335,331
To United States	17,936,953	16,857,997	16,865,407	21,772,635	30,679,451
	20,653,845	19,376,335	19,419,893	25,616,398	36,014,782

The price of refined nickel in New York remained practically constant throughout the year—the quotation being "Large lots, contract business, 40 to 45 cents per pound. Retail spot from 50 cents for 500 pound lots up to 55 cents for 200 pound lots. The price for electrolytic is 5 cents higher."

Iron.

Iron Ore.—Excluding Quebec, for which complete returns have not been received, the production of iron ore in 1910 was 254,915 short tons, valued at $566,109. The shipments may be classified as magnetite, 124,535 tons, hematite, 130,380 tons. In 1909 the total shipments were 268,043 tons, valued at $659,316, and comprised magnetite, 74,240 tons, hematite, 190,473 tons, and bog ore, 3,330 tons.

Exports of iron ore from Canada during 1910 are recorded by the Customs Department as 114,499 tons, valued at $324,186. This is chiefly from Moose Mountain mine, Ontario, Torbrook, N.S., and Bathurst, N.B.

Although not a Canadian production, it may be of interest to state that the two Canadian companies operating the Wabana mines, shipped during the year 1,259,626 short tons: of which 808,762 tons were shipped to Sydney and 450,864 tons to the United States and Europe.

Pig Iron.—An increase of 5·58 per cent is shown in the production of pig iron in Canada in 1910 as compared with 1909. The total production in 1910 was 800,797 short tons, valued at $11,245,630, as compared with 757,162 tons, valued at $9,581,864, in 1909. These figures do not include the output from electric furnaces making ferro-products, which are situated at Welland and Sault Ste. Marie, Ont., and Buckingham, Que. Of the total output of pig iron during 1910, 17,164 tons valued at $333,956, or $19.78 per short ton, were made with charcoal as fuel, and 783,633 tons valued at $10,911,674, or $13.92 per ton, with coke. The amount of charcoal iron made in 1909 was 17,003 tons, and iron made with coke was 740,159 tons. The classification of the production of 1910, according to the purpose for which it was intended, was as follows: bessemer, 219,492 tons; basic, 425,400 tons; foundry, including miscellaneous, 138,741 tons.

The amount of Canadian ore used during 1910 was 160,290 tons; imported ore 1,406,668 tons; mill cinder, etc., 22,671 tons.

The amount of coke used during the year was 993,037 tons, comprising 499,717 tons from Canadian coal and 493,320 tons imported coke or coke made from imported coal.

The consumption of charcoal was 1,615,919 bushels.

Limestone flux was used to the extent of 569,355 tons.

In connexion with blast furnace operations there were employed 1,403 men, and $1,006,727 were paid in wages.

The total daily capacity of 16 completed furnaces was, according to returns received, 2,880 tons.

The number of furnaces in blast December 31, 1910, was 11.

The production of pig iron by provinces in 1909 and 1910 was as follows:—

Province.	1909.			1910.		
	Tons.	Value.	Per ton.	Tons.	Value.	Per ton.
		$	$ cts.		$	$ cts.
Nova Scotia........	345,380	3,453,800	10 00	350,287	4,203,444	12 00
Quebec.............	4,770	125,623	26 34	3,237	85,256	26 34
Ontario............	407,012	6,002,441	14 75	447,296	6,956,930	15 55
Total........	757,162	9,581,864	12 65	800,797	11,245,630	14 04

The exports of pig iron during the year are reported as 9,763 tons, valued at $296,310. Probably the greater part of this is ferro-silicon and ferro-phosphorus, produced at Welland and Buckingham, respectively.

There were imported during the year 227,753 tons of pig iron, valued at $3,122,695; 16,106 tons of charcoal pig valued at $242,152, and 18,900 tons of ferro-manganese, valued at $464,741.

Steel.—The total production of ingots and castings in 1910 was approximately 822,281 short tons, of which 803,600 tons were ingots, and 18,681 tons were castings. The figures have been partially estimated, the records of the Ontario Iron and Steel Company having been unfortunately destroyed by fire. The production in 1909 was reported as 754,719 short tons, made up of 739,703 tons of ingots and 15,016 tons of castings.

Returns from seven of the principal rolling mills report the production in 1910 of steel in the following shapes: blooms and billets 635,500 short tons; rails 399,761 tons; rods and bars 214,233 tons; miscellaneous rolled products 23,167 tons.

Statistics showing the open-hearth and bessemer steel production for four years are as follows:—

——	1907.	1908.	1909.	1910.
	Tons.	Tons.	Tons.	Tons.
Ingots—Open-hearth (basic)........	459,240	443,442	535,988	580,932
Bessemer (acid)........	225,989	135,557	203,715	222,668
Castings—Open-hearth........	20,602	9,051	14,013	18,083
Other steels........	1,151	713	1,003	598
Total........	706,982	588,763	754,719	822,281

Iron and Steel Bounties.—Following is a statement of the bounties paid on iron and steel during the calendar years 1909 and 1910, as kindly furnished by the Trade and Commerce Department. As no bounty is paid on iron made from mill cinder or ingredients other than ore, the figures do not show the total output of the furnaces but only those quantities on which bounty was paid.

	1909.		1910.	
	Quantity on which bounty was paid.	Bounty.	Quantity on which bounty was paid.	Bounty.
	Tons.	$ cts.	Tons.	$ cts.
Pig iron made from Canadian ore	126,297·55	214,705 80	84,758·70	76,282 83
Pig iron made from imported ore	607,718·09	425,402 64	695,891·23	278,356 52
Total, pig iron	734,015·64	640,108 44	780,649·93	354,639 35
Steel ingots	729,189·37	766,470 41	767,379·39	460,427 64
Steel wire rods	81,405·42	488,432 70	88,179·58	529,077 60
Total bounty paid on iron and steel		1,895,011·55		1,344,144·59

Asbestos.

The total shipments of asbestos in 1910, with one firm still to hear from, are reported as 75,678 tons, valued at $2,458,929; as compared with 63,349 tons, valued at $2,284,587 in 1909, an increase of about 19 per cent in tonnage and 7·6 per cent in total value.

The number of men employed in mines and mills is reported as 3,443, at a wage cost of $1,393,856. While the shipments are reported as above, the actual production was returned as 4,815 tons of crude and 91,353 tons of mill stock produced from 1,474,527 tons of asbestos rock, or a total production of 96,168 tons; stock on hand at the end of the year totalled 39,310 tons, as compared with 20,921 tons on hand on December 31, 1909.

The following tabulated statement shows the production and shipments during 1910 and the stock on hand at the end of the year:—

	Production.	Shipments.			Stock on hand Dec. 31.	
	Tons.	Tons.	Value.	Per ton.	Tons.	Value.
			$	$		$
Crude No. 1	1,971	1,688	445,130	263 70	1,605	426,782
" " 2	2,844	1,732	171,684	99 12	2,842	405,419
Mill stock No. 1	16,026	12,830	701,681	54 69	6,933	403,747
" " 2	56,321	42,612	997,987	23 42	24,541	591,752
" " 3	19,006	16,816	142,447	8 47	3,389	29,988
Total asbestos	96,168	75,678	2,458,929	32·49	39,310	1,857,688
Asbestic	....	24,707	17,629	0·71	......	

In the absence of a uniform classification of asbestos of different grades, the above sub-divisions have been adopted purely on a valuation basis. Crude No. 1 comprising material valued at $200 and upwards and Crude No. 2 under $200. Mill stock No. 1 includes stock valued at from $45 to $100; No. 2 from $20 to $30; No. 3 under $15.

The shipments of asbestos in 1909 were in detail as follows:—

Crude No. 1: 912 tons, value $246,655, or $270.37 per ton;
Crude No. 2: 2,162 tons, value $328,855, or $152.11 per ton.
Mill stock No. 1: 14,776 tons, value $785,731, or $53.18 per ton;
Mill stock No. 2: 32,417 tons, value $800,728, or $24.70 per ton;
Mill stock No. 3: 13,082 tons, value $122,618, or $9.37 per ton;
Total: 63,349 tons, value $2,284,587, or $36·06 per ton; asbestic, 23,951 tons, value $17,188.

The exports of asbestos during the twelve months ending December, 1910, are reported by the Customs Department as 71,485 tons, valued at $2,108,632, comprising: 57,939 tons, valued at $1,505,477 to the United States; 6,700 tons, value $280,452, to Great Britain; 440 tons, value $15,925, to Germany; 2,187 tons, value $94,619, to France, and 1,242 tons, value $43,948 to other countries.

The imports of manufactures of asbestos during the same period are reported as valued at $230,489.

Corundum.

There was an increased production of corundum in 1910. The quantity of corundum ore treated during the year was 37,183 tons, from which was produced 1,686 tons of grain corundum. The shipments were 106 tons sold in Canada and 1,774 tons sold in other countries, a total of 1,870 tons, valued at $198,680.

Coal and Coke.

The total coal production in Canada in 1910, comprising sales and shipments, colliery consumption and coal used in making coke, is estimated at 12,796,512 short tons, valued at $29,811,750. This is an increase of 2,295,037 tons, or nearly 22 per cent over the production of 1909, and is the largest production of coal yet recorded for Canada.

There has been an increased production from practically all the larger collieries, and in the Province of Alberta many new mines are being opened up and developed. The largest increases have been in the west—Alberta showing an increase of nearly 42 per cent and British Columbia over 27 per cent, while Nova Scotia shows an increase of a little over 13 per cent. The total production is almost equally divided this year between the eastern and western coal fields; Alberta contributing about 22 per cent of the whole as compared with 10 per cent in 1905 and 5 per cent in 1900.

The production by provinces was approximately as follows, the figures for 1908 and 1909 being also given. With respect to Alberta, while the table below shows a production in 1910 of 2,824,929 tons, the Provincial Mine Inspector estimates the output at over 3,000,000 tons.

Province.	1908.		1909.		1910.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$
Nova Scotia	6,652,539	13,364,476	5,652,089	11,354,643	6,407,091	12,871,388
British Columbia	2,333,708	7,292,838	2,606,127	8,144,147	3,319,368	10,373,024
Alberta	1,685,661	4,127,311	1,994,741	4,838,109	2,824,929	6,161,055
Saskatchewan	150,556	253,790	192,125	296,339	190,484	293,448
New Brunswick	60,000	135,000	49,029	98,496	53,455	106,910
Yukon Territory	3,847	21,158	7,364	49,502	1,185	5,925
Totals	10,886,311	25,194,573	10,501,475	24,781,236	12,796,512	29,811,750

The exports of coal are reported by the Customs Department as 2,377,049 tons, valued at $6,077,350, as compared with exports of 1,588,099 tons in 1909, valued at $4,456,342.

Imports of coal during the year include: bituminous, 5,966,466 tons, valued at $11,919,341; slack, 1,365,281 tons, valued at $1,795,598; and anthracite 3,266,235 tons, valued at $14,735,062; or a total of 10,597,982 tons, valued at $28,450,001.

There was a greater importation of each class of coal than in 1909, when the total imports were 9,872,924 tons.

Coke.—The total production of oven coke in 1910 was about 897,273 short tons, as compared with a production of 862,011 tons in 1909. The total quantity of coal charged to ovens was 1,373,793 short tons. By provinces the production was: Nova Scotia, 507,996 tons; Ontario, 25,959 tons; Alberta, 121,578 tons, and British Columbia, 241,740 tons. The coke is all made from Canadian coal with the exception of that made by the Atikokan Iron Company at Port Arthur, Ontario. All of the coke produced was used in Canada with the exception of 50,922 tons sold for export to the United States, chiefly from Alberta. The quantity sold for export in 1909 was 77,407 tons.

The quantity of coke imported during the calendar year was 737,088 tons, valued at $1,908,725, as compared with imports of 661,425 tons, valued at $1,508,627, in 1909.

Chromite.

No returns of production of chromite have been received, but 619 tons are reported as having been shipped by rail from Coleraine and Black Lake. An export of 15 tons valued at $150 is also reported by the Customs Department.

Petroleum and Natural Gas.

The production of crude petroleum shows another large falling off in 1910, the production being only 315,895 barrels, or 11,056,337 gallons, valued at $388,550; as compared with 420,755 barrels, or 14,726,433 gallons, valued at $559,604, in 1909. The average price per barrel was also less, being about $1.23 in 1910, as compared with $1.33 in 1909.

The above statistics of production have been kindly furnished by the Trade and Commerce Department, and represent the quantities of oil on which bounty was paid, the total bounty payments being $165,845.06 in 1910 and $220,896.50 in 1909.

The production in Ontario by districts, as furnished by the Supervisor of petroleum bounties, was, in 1910, as follows, in barrels: Lambton, 205,456; Tilbury and Romney, 63,058; Bothwell, 36,998; Leamington, 141; Dutton, 7,752, and Onondaga (Brant county), 1,005.

The production in New Brunswick was 1,485 barrels.

In 1909 the production by districts was as follows, in barrels: Lambton, 243,123; Tilbury and Romney, 124,003; Bothwell, 38,092; Leamington, 5,929, and Dutton, 9,513. New Brunswick produced 95 barrels.

While the production has been decreasing the imports as might be expected, have been increasing. The total imports of petroleum oils, crude and refined, in 1910, were 84,629,334 gallons, valued at $4,826,745, in addition to 1,362,235 pounds of wax and candles, valued at $80,106. The oil imports included: crude oil, 53,604,053 gallons; refined and illuminating oils, 7,656,727 gallons; gasoline, 16,679,691 gallons; lubricating oils, 4,081,257 gallons; other petroleum products, 2,607,606 gallons.

The production of natural gas was valued at $1,312,614, being $68,568 for the Province of Alberta and $1,244,046 for Ontario. These values represent as closely as can be ascertained the value received by the owners of the wells for gas produced and sold or used and do not necessarily represent what the consumers have to pay for the gas, since in a number of instances the gas is re-sold once or twice by pipe line companies before reaching the consumer. In Alberta, also, some gas is being used by brick manufacturers for which no estimate has been obtained as to quantity or value. The total quantity of gas used in Ontario exceeded 7,036 million feet, and in Alberta over 450 million feet. A considerable flow of gas is reported from the new wells of the Maritime Oil Company, Limited, in Albert county, New Brunswick, which it is proposed to pipe to Moncton.

Salt.

Complete returns of salt production show total sales of 84,092 tons, valued at $409,624, for the salt alone. Packages used were valued at $173,446. Stock on hand at the end of the year was reported as 2,474 tons. Two hundred and eight men were employed and $112,909 paid in wages. The production was about the same as in 1909.

Imports of salt during the calendar year were: salt in bulk and bags dutiable, 20,174 tons, valued at $97,326, and salt free of duty 108,794 tons, valued at $364,735.

Cement.

Complete statistics have been received from the manufacturers of cement, covering their production and shipments during the year 1910. These returns show that the total quantity of cement made during the year, including both Portland and slag cement, was 4,396,282 barrels, as compared with 4,146,708 barrels in 1909, an increase of 249,574 barrels, or 6 per cent.

The total quantity of Canadian Portland cement sold during the year was 4,753,975 barrels, as compared with 4,067,709 barrels in 1909, an increase of 686,266 barrels, or 16·87 per cent. The total consumption of Portland cement in 1910, including Canadian and imported cement, and neglecting an export of Canadian cement valued at $12,914, was 5,103,285 barrels, as compared with 4,209,903 barrels in 1909, or an increase of 893,382 barrels; or 21·22 per cent.

Detailed statistics of production during the past four years are shown as follows:—

—	1907.	1908.	1909.	1910.
	Barrels.	Barrels.	Barrels.	Barrels.
Portland cement sold	2,436,093	2,665,289	4,067,709	4,753,975
" " manufactured	2,491,513	3,495,961	4,146,708	4,396,282
Stock on hand January 1	299,015	383,349	1,098,239	1,180,231
" " December 31	354,435	1,214,021	1,177,238	822,538
Value of cement sold	$3,777,328	$3,709,063	$5,345,802	$6,414,315
Wages paid	$956,080	$1,275,638	$1,266,128	$1,323,264
Men employed	1,786	3,029	2,498	2,085

The average price per barrel at the works in 1910 was $1.34, as compared with an average price of $1.31 reported for 1909, and $1.39 in 1908.

The imports of Portland cement into Canada during the twelve months ending December 31, 1910, were 1,222,586 hundredweight, valued at $468,046. This is equivalent to 349,310 barrels of 350 pounds at an average price per barrel of $1.34. The imports in 1909 were 142,194 barrels, valued at $166,669, or an average price per barrel of $1.17.

The imports from Great Britain during 1910 were 123,880 barrels valued at $130,951; from the United States 168,972 barrels valued at $253,463; from Belgium 19,027 barrels, valued at $20,618; and from other countries 37,431 barrels, valued at $63,014.

Following is an estimate of the Canadian consumption of Portland cement for the past six years:—

Calendar Years.	Canadian.		Imported.		Total.
	Barrels.	Per cent.	Barrels.	Per cent.	Barrels.
1905	1,346,548	59	918,701	41	2,285,249
1906	2,119,764	76	665,845	24	2,785,609
1907	2,436,093	78	672,630	22	3,108,723
1908	2,665,289	85	469,049	15	3,134,338
1909	4,067,709	97	142,194	3	4,209,903
1910	4,753,975	93	349,310	7	5,103,285

EXPORTS OF THE PRODUCTS OF THE MINE, YEAR 1910.

(Compiled from Trade and Navigation Monthly Statements).

Products.		Quantity.	Value.
			$
Arsenic	Lbs.	4,512,673	173,932
Asbestos	Tons.	71.485	2,108,632
Barytes	Cwt.	5	150
Chromite	Tons.	15	150
Coal	"	2,377,049	6,077,350
Feldspar	"	15,601	47,962
Gold			5,491,051
Gypsum	Tons.	346,081	416,725
Copper, fine, in ore, etc	Lbs.	56,964,127	5,840,553
Lead, in ore, etc	"	46,800	1,308
" pig	"	7,712,253	248,174
Nickel, in ore, etc	"	36,014,782	4,039,040
Platinum, in ore, concentrates, etc	Ozs.	2,254	62,776
Silver, in ore, etc	"	30,699,770	15,649,537
Mica	Lbs.	937,263	330,903
Mineral pigments	"	3,491,737	29,839
Mineral water	Gals.	16,136	7,169
Oil, refined	"	2,818	462
Ores—			
Antimony	Tons.	239	14,095
Iron	"	114,499	324,186
Manganese	"	4	160
Other ores	"	9,534	641,426
Plumbago	Cwt.	15,768	53,008
Pyrites	Tons.	30,434	110,071
Salt	Lbs.	275,200	2,618
Sand and gravel	Tons.	624,824	407,974
Stone, ornamental	"	446	3,352
" building	"	63,407	18,867
" for manufacture of grindstones	"	308	338
Other products of the mine			134,462
Manufactures—			
Brick	M.	390	2,762
Aluminium, in bars, etc	Cwt.	77,224	1,160,242
" manufactures of			3,741
Cement			12,914
Clay, manufactures of			9,061
Coke	Tons.	57,971	250,715
Grindstones, manufactured			23,164
Gypsum, ground			12,306
Iron and steel—			
Stoves	No.	1,058	15,832
Castings, N.E.S			51,958
Pig iron	Tons.	9,763	296,310
Machinery (linotype machines)			39,438
" N.E.S			301,961
Sewing machines	No.	17,834	188,196
Typewriters	"	5,970	409,326
Scrap iron and steel	Cwt.	233,264	171,603
Hardware, tools, etc			88,844
" N.E.S			43,472
Steel, manufactures of			1,110,925
Lime			44,762
Metals, N.O.P			133,426
Plumbago, manufactures of			66,658
Stone, ornamental			5,272
" building			80
Total			46,679,238

THE MINERAL PRODUCTION OF CANADA IN 1909.

(Revised.)

Product.		Quantity.	Value. (b)	Per cent of Total.
METALLIC.			$	%
Antimony ore	Tons*	35	1,575	......
Antimony, refined	Lbs.	61,207	4,285	......
Cobalt (k)	"	....	94,609	0·10
Copper (e)	"	52,493,863	6,814,754	7·42
Gold	Ozs.	453,865	9,382,230	10·22
Pig iron from Canadian ore (d)	Tons.	149,444	2,222,215	2·42
Iron ore (a)	"	21,956	61,954	......
Lead (e)	Lbs.	45,857,424	1,692,139	1·84
Nickel (f)	"	26,282,991	9,461,877	10·30
Silver (g)	Ozs.	27,529,473	14,178,504	15·44
Zinc ore	Tons.	18,371	242,699	0·26
Total		....	44,156,841	48·08
NON-METALLIC.				
Arsenic	Tons.	....	67,446	......
Asbestos	"	63,349	2,284,587	2·49
Asbestic	"	23,951	17,188	......
Chromite	"	2,470	26,604	......
Coal	"	10,501,475	24,781,236	26·99
Corundum	"	1,491	162,492	0·18
Feldspar	"	12,783	40,383	......
Graphite	"	864	47,800	......
" artificial	"	257	....	......
Grindstones	"	4,275	54,664	......
Gypsum	"	473,129	809,632	0·88
Magnesite	"	330	2,508	......
Mica	"	369	147,782	0·16
Mineral pigments—Barytes	"	179	1,120	......
" " Ochres	"	3,940	28,093	......
Mineral water		....	175,173	0·19
Natural gas (h)		....	1,207,029	1·31
Peat	Tons.	60	240	......
Petroleum (i)	Bls.	420,755	559,604	0·61
Phosphate	Tons.	998	8,054	......
Pyrites	"	64,644	222,812	0·24
Quartz	"	56,924	71,285	......
Salt	"	84,037	415,219	0·45
Talc	"	4,350	10,300	......
Total		....	31,141,251	33·91

* Short tons throughout.

(a) Exports.

(b) The metals, copper, lead, nickel, and silver are for statistical and comparative purposes valued at the final average value of the refined metal. Pig iron is valued at the furnace, and non-metallic products at the mine or point of shipment.

(c) Copper content of smelter products and estimated recoveries from ores exported, at 12·982 cents per pound.

(d) The total production of pig iron in Canada in 1909 was 757,162 tons, valued at $9,581,864, of which it is estimated 607,718 tons valued at $7,359,649 should be credited to imported ores.

(e) Refined lead and lead contained in base bullion exported at 3·690 cents per pound, the average price for the year in Toronto.

(f) Nickel content of matte produced at 36 cents per pound (the average minimum quotation for nickel in New York less 10 per cent). The value of the nickel contained in matte was, as returned by the operators, $2,810,748, or an average per pound of 10·7 cents.

(g) Estimated recoverable silver at 51·503 cents per ounce.

(h) Gross returns for sale of gas.

(i) Quantity on which bounty was paid and valued at $1.33 per barrel.

(k) Value received by shippers of silver cobalt ores for cobalt content.

THE MINERAL PRODUCTION OF CANADA IN 1909—*Concluded.*

(*Revised.*)

Product.		Quantity.	Value. (b)	Per cent of total.
STRUCTURAL MATERIALS AND CLAY PRODUCTS.			$	%
Cement, Portland	Bls.	4,067,709	5,345,802	5·82
Clay products—				
Bricks, common	No.	539,228,708	4,212,424	4·59
" pressed	"	57,264,656	630,677	0·69
" paving	"	3,759,803	67,408	....
" moulded and ornamental			8,866	......
Fireclay and fireclay products			78,132	......
Fireproofing and architectural terra-cotta			113,886	0·12
Pottery			285,285	0·31
Sewer-pipe			645,722	0·70
Tiles, drain	No.	27,571,097	408,440	0·44
Lime	Bus.	5,592,924	1,132,756	1·23
Sand-lime brick	No.	27,052,864	201,650	0·22
Sand and gravel (exports)	Tons.	481,584	256,166	0·28
Slate	Squares.	4,000	19,000	......
Stone—				
Granite			454,824	0·50
Limestone			2,139,691	2·33
Marble			158,441	0·17
Sandstone			374,179	0·41
Total, structural material, etc.			16,533,349	18·01
" all other non-metallic			31,141,251	33·91
Total, non-metallic			47,674,600	51·92
" metallic			44,156,841	48·08
Total value, 1909			91,831,441	100·00

ANNUAL MINERAL PRODUCTION IN CANADA, SINCE 1886.

Year.	Value of production.	Value per capita.	Year.	Value of production.	Value per capita.
	$	$ cts.		$	$ cts.
1886	10,221,255	2 23	1899	49,234,005	9 27
1887	10,321,331	2 23	1900	64,420,877	12 04
1888	12,518,894	2 67	1901	65,797,911	12 25
1889	14,013,113	2 96	1902	63,231,836	11 55
1890	16,763,353	3 50	1903	61,740,513	11 03
1891	18,976,616	3 92	1904	60,082,771	10 36
1892	16,623,415	3 39	1905	60,078,999	11 35
1893	20,035,082	4 04	1906	79,286,697	12 55
1894	19,931,158	3 98	1907	86,865,202	13 35
1895	20,505,917	4 05	1908	85,557,101	12 32
1896	22,474,256	4 38	1909	91,831,441	12 82
1897	28,485,023	5 49	1910	105,040,958	14 02
1898	38,412,431	7 32			

APPENDIX II.

CONFERENCE ON PROPOSED LEGISLATION TO REGULATE THE MANUFACTURE, IMPORTATION, AND THE TESTING OF EXPLOSIVES.

OTTAWA,
September 26, 1910.

SIR:—I beg to transmit, herewith, a copy of the proceedings in connexion with the Conference on the proposed legislation to regulate the manufacture, importation, and testing of explosives, held in Room 16, House of Commons, Ottawa, on September 23, 1910. At the said Conference it was resolved that the proceedings be immediately printed, and placed in the hands of those in attendance, so that the recommendations of Captain Desborough—H.M. Inspector of Explosives—could be deliberately considered, and dealt with at the adjourned meeting to be held in Room 16, House of Commons, Ottawa, on Friday next, September 30, at 10 a.m.

Hoping you may find it convenient to be present.

Yours very truly,

(Signed) **Eugene Haanel,**
Director of Mines.

Digest of Proceedings.

ROOM 16, HOUSE OF COMMONS,
OTTAWA, September 23, 1910.

The Conference met at 10 a.m., Dr. Eugene Haanel, Director of Mines, in the chair. The attendance was as follows:—

Captain Desborough, H.M. Inspector of Explosives, Home Office, London.
Thomas C. Gibson, Deputy Minister of Mines for Ontario, Toronto.
Joseph G. S. Hudson, Mines Branch, Dept. of Mines.
Winthrop Brainard, Vice-President Hamilton Powder Company, Montreal.
J. Murray Wilson, Manager Hamilton Powder Company, Beloeil Station, Que.
G. A. Wutty, Manager Hamilton Powder Company, Windsor Mills.
D. W. Brainard, Dominion Cartridge Company, Montreal.
E. J. Johnston, Dominion Cartridge Company, Brownsburg, Que.
W. D. Barclay, Gen. Man. C.N. and Q. and L. St. John railways, Que.
E. Tiffin, Intercolonial railway, Moncton, N.B.
A. J. Hills, Supt. C.N.O. Ry., Toronto.
M. J. Butler, Gen. Man. Dominion Iron, Steel, and Coal Company, Sydney, C.B.
W. H. McDougall, Asst. Gen. Man., Dominion Iron, Steel, and Coal Company, Sydney, C.B.

A. C. Tagge, Gen. Supt. Canada Cement Company, Montreal.

C. D. McPhee, G. and M. Fuse Works, Arnprior, Ont.

A. E. Blood, Bureau Safe Transportation of Explosives, New York, Toronto

Col. J. M. Taylor, Bureau of Safe Transportation of Explosives, New York.

Daniel Smith, President Ontario Powder Company, Kingston.

C. A. McPherson, Secretary Ontario Powder Company, Kingston.

W. T. Roddin, President Standard Explosives Company, Montreal; Western Export Company, Vancouver.

W. M. Lowery, President Ontario Torpedo Company, Petrolia.

H. R. Drackett, Superintendent Standard Explosives Company, Vaudreuil.

Jas. J. Riley, Vice-President Northern Explosives Company, Montreal.

E. A. LeSueur, Ottawa.

G. M. Howard, A. L. Howard Company, Fulminate of Mercury Works, Sherbrooke, Que.

H. A. Nicholls, Dominion Explosives Company, Ottawa.

Lionel Kent, The Energite Explosives Company, Montreal.

P. E. LeMarch, The Energite Explosives Company, Cobalt.

The CHAIRMAN.—As you are aware, the Honourable Mr. Templeman, Minister of Mines, proposes to introduce at the next session of Parliament a Bill to regulate the manufacture, importation, and testing of explosives in the Dominion of Canada. The Department of Mines last year drafted a Bill for presentation to the House. We deemed it advisable, however, before presenting a Bill on so important a matter, to avail ourselves of the experience of His Majesty's Inspector of Explosives in England who has for many years administered the English law, and who is at the head of the testing station in England. I, therefore, recommended the Minister that application be made to the Home Office in order that we might avail ourselves of his services; and they have been good enough to loan him to us. He has travelled over the country and inspected the various factories where explosives are manufactured, and made himself conversant with the conditions in Canada. He is now prepared to offer certain recommendations, and I have called this conference in order that you might hear the recommendations which Captain Desborough is to make to the Government; so that you might have an opportunity of taking note of his recommendations, and offering your own suggestions, and possibly criticisms in connexion with these recommendations. I shall now call upon Captain Desborough to be good enough to state to you what his recommendations will be.

Captain DESBOROUGH.—Doctor Haanel and gentlemen, the task you have put upon me is rather difficult to carry out in such a short time. I have only been able to get a very general idea of your conditions here, and I felt it was absolutely necessary before I sent in an official report, that the recommendations which I shall sketch out roughly to you—the gist of my recommendations—should be submitted to you for your criticism. The first principle which should be adopted in framing regulations to govern the explosives industry is, what we call in England, the system of authorization of explosives. The meaning of that is this, that before any explosive is allowed to be imported or manufactured for sale, the explosive has to be submitted to the chemical advisers of the explosives department, and they have to satisfy themselves that it is reasonably insensitive to friction and percussion, and that it possesses a reasonable degree of chemical stability. This does not preclude the manufacture of experimental explosives to enable a manufacturer to work out a new type of explosive, but it means that before that explosive is put on the market it must go through the hands of the chemical advisers of the Department. I do not know that it is necessary for me to go into the details of the principles on which our chemical advisers examine explosives. In fact I am sure it would take much too long, but amongst the tests they use are those of the falling weight and the broom stick test, which does not seem to be known over here. The method of the broom stick test is to spread out a thin layer of the explosive on a wooden board and strike it a glancing blow with a wooden broomstick. Ordinary gunpowder can readily be fired in that way. Then, as far as chemical tests of explosives go, the principal test used is known as the heat test. I imagine that most manufacturers here are more or less familiar with the details of the heat test, so I need not refer to it here. In conjunction with the heat test, they keep the explosives in alternately dry and moist atmospheres, at a temperature of about 90 degrees Fahrenheit, and take the heat test from time to time, and observe the effect on the heat test. There is also another test, to ascertain if an explosive containing nitro-glycerine is liable to exudation or liquefaction. The next point is the manufacture of the explosive. I think the Dominion Government should alone be responsible for the licensing of factories. As they will be responsible for the type of explosive which is put on the market, they ought to have some control over the manufacture. The principle we use in England regarding the licensing of factories depends on what we call the table of distances. That is, the maximum quantity of explosive allowed to be in any building depends on the distance it can maintain from other buildings connected with the factory, and also from certain prescribed buildings and works outside the factory. These distances are shown in two tables of which I have copies here. One is called the table for outside distances, and the other is what we call the intra-factory distance table. I will just give you one instance here. Take a blasting explosive. We should be prepared to allow 30,000 pounds in a building, provided it was adequately mounded, and was at a distance of 65 yards from other buildings. If the mound were not erected, then we should cut down the quantity to 6,000 pounds. It shows the great trust we put in mounded buildings. Other points which the licenses should embody are the construction of the buildings. We do not lay down any hard and fast construction for any particular buildings; but we work on the principle that buildings in which operations of manufacture are carried out should generally be of light construction, so that in the event of an explosion there should be no heavy debris flying about the factory. As far as storage is concerned, we insist at present on substantial buildings. The reason of this is, that we consider danger of explosion in a magazine comes mostly from without. If a system of authorizing explosives is enforced there should be no danger of spontaneous ignition inside a magazine. Therefore, it is necessary to have the magazine fairly substantial to protect it from dangers from without. That does not mean of necessity that you are to have your buildings constructed of either stone or brick. In certain cases we have corrugated iron magazines, which in our climate have very great advantages. If you have an explosion in a corrugated iron magazine the corrugated iron crumples up and does not fly. I would not propose in any legislation to lay down hard and fast rules as to the construction of buildings, but would have each case considered on its merits. If a manufacturer could provide a light construction and at the same time protect it from outside dangers, I think he should be perfectly at liberty to use such a structure.

Then as regards the number of work-people allowed in a building, we in our licenses limit the number. We have no very strict rule about it, but we think, and I am sure the manufacturers will agree with me, that it is advisable to limit the number as far as possible. As a general rule in buildings where nitro-glycerine is manufactured, the maximum number of persons employed is four. In buildings where the explosive is packed into cartridges, the maximum is four. Where the cartridges are boxed the limit of six is generally assigned. One of the points which struck me over here is that, as a general rule, you crowd your explosives up too much. It means that if you get an explosion in one building you not only lose probably a good deal of life, but you put your factory out of action. Now, on economic grounds, I believe it would be sounder for you to split up your risks—have smaller quantities and more buildings. With large quantities it is necessary to have your buildings very much apart. What has impressed itself on me very much is the fact, that in one factory—I will not mention names—they killed eleven people last year in packing cartridges. In the whole of England the average death rate is about five or six a year, and the actual use in England is about 15,000 tons, and the output somewhere in the neighbourhood of 40,000 tons, so I think you can do a great deal in preventing the loss of life which has gone on here. There is one other point about the licensing of factories; the system we follow is that the applicant should practically, in consultation with our Department, draft the license. When the terms and details have been arranged, the applicant has to lay the draft of the license before the local authorities. In this country presumably it would be the municipality, but of that, of course, I am not competent to speak. Then the local authority can either give its assent to the establishment; or its assent with conditions; or its dissent. In those circumstances an inspector of explosives is sent down to hold an inquiry, and to make a report to the Home Office. On his report the Home Secretary can either agree with the local authorities. decision, or over-ride it, or assent with modified conditions. He has an absolutely free hand. There are several occasions on which the local authorities have dissented, and their dissent has been upheld. In one case the factory had made no arrangements about the discharge of acid affluents, and they were proposing to discharge it into the river where the local authorities thought it would be objectionable. In that case the dissent was upheld. On one occasion the local authorities said they thought the distance of the various buildings from neighbouring dwelling houses was not sufficient. As these distances were based on our table of distances the Home Secretary refused to allow their dissent, and the license was granted. There is one other point on which I have not touched, and that is, the position of existing factories. I think existing factories should not be treated in the same way as new factories, for the present, and I propose to recommend that a certain time should elapse before they come into conformity with the system which I have outlined, except in the case of any definite building which may be regarded as a menace to the public. I do not mean that the public must come and say they think a building is definitely dangerous, but that the officers appointed under the new Act, when visiting a factory, should take particular note if there is any building which they think is absolutely dangerous, or is thought to occasion any special danger, and that then the manufacturer should be required to make some alteration, possibly by the erection of a mound screening the building, and possibly by the reduction of the maximum quantity allowed in the building.

The next point is the storage of explosives. I do not think the new Bill should interefere with any magazines which are lawfully existing at the present time in virtue of licenses granted by the provincial authorities. It is perfectly unnecessary, to my mind, to duplicate the work; the new department will have plenty of work without interfering with existing licensed magazines. With regard to magazines which are not licensed, I think a somewhat similar procedure should be adopted to that I have sketched for licensing factories—that is, the site should depend upon the distance the magazine could maintain from outside works, and the quantity should also be limited in accordance with this distance.

There is another point, the question of lightning conductors. I am not suggesting that the English practice should be followed, that every magazine should be equipped with a lightning conductor. The effect in England is that a bit of copper wire is attached to a building and occasionally it is about as much use as a horse-shoe would be on a door. What I have suggested is, that members of the scientific staffs of universities in Canada, together with representatives of the explosives trade, should form a committee, and that committee should consider the best and most economic form of protection from lightning which they can devise, and then in the interest of safety I think the occupiers of the magazines would be well advised to protect their buildings in such a way.

Then the next point is the transportation of explosives. As far as transportation by rail is concerned, I think matters should be left exactly as they are—that is, that the Railway Commissioners should control the transportation. The only difference the new legislation will have as regards that is that the quality of the explosive will be better looked after, not only when it is first made, but subsequently by a system of sampling which I shall talk about later. As regards transportation by water and by road, I think general regulations should be made, not in detail in the Act, but in virtue of sections in the Act. Generally speaking, what is desired in any Act is not to put in detail, but simply give the Minister of Mines power to make regulations. If detail is put in, the practice becomes hard and fast, and there is no scope for making changes to meet special conditions. There is one point I met in transportation by water in the far west; I heard of a case where 100 tons of explosives were put on a vessel and on top of this 100 tons a cargo of gasoline was placed. I think that is absolutely wrong. If a fire started in that vessel, and it was in the middle of Vancouver harbour, the shipping would be considerably diminished.

There is a point that has nothing to do with legislation, that has struck me—that is, the use of floating magazines where the climatic conditions are suitable. In England a large part of our explosives is stored in floating magazines. These consist of old hulks which are moored in places directed by the harbour authority, and the explosive is stored below the water line. It is a very convenient form of storage. It is out of the way of the public. You will not have people trespassing around your magazine, and it is very convenient where transportation by water is to be effected afterwards. I think such buildings should be licensed in much the same way as an ordinary magazine.

Another question is the importation of explosives. I think the English lines should be followed pretty closely there—that is, that no explosive should be imported into the country for sale until it has been authorized. It will be authorized in exactly the same way as other explosives, and when an explosive has been authorized before the importer takes out a license to import, he should have at his disposal a licensed place of storage; a license not being granted until he can show that he has storage accommodation for the explosives he proposes to import. On importation the explosive will be consigned directly to a specified place, where the samples will be taken by the Customs Officers; and until those samples have been examined by the chemical department, and reported upon as satisfactory, the explosive should remain under detention at the place of storage. If the samples prove satisfactory on examination, the explosives would be released. If they were doubtful an opportunity might be granted of further sampling, and possibly the explosive released on the condition it was used up within a limited time. If the explosive proved to be of bad quality, but not immediately dangerous, it ought to be exported, and if of a bad quality and dangerous, it should be destroyed. This would apply to explosives coming from the United States, or any other part of the world.

Then the next point is the system of inspection and sampling. It is perfectly useless to have any licensed places unless you have a certain number of people who will pay visits to see that the terms of the license are observed. I do not think you will find inspection—provided that suitable selection is made of the class of persons appointed inspectors—a very formidable thing to encounter. I think I may say that in England we are not regarded as arch enemies by most manufacturers, and very often we are regarded more as a bureau of information and assistance. It is absolutely necessary that the inspector should take samples, not only of current manufacture, but of explosives that have been manufactured for some time, to see that the standard is being maintained.

The next point, which is somewhat of detail, is the establishment of a testing station, which will be primarily for coal mine explosives. I do not know that it is necessary for me to go into the details of the test; but generally speaking the test consists of firing a charge from a cannon into an inflammable atmosphere of air and coal gas, or any other gas which may be settled on; also firing charges of explosives into a gallery in which coal dust has been placed. I have with me here a copy of the last Belgium permitted list, showing the types of explosives which have passed the Belgian test. I cannot guarantee that similar explosives will pass the new test here, but it will give you an indication roughly of the class of explosives it will probably be necessary to manufacture. There is a practical point in the working of the testing station which our manufacturers now admit—that before the testing station was established they used to incorporate their explosives for a certain time, and were absolutely convinced that they were the very best on the market and thoroughly incorporated. Since the establishment of the test station they have become satisfied that incorporation is not at all an easy thing, and it is not merely sufficient to mix things together in a rough and ready way, but a good deal of attention has to be paid to the method of mixing. The test we use for comparing the relative kinetic value consists of a ballistic pendulum. With well made explosives firing charges of four ounce weight, I get a swing of rather over 3″, and if I fire three shots I do not expect to get a greater variation than 0·010 of an inch. Then another point which might be taken up with the testing station is, investigations not only into the kinetic energy by ballistic pendulum, but also the velocity of the explosion. The object of this is to give the user some sort of idea of what a particular explosive will do. At present each new inventor says his explosive will do everything. People who deal with explosives know that is absolute nonsense. Explosives suitable for one sort of work will not do for another sort. What must be ascertained is the kinetic energy and the velocity of explosion.

Then there is the investigation of accidents in factories. If any accident by fire or explosion occurs in a factory, whether it causes bodily injury or not, it should be reported and investigated, if not by the inspector, at any rate by the staff of the factory. Very often far more is learned from an accident which does not cause injury than from one where everything is wiped out. I should like to make a criticism here generally of the factories I have visited. I think that on general lines you are right enough, but you do not pay sufficient attention to details. You have to remember that the main causes of explosions are apart from fire and spontaneous decomposition, which should not occur in a factory—except, perhaps in case of nitro-glycerine. Where decomposition takes place, there, as a rule, it does not cause an explosion. You can drown the charge in time. The danger is, of striking a thin film of explosive a blow. That will be very much worse if there is grit mixed with the explosive, and what you want particularly to look to is, to avoid any unnecessary blows. In one factory—I cannot remember the name of the machine, but it is an ordinary cartridge packing machine—I found the two big supports of the machine were loose, and every time this machine was operated it came down with a thump on the ground. Now that should not have been allowed. It was running an unnecessary risk and there was no object to be gained. Another point is that steps ought to be taken to prevent grit getting into an explosive. You cannot avoid it altogether, but you can take such steps as are possible, and one is lining the building. I notice here rubberoid is used. It seems to be an excellent material for lining a building. The buildings were as a rule properly lined, but some were not.

Then as regards accidents, in storage, transportation, and use of explosives, I feel quite sure that the Provincial Governments will assist the new department by giving information regarding accidents, both in storage and use; but it is useless to make what I might call a book of casualties. You want to have the accidents investigated in a more or less intelligent way, because it is only by ascertaining the causes of accidents and the nature of accidents, that it is possible to suggest any means of preventing them. Of course I do not mean for a moment to suppose that one will ever be able to entirely prevent accidents. That, of course, is impossible. Perhaps it would be convenient if I shortly told you the cause of accidents in the use of explosives in England. Many of them come, of course, from the use of frozen explosives. That is a thing that supervision alone can guard against. Then a certain number of accidents come from the use of weak or inefficient detonators. I am not prepared to offer any suggestion as to how you can get around that except by going for the manufacturer of the detonators, and insisting that the quality shall be good. I know of no really satisfactory test for comparing the strength of detonators; but it is a subject which should receive attention when the new testing station is established here. We have been meaning to take it up in England for a number of years, but the opportunity has never offered. Then there is another kind of accident which is very common in England. It is striking unexploded cartridges in removing debris. This is either due to frozen explosives, or to a weak detonator, or to a fault in the explosive itself. That refers more to gelatinous explosives.

Mr. BRAINARD, *Hamilton Powder Company*.—There are some things in connexion with Mr. Desborough's remarks which I should like to get information about. In this country there are a number of instances where in putting up supplies for the market you can only use the cold weather, and you have to fill up stock in the winter weather for the whole year. If you license those magazines on the maximum quantity they contain, I do not know where you would put the factories, because they would be too far away from the source of consumption, as a rule.

Captain DESBOROUGH.—What quantity would you want to put in?

Mr. BRAINARD.—It varies with the extent of the demand. Some of our magazines have 100 tons.

Captain DESBOROUGH.—According to this table, 50 tons could be 3,500 yards from a dwelling house. If you erect mounds it will be 1,750 yards. If it is so placed that the ground interposes a satisfactory screening you would be allowed to have it within 800 yards.

Mr. BRAINARD.—A number of these magazines are erected on land leased from private individuals and are not the property of the people making the explosives.

Captain DESBOROUGH.—I understand the magazines are under the control of the Provincial authorities—is that so?

Mr. BRAINARD.—I do not think private magazines on private property where explosives for their own consumption are stored, are.

Captain DESBOROUGH.—I do not know whether the Government here will accept the system we have—that is, if the occupier of a dwelling house gives his consent to the establishment of a magazine, the distances which have to be maintained are very much less. In that case the distance for 50 tons is 850 yards. That means it would be half—425 yards; if there is a mound, and if there is a substantial natural feature of the ground in between, the distance would be a quarter, or only a little over 200 yards.

Mr. BRAINARD.—Your schedule of distance would be enforced in cases of that kind?

Captain DESBOROUGH.—Yes. Personally I think you would do better to put up, instead of one magazine containing 100 tons, two magazines containing 50 tons each.

Mr. BRAINARD.—Most of these magazines are in a part of the country where concrete and sand cannot be had, and they are made of logs.

Captain DESBOROUGH.—Personally I would not object to that. No hard and fast construction should be laid down. Each case should be treated on its merits. You must not take anything I say as binding the Department at all.

Mr. BRAINARD.—When the English Explosives Act was enforced, were not existing factories licensed as they stood, without changes?

Captain DESBOROUGH.—Yes.

Mr. BRAINARD.—You do not propose to do that here?

Captain DESBOROUGH.—I am told it is not proposed to do it. It has been found very objectionable in England. In certain towns in England you walk along the main street and you hear gunpowder wheels running on either side of you. There is a magazine I am thinking of on the banks of the River Thames which has generally about 200 tons of explosives in it. That magazine is absolutely surrounded by houses and is on the river side, and if it should explode it would flood about 200 miles of country. It is an objectionable magazine and we wish we could get rid of it, but we have not the power.

Mr. BRAINARD.—I was not alluding to magazines so much as to manufacturing plants.

Captain DESBOROUGH.—In the discussions I have had with the authorities here I suggested originally that the factories should be left more or less as they are provided exceptional buildings were changed. I have been told, however, that that is not considered a good policy, so I suggested as a compromise that a limited time, so many years, should be allowed to elapse before a change was required.

Mr. BRAINARD.—I should like to know whether the proposed safety regulations for permitted explosives are to be the English?

Captain DESBOROUGH.—I ought to have told you that. The English test is being changed, and I drew up the specifications for a new gallery before leaving England. I heard this morning that they are getting on with the structure, and I suggested that the Canadian Government should wait until the English experiments are concluded. In England the gallery will be 5 feet in diameter, 44 feet long, and charges tamped with a plug will be used; and the maximum charge which will not fire the gas or dust mixture will be determined—that is the charge which will be allowed in practice. The Continental people are able to get explosives up to $2\frac{1}{4}$ pounds in weight—in fact they fill their gun completely.

Mr. BRAINARD.—You say the transportation is to be controlled by the Railway Commissioners?

Captain DESBOROUGH.—They control transportation by rail at present.

Mr. BRAINARD.—The rules will be similar to the rules in New York?

Captain DESBOROUGH.—They have adopted the same rules as the New York rules at present.

Mr. BRAINARD.—But the test will be made at Ottawa?

Captain DESBOROUGH.—Yes. There is one point I should mention. I have recommended that the Railway Commissioners should be approached regarding the transportation of small quantities of explosives. Everyone is aware that this transportation goes on now, and is nearly certain to continue, on railway trains where passengers are carried. It should be recognized that it goes on and should be regulated.

Mr. BRAINARD.—The Federal authorities have the official say about licensing; suppose there is a difference between the local authority and the Federal, will the

Federal authority prevail? Is not the object of this legislation to give the power of decision to the Federal authorities and take it out of the hands of the municipal authorities?

Captain DESBOROUGH.—It is proposed to do so as far as it is legally possible, but where the Provincial Governments have definite powers of licensing, then the Federal Government cannot come in at all. I think there is no doubt that in many cases the Provincial Governments will co-operate with the Federal Government, and I am quite sure that the Federal Government will be prepared to advise on every possible occasion.

Mr. BRAINARD.—About the strength of detonators, are you going to apply the same import rules to detonators as to explosives?

Captain DESBOROUGH.—Explosives include detonators.

Mr. BRAINARD.—There is nothing to prevent a man importing weaker detonators than are made in this country.

Captain DESBOROUGH.—Not only detonators but fireworks and sporting cartridges should all be examined. I would go further than they go in England in dealing with sporting ammunition. I think the explosives with which this ammunition is loaded should be required to come up to the same standard as that manufactured in the country.

Mr. BRAINARD.—Is it the intention of the Government to get after the consumer of these explosives as well as the manufacturer? That is, will a contractor be told that he must use only detonators of a certain strength?

Captain DESBOROUGH.—That cannot be done, I believe, as far as the use of ordinary explosives is concerned, but I think it will be done with the co-operation of the local governments as regards coal mine explosives. It would be an excellent thing if it could be done with all explosives, but I do not know if there is power.

Mr. P. LESUEUR.—In connexion with lightning protection, a principle was discovered a very long time ago which does afford absolute protection to buildings from lightning, and which has not been applied for ordinary dwellings, because of the impracticability of it, but it is quite possible for magazines. It was discovered by Faraday. It amounts to this. Inside a metal cage of any kind, as, for instance, ordinary girders of a closed bridge, no electrical phenomena can take place. This is the result, that if you have a metal roof on your magazine—tin or galvanized iron—and more or less surrounding the sides, leaving plenty of room for one door—there is only one door I believe permitted—and bury this wire netting, which may be in the form known as chicken netting, there can be no manifestation of lightning, even the mildest sort, such as would be detected by the electroscope. If a building should be actually struck by lightning, the lightning does not have a disruptive effect, provided it strikes a sufficient surface. If a wire netting were not sufficiently large it would be burned up by the electric discharge. The netting I speak of surrounding a magazine has at least twenty times sufficient carrying capacity for the heaviest lightning stroke. That appears to have been recognized in Europe; because some four years ago I saw a reference in the Engineering and Mining Journal of some place in Continental Europe where this principle, long recognized, was being applied to magazines, as being the one absolute security.

Captain DESBOROUGH.—There are very elaborate, what we call cage systems, adopted in Germany and in some places in England. My point was I did not think anything of that sort should be prescribed until people over here, particularly manufacturers, had the opportunity of trying to work out the most economical system. I laid a great deal of stress on the economical side of it.

Mr. BRAINARD.—Black powder manufacture has not been mentioned. Are you going to impose the same restrictions as to quantities?

Captain DESBOROUGH.—The factories should be licensed on the same system. For smaller quantities there is a greater reduction of distance for gunpowder.

G. M. HOWARD, of the *A. L. Howard Company, Sherbrooke, Que.*—As regards the number of employes you mentioned only the manufacturing of dynamite and the charging of cartridges. Now, I presume the regulation regarding that would differ for different manufacturing?

Captain DESBOROUGH.—Quite so. My idea is, each case should be treated on its merits. It is impossible to lay down hard and fast rules. For instance, in sporting ammunition there is not the risk there is in loading blasting cartridges, and therefore, each case should be treated absolutely on its merits.

D. W. BRAINARD, *Dominion Cartridge Company, Montreal.*—I was wondering about working magazines. Each loading building will have a small magazine outside, with comparatively little powder in it, say four or five kegs. It means considerable expense if you have to move these a long distance, and have to be continually running backwards and forwards.

Captain DESBOROUGH.—I quite appreciate that.

Mr. BRAINARD.—We should have as large an allowance as possible for small magazines.

Captain DESBOROUGH.—We consider that we have here—for 300 pounds, twenty-five yards is the distance, but if you have a screening wall in between we allow for 200 pounds at twelve and a half yards.

Mr. BRAINARD.—Is the wall of the building counted a screening wall?

Captain DESBOROUGH.—No. I do not think you need be apprehensive of any trouble there. Probably you could by partitioning your little magazine produce the same effect.

Mr. BRAINARD.—About magazines for storing detonators, it is rather complicated on that, because as soon as you can store enough for your day's work, you will need a double handling. You will have to take them to your magazine and load them again, whereas if you could start with say 60,000——

Captain DESBOROUGH.—Sixty thousand means a very small quantity of contained explosive. The distance is based entirely on contained explosive as far as detonators are concerned.

Mr. BRAINARD.—The Canadian detonators are made of practically the same strength as the American and English, and the only trouble we have from the manufacturing point of view is, that periodically some dealer will import lightly charged caps and we cannot sell a heavily charged cap cheap enough to compete with them, and we would be forced to manufacture a lower grade.

Captain DESBOROUGH.—Would it be sufficient if the weight of the detonator were strictly defined, so that imported detonators would require to come up to the standard?

Mr. Brainard.—That would be satisfactory. The trouble now is that a 5 grain detonator is imported, whereas we manufacture nothing under 8·3 grains.

Captain Desborough.—The standard detonator with us is the No. 6 which contains one gramme of composition.

Mr. Brainard.—How would you have your testing of imported ammunition done? Every dealer will import such quantities that it would be difficult to take a sample out of it.

Captain Desborough.—It will soon become known, that each man who imports ammunition has to take out a license, and that samples will be taken by the Customs for examination by the Explosives Department, and consequently only large importations will be made.

H. R. Drackett, *Superintendent Standard Explosives, Vaudreuil.*—I should like to inquire how the table of distances will apply in the way of protection outside the factory. For instance, our plant is located in a heavy bush.

Captain Desborough.—We quite appreciate the value of timber for preventing the projection of debris, but there is no guarantee that timber will grow forever, and if that timber is ever destroyed you do not get the protection afforded by it, and it would upset the whole system of distances at once. That is why we do not take timber into account in measuring distances.

Mr. Brainard.—Is there going to be any prescribed form of buttress?

Captain Desborough.—My opinion is there should not be except in the most general terms. Practically what we find best is sand or earth without heavy rubble in it, about 3 feet thick at the top and supported on either side by timber or by corrugated iron, it stands the weather so much better in England.

Mr. LeSueur.—About how thick would that be at the bottom?

Captain Desborough.—If you have corrugated iron or timber revetment, they are almost vertical.

Mr. LeSueur.—A matter of about 3 feet?

Captain Desborough.—Yes, but it is objectionable having heavy rubble in these mounds. I may mention that the German Government carried out some experiments two years ago on magazine construction. They used a type of re-inforced concrete and exploded fairly heavy charges inside the building. They found the particular concrete was so pulverized that there was no projection of debris for any distance.

Mr. D. H. McDougal, *Dominion Coal Company.*—You were speaking of a 100-ton storage magazine, and you suggested that it would be better to have two 50-ton magazines—how far apart would you propose to locate them?

Captain Desborough.—One hundred yards apart, or half that if there is an earth bank in between.

Mr. McDougal.—In that case the location governing the 50-ton plant, and the distances from residences would apply?

Captain Desborough.—Yes.

Mr. McDougal.—I should like to inquire if it is the intention to have explosives which are now on the permitted list in England, admitted for use in Canada without inspection on this side?

Captain Desborough.—I think it would be advisable to inspect every explosive that comes into the Dominion.

Mr. McDougal.—In that case you would propose, I presume, to be prepared for immediate inspection. Take the case of a shortage in the explosive supply, a company waiting for a consignment to arrive; would you have immediate inspection or would you propose to permit the use of explosives in the meantime?

Captain Desborough.—All I can tell you is what we do in England. We have been able from the time of importation to release occasionally within two days. Of course, your distances are somewhat greater here, but a certain amount of power ought to be allowed to the inspector, if he knew the factory and origin, to allow the explosive to be taken into use. We frequently do that in England.

Mr. McDougal.—Supposing your testing station were located at Ottawa, and the explosives arrived in Nova Scotia, it would take two days to send samples here.

Captain Desborough.—My view is this, that if any English manufacturer wished to get his explosive on the Canadian permitted list, he would submit a sample to be tested at Ottawa. Then subsequent importations would only be chemically tested, unless the occupier of the mine, or the mines inspector of the district wished any particular sample to be tested. I do not mean that each importation should go through the firing test, but only through the chemical test.

G. A. McPherson, *Ontario Powder Company, Kingston.*—May I ask if there are any drafts of the proposed Bill? It seems to me if we had a draft of the Bill actually before us we could study it and ask more pointed questions than we can in a general discussion.

Captain Desborough.—I can only give you the system in England. Any draft of a Government Bill is absolutely the property of the Minister, and kept confidential until laid on the table of the House. I imagine the same procedure is adopted here with regard to Government Bills.

Mr. McPherson.—There are many details that would be incorporated in the Act which we are scarcely in a position to consider to-day. One point occurs to me—what tests will be necessary for factories to enforce? How many tests? In making nitro-glycerine we run it in batches. Have we to test every batch or take a sample for a number of days and test it?

Captain Desborough.—The point, and a very necessary point, is that the factory should have a chemical department to see that they are bringing their explosives up to the required standard. There is no obligation on you to do so, but for your own protection you ought to do so. The original sample for authorization will be submitted by you, and will be subjected to certain tests by the chemical department: amongst others a stability test of some sort. If that sample proves itself to have a reasonable degree of chemical stability then it will be authorized, and you will be required to produce explosives which will pass a certain test. I may say that, at the present time, most explosives are examined chemically in England by what is known as the heat test. A committee is sitting at present in England to discuss the whole question of standardizing that heat test, and recommending another test which may be used as a check test. Everyone admits the heat test is not altogether satisfactory; but it happens to be a test that is very easy to carry out. What we want is that the manufacturer should not have his explosive condemned on one test, but that there should be other tests which could be used in the event of the explosive failing to pass the heat test. I might say it is very exceptional in England, on sampling explosives, to find one which does not satisfy the heat test. I have taken samples of dynamite twenty years old and they have been perfectly satisfactory.

Mr. McPherson.—I have had the impression that the reason for the movement to have this legislation passed is the number of accidents that have occurred on works. Will there be any move to license blasters where the actual accident occurs?

Captain Desborough.—I am suggesting that where the use of explosives is not already governed by such legislation as the Mines Regulation Act, the Minister of Mines should have power to make certain rules governing the use of explosives. That I take it would apply principally to construction works. What the scope of those rules is to be I have not definitely thought out, but I thought the Department would probably form a small committee and consult users with a view to framing a code. I quite agree that some regulations to govern firing are absolutely necessary.

Mr. McPherson.—We who are engaged in the manufacturing business feel very strongly the great number of deaths is due really to the reckless handling of explosives after they reach the point of consumption rather than to any defect in the factory.

Captain Desborough.—I quite agree with you, but you have to recognize this, that if you are going to inspect every place where explosives are used you will have half the population of Canada inspecting the other half.

Mr. McPherson.—Very true, but if we are to get out of the evil we must strike at the root.

Captain Desborough.—I think rules ought to be adopted to govern the use of explosives, and inspectors should be appointed whose principal duty would be instruction, very much in the same way as the Railway Transportation Bureau send out men to give instructions.

Mr. McPherson.—In regard to the regulations I did not quite catch whether the Federal or Provincial authorities should govern. A point very vital to persons interested in the use of explosives is the possibility that the local authorities might clash with the Dominion.

Captain Desborough.—That has been the great difficulty in this legislation. I am not a lawyer, but that is a matter which is being considered by the lawyer who is looking after the legal side of the proposed legislation.

Mr. McPherson.—The point I have mostly in mind is this—the question of local taxation. A point comes to my mind now; a few years ago we attempted to open a magazine here in Ottawa. As it happened there were no regulations at the time, but the municipality exacted a license of $500 which drove us completely out of this end of the country. Suppose the Province that is interested exacts a tax, are we likely to be subject to a further tax by the municipality, a tax that appears unjust on the face of it?

Captain Desborough.—My idea is this: where the Dominion Government has power to license a magazine, that a comparatively small fee should be paid for that license, and that no other license fee should be exacted, but I cannot tell you whether the Municipal or the Provincial people have power to extract anything from you or not.

Mr. McPherson.—My reason for bringing this up was it occurred to me it might be possible to overcome that in this legislation.

Captain Desborough.—It is a point that the lawyer who is looking after the legal side of the Bill is going into.

The Chairman.—All legal questions are in the hands of the Department of Justice who are looking after this matter entirely.

W. M. Lowery, *Ontario Torpedo Company, Petrolia.*—We manufacture nitro-glycerine and use it for oil and gas wells in its natural state. How would we get samples here?

Captain Desborough.—How do you transport it?

Mr. Lowery.—With teams.

Captain Desborough.—The liquid nitro-glycerine?

Mr. Lowery.—Yes.

Captain Desborough.—Well, I cannot say that that is a wise proceeding at all.

Mr. Lowery.—That is the only way. It is just a point that occurred to me.

Captain Desborough.—A very important one from your point of view.

Mr. Lowery.—It does not come under the head of dynamite, so we cannot ship it at all.

Captain Desborough.—Do you transport it great distances?

Mr. Lowery.—Sometimes a couple of hundred miles with a team.

Captain Desborough.—Why do you not adopt the original system of Alfred Nobel, that is absorb your nitro-glycerine with kieselguhr for safe transportation, and afterwards extract the nitro-glycerine from the kieselguhr?

Mr. Lowery.—That would not do in this case. You have to use it as soon as you get it there.

Captain Desborough.—I cannot give you an answer right off. It requires a good deal of consideration.

A. C. Tagge, *Canada Cement Company.*—From the standpoint of the user of small quantities, may I ask what is your recommendation for a small magazine suitable for holding a carload, say ten tons?

Captain Desborough.—In what respect?

Mr. Tagge.—Distance from other buildings and public roads?

Captain Desborough.—That would be governed more or less by this table which would have to be modified more or less to suit Canadian conditions. Some do not apply and others should be inserted. For a dwelling house with the consent of the occupier the distance for ten tons is 250 yards, and without the consent of the occupier 850 yards. Those distances should be halved if the building is mounded, and reduced three-quarters if there are substantial natural features of the ground in between.

Mr. Tagge.—How would the location of that be with reference to public roads?

Captain Desborough.—Our distance is 120 yards without mounds.

Mr. Howard.—The transportation of samples might possibly be a very serious matter. As regards crude fulminate of mercury, it is not allowed to be transported at all except in a freight car by itself. You cannot carry it on your person in a crude state if it is known, and the transportation of a sample, if a sample is required to be sent, even a small quantity, might be a serious matter.

Sometimes quite considerable quantities are imported and manufactured in different places in the country, and as I understand a sample must be furnished at some time or another if you are going to obtain a license.

Captain DESBOROUGH.—Fulminate of mercury is so well known that I think the chemical department would authorize it without examination. I cannot understand why anyone should want to carry fulminate of mercury in its crude state on his person.

Mr. HOWARD.—Except for a sample.

Captain DESBOROUGH.—We have a system in England by which persons are allowed to carry samples to the central office in London.

Mr. HOWARD.—Railways will not carry such persons here.

Captain DESBOROUGH.—I think that could be arranged.

J. J. RILEY, *Northern Explosives Company, Montreal.*—For my own part I am very glad to have an opportunity of coming here, and on behalf of my Company we welcome the fact that the Dominion is going to undertake the legislation which we felt was coming. We do not want provincial legislation with different laws and regulations in every Province. I had hoped we would have heard to-day something more definite than we have had put before us by Captain Desborough for discussion. There are various points he has dealt with very generally, but we have not had a chance to go into many matters. No doubt the details will be left to us later when we see the Bill. If we could have a draft outline, not necessarily the Bill itself, embodying the table of distances and other matters that we could study carefully, perhaps we could have expressed our views more clearly on this question. There are a great many things that will come up. For instance, one of the questions Captain Desborough mentioned, to try and get us lighter rates as they have in the States, the right to transport less than 5,000 pounds without paying for 5,000 pounds—such matters as that. Then there is the question of taxes to be raised, the cost of this testing station and bureau, and other important matters especially for small companies. The question of the cost of running a bureau must be considered. If we could possibly have, before this becomes a finality, some sort of rough draft, not necessarily the Act itself, we might have a better opportunity of studying it. While I say this, I do not wish to convey the impression that we are not favourable to the movement; in fact we are extremely favourable to legislation being prepared, but we have not had an opportunity of going into the details to-day.

Captain DESBOROUGH.—What I have been endeavouring to do in the Act itself is, to put in as little detail as possible, for this reason: if you put in detail you stereotype the practice, and that is bad for the industry and for the country. My view was, the Department would probably follow the English system, and when any change is made by Order-in-Council, the trade would be first consulted.

Mr. RILEY.—That from your point of view is extremely nice. If we had you here permanently carrying out the Act there would possibly be no trouble, but in this Act we are up against a difficulty of getting inspectors to carry it out.

Captain DESBOROUGH.—I quite admit that the administration of any Act depends very largely on the inspection staff, and I can only tell you I have spoken very strongly to Mr. Templeman on the subject, and urged him that he must really try to get the best men he can; and to do that he must be prepared to pay them adequately. The other matter you have touched on, the matter of fees, I cannot suggest definitely what fees should be paid over here; but I am leaving behind me the scale of fees we have, and I am told they are extraordinarily insignificant; but whether the Dominion Government will be satisfied with an insignificant scale of fees or not I do not know. For instance, a factory license in England costs £10—less than $50—and is in perpetuity, so long as the terms of the license are observed. I understand a license in perpetuity is not considered advisable here, and it will be renewable each year.

Mr. RILEY.—Another point that does not seem to have been touched upon by Mr. McPherson, is the use of explosives. I agree with him that most of the accidents which have occurred have been in connexion with the use of explosives after they have left the factory. It is a difficult matter to tackle by legislation, and I would suggest the Government should deal with it as the other Departments do—for instance, the Dairy Department—by instructors.

Captain DESBOROUGH.—That is very wise.

Mr. LESUEUR.—Many of the men employed on construction works are foreigners who do not understand the language, and even if they did it would be hard to teach any of them who are over forty years old anything new. The instructors would find it difficult to teach an old dog new tricks.

Captain DESBOROUGH.—The Norwegian Consul has written to Norway suggesting that no more emigrants should come to Canada because they are being destroyed so quickly.

Mr. LOWERY.—In storing nitro-glycerine in the pure state, will a pound of it be considered equal to a pound of dynamite?

Captain DESBOROUGH.—No, I think nitro-glycerine should have a greater distance. It has been our experience that during the manufacture of nitro-glycerine the radius of destruction is greater. Nitro-glycerine is only used as a drug in England. It is a matter which will have to be discussed later on.

Mr. BRAINARD.—Is there any restriction on ordinary smokeless powder? Take ammunition factories—we have eight or nine types of standard smokeless powders. There is no restriction with regard to the storing of these in the one magazine, supposing it contains no higher explosive?

Captain DESBOROUGH.—No, we look upon them all as being equally dangerous, or if you prefer it, equally safe.

Mr. RILEY.—When will the Bill likely go into effect, and what time will you give us to conform to the Bill?

The CHAIRMAN.—That is still under consideration. This Conference is solely preliminary to the draft of the Bill, but as far as the administration is concerned I am quite sure that the Minister will be very glad indeed to obtain the ablest inspector that can be had. The administration is the important part of the whole thing.

Captain DESBOROUGH.—What limit of time would you think reasonable after which you would be required to conform with the new system?

Mr. BRAINARD.—I agree with Col. Riley that we would have to see the Bill and learn what detail is embodied in it.

Captain Desborough.—The Bill will have very little detail. It will simply say so far as licensing a factory is concerned that no explosives may be manufactured except in a licensed factory and the Minister of Mines will grant such license.

Mr. Brainard.—With regard to the time, all the eastern dynamite plants in Quebec cannot do construction work in the factory in winter. You have to keep the plant going and your building operations are restricted to the summer months.

Captain Desborough.—I do not want to tie you down to a definite time. If you say anything it will not be cast in your teeth afterwards; but would three years be enough?

Mr. Brainard.—I would rather have five.

Mr. Riley.—Five years is better. It means constructing a great many buildings. For existing factories five years is little enough.

Mr. Brainard.—I do not know whether it has come to your notice or not, but the Bureau of Safe Transportation of Explosives in the States has been in consultation with the manufacturers for five or six months past, for the revision of the English distance tables. I have a copy of the list here—it is not made public yet—in which the results of the investigations are given as compared with the existing English laws. Before you go I should like to have the privilege of showing you this.

Captain Desborough.—I should like to have a copy of it. I do not look upon this table I have as perfect. It was drawn up thirty years ago and things have advanced very much since then. When you start a table of this kind it is difficult to alter it; but I do not think it is applicable to Canadian conditions as it stands. Personally I feel, as far as magazines are concerned, if you could evolve the perfect magazine which will not scatter heavy debris, it is quite possible the distances mentioned here could be materially diminished.

The Chairman.—I would advise you, gentlemen, to obtain all the information you can from Captain Desborough. You see in what a peculiar position we are placed. The Captain will sail on the 6th of October, and after that if any point comes up it will be necessary to correspond with him, and you know that is not a very satisfactory way of getting information. It takes a long time, and sometimes certain parts are misunderstood. The Conference is held for the sole purpose of enabling Captain Desborough to see how you feel with regard to his recommendations, in order that he may finally revise the draft Bill, made up last year. Therefore, I shall be very glad indeed if you will ask any questions that occur to you, and inform yourselves, as far as you can, as to the character of the Bill.

Captain Desborough.—With regard to the table of distances, I did not propose that any table of distances should be definitely incorporated in the Bill. What I wanted was, that the licensing of factories should be carried out on the general principle that the quantity of explosives allowed to be in a building depended upon the distance of the building from other buildings. I may say the Germans have recently issued new regulations which practically adopt this particular table.

Mr. McPherson.—I should like to say this meeting has been called for the purpose of absorbing what Captain Desborough has explained. The difficulty I find is that while we have his exposition of his position, we have nothing we can study over. If we have something definite before us, we can state our objections or otherwise. Many questions will occur to us after this meeting has adjourned, which at the moment do not come to us, because we have nothing in black and white that we can study as a basis. If we had something to look over we could see the position distinctly, and it seems to me it would advance the matter very quickly if we could have before us something like a synopsis of the Bill. With such a statement before us, we could come back with quite a budget which could be discussed here. I do not know if there is any draft of the Bill of last year, or whether it could be submitted to us.

The CHAIRMAN.—The Bill which has been drafted, only gives general powers, and contains scarcely any detail. All the detail belongs to the administration; that is to say, when new regulations are to be made, authorized by the Bill, it will be done by Order-in-Council. There will be plenty of opportunity given the parties affected by such Order-in-Council, for consultation. I do not think the draft Bill would tell you anything specially. All the main points will be administration affairs and Orders-in-Council, and you will have plenty of opportunity to be consulted in the matter. The Bill is in the hands of the lawyer solely for the purposes of ascertaining how far the Dominion Government can go, without interfering with the Provincial authorities. It will be a very short Bill, indeed. Some matters that Captain Desborough has presented to you are the vital points which he is going to recommend, and I am very anxious that you should ask him every question that affects you; because on this will be based his final report to me. We cannot proceed in any other way; it is utterly impossible for me to take any other course. The Bill does not belong to me, but to the Minister. I am very glad one particular point was mentioned: it is better to have no law than to have a law poorly administered. This subject is of such a technical character, and of such vital importance that it is necessary to have the very ablest and best man available, at the head of the inspection. The question of salary arises. The salaries offered by the Government are too low to tempt anyone with special ability to accept the position; but in this case an exception ought to be made.

THOMAS GIBSON, *Deputy Minister of Mines for Ontario*.—The discussion upon this matter has proceeded so far, almost entirely from the point of view of the manufacturers of explosives. I assume that most of the gentlemen present in this meeting are manufacturers of explosives, or represent manufacturers of explosives. I had the honour to receive an invitation to attend this Conference, and I am very glad indeed to be here. I wish to say at the outset, that so far as I can speak for the Government of the Province of Ontario, they are heartily in sympathy with the decision of the Dominion Government to legislate upon this matter. In fact it has been the view of the Bureau of Mines in Ontario—and I think the view of a good many of the mine owners of Ontario—that in this question of explosives, the supervision of manufacturing has been left too long in abeyance, and that the time has fully come when some step should be taken to put it in a more satisfactory position. At the root of all legislation in Canada, as the Chairman has pointed out, lies the question of what jurisdiction does the proposed legislation come under. We have a Federal system, the Government of the Dominion of Canada; and the governments of the several provinces of Canada; and the constitution of our country divides the jurisdiction between the Parliament of Canada and the various local legislatures. It would be not only inadvisable, but it would be useless to attempt to disregard these fundamental provisions of the constitution of our country in any legislation whatever. In this legislation, as it has been roughly suggested, so far, undoubtedly questions of jurisdiction will arise. I am not here to say what the position of the Government of the Province of Onatrio will be with regard to any legislation until that legislation is before us. I have not any doubt, whatever, that the legal adviser of the Dominion Government in connexion with this proposed legislation will take the utmost care to preserve the spirit and letter of the constitution in regard to the powers and functions which belong to the central government, and those which belong to the local government. It would seem to me a reasonable division if it could be on these lines: that the supervision of the manufacture of explosives, and the supervision and inspection of distributing magazines should be in the hands of the Dominion Government, and subject to Federal legislation.

That is a matter of trade and commerce, as I understand it, and so long as the explosive remains in the form of a commodity which is open to purchase and sale: then I think it is and ought to be subject to the supervision and jurisdiction of the Dominion Government and Parliament. It is somewhat different when you come to put that explosive into action, when you carry it into the quarries, the mines, or whatever work it is to be used for. The question of the use of explosives, how they should be used in mines for instance—I speak of mines and quarries because they come under the Department to which I belong—these have been regulated in the past by Provincial legislation. There seems to be no doubt that the Provinces have power to enact such legislation. I do not suppose for a moment that the Dominion Government will attempt to trench on that ground of jurisdiction. The use of explosives in mines differs from the use of explosives in public works: for instance, such works as the construction of railways, in which large quantities of explosives are used. The great majority of the railways are under jurisdiction of the Federal Government, but the mining lands of the Provinces belong to the Crown, as represented by the Provinces. They are sold by them, and in the legislature of these several Provinces, lies the power to enact such legislation as they may desire to attach to any lands, or mines, or quarries in these various Provinces. I only wish to make the point clear so that there may not be any misapprehension on the subject. This is not a matter, I assume, which very vitally concerns the manufacturers of explosives, except in this way, that whatever legislation is enacted must be authoritative legislation, and must be enacted by that government to which, under the constitution, such powers and functions are assigned. Otherwise the legislation will be ineffective and at the mercy of those whom it is intended to stop, if they should choose to oppose it and defend it in the courts. Should a matter ever come before the courts they will undoubtedly decide whether the legislation is constitutional or otherwise. There are two matters of public importance which might be achieved by legislation of this kind. I do not say this with any intention or desire to reflect on the manufacturers of explosives in Canada. I think there is a possibility of improvement in all things, and I have no doubt it is possible to improve the character of explosives which are used and manufactured in our own country. If the legislation will enact that factories for the manufacture of explosives in Canada are to be subject to supervision, and that supervision is the right kind of supervision, it will have a tendency to improve the quality of explosives, and will be a guarantee to the man who uses the explosive that he is getting what he thinks he is getting; that he is not getting 35 or 40 per cent dynamite, when he is paying for 50. That will have a tendency—by improving the quality of explosives—to lessen the number of accidents which occur in our mines. It is undoubtedly true, and distressingly true, that we have too many accidents in our mines. How many accidents are due to the inferiority of explosives or to the negligence, incompetence, or ignorance of those who use the explosives is a matter I am not prepared to decide, and which I fancy will be very difficult to determine, but anything that can be done in the way of improving the situation will be generally welcomed. The point of view I look upon it from, is of necessity different from the point of view you gentlemen look upon it from. What the Government of Ontario has in mind is the improvement of conditions in our mines, and especially the safety and health of those employed in the mines. If this legislation is of such a character as to improve conditions in that respect, it will have the sympathetic and hearty co-operation, so far as I am able to pledge it, of the Department which I have the honour to represent. (Applause).

Mr. Brainard.—I know it is quite impossible to get a draft of the Bill, but could we not adjourn for a few days and in the meantime have copies of the minutes of this meeting sent to us, and we could then hold another general meeting?

The Chairman.—Copies will be sent to every one who is here to-day. I may explain that Captain Desborough has been travelling all over the country. He was to have sailed on the 16th of this month. We cabled asking permission to have him remain with us a little longer—for I did not know exactly when Captain Desborough would be back and when we could hold a Conference—and he has been allowed to stay until the 6th of October.

On motion, the meeting decided to adjourn, and to hold another Conference a week hence (September 30, 1910).

The meeting then adjourned.

(*For Report of Proceedings of adjourned Conference, see page* 204.)

ADJOURNED CONFERENCE ON PROPOSED LEGISLATION TO REGULATE THE MANUFACTURE, IMPORTATION, AND TESTING OF EXPLOSIVES.

Room 16, House of Commons,
Ottawa, September 30, 1910.

The Conference resumed at 10 a.m., Dr. Eugene Haanel, Director of Mines, in the chair.

There were present:—
Captain Desborough, H.M. Inspector of Explosives, Home Office, London.
Joseph G. S. Hudson, Mines Branch, Department of Mines.
E. T. Corkill, Inspector of Mines for Ontario, Toronto.
William McMaster, President Hamilton Powder Company, Montreal.
J. Murray Wilson, Manager Hamilton Powder Company, Belœil Station, Que.
A. E. Blood, Bureau Safe Transportation of Explosives, New York, Toronto.
Daniel Smith, President Ontario Powder Company, Kingston.
C. A. McPherson, Secretary Ontario Powder Company, Kingston.
H. R. Drackett, Superintendent Standard Explosives Company, Vaudreuil.
Jas. J. Riley, Vice-President Northern Explosives Company, Montreal.
E. A. LeSueur, Ottawa.
Lionel Kent, The Energite Explosives Company, Montreal.
Mr. Gallagher, Standard Explosives Company, Vaudreuil.
Col. William White, Ottawa.

The Chairman.—At the last meeting, which was held on the 23rd of September, the parties interested in the proposed legislation on explosives heard the recommendations of Captain Desborough, which he is to make to the Government; in connexion with the drafting of the proposed Bill. It was thought desirable that an opportunity should be given to the parties who were then present to digest what he said, and to prepare themselves to ask further questions at an adjourned meeting. We are here this morning for this purpose, and if you have any further questions to ask, or if you desire to discuss with Captain Desborough points which may have come up in your minds with respect to the proposed Bill, I shall be very glad if you will proceed to do so. A desire was expressed at the meeting held on the 23rd inst. that copies of the proceedings should be sent to those present on that occasion. We had less than a week to get that report out, but copies were mailed, and I hope you received them in time to enable you to read the report, and digest it. Captain Desborough desires me to mention that he has a recommendation to make, in connexion with the appointment of a committee to consider the best type of magazine construction, and I should like to hear from him on that point.

Captain Desborough.—Dr. Haanel and gentlemen: I am recommending to the Mines Department that they should consider the advisability of forming a small committee: consisting of a member of the Mines Department; possibly an officer from the Militia Department who is interested in the storage of explosives; one member of the Public Works Department—who would be an expert on buildings, and two representatives of the explosives trade. I should suggest that the explosives trade be prepared to supply a limited quantity of explosives for these experiments, and that the experiments should, in general, consist of putting up three or more types of magazines, and then exploding say a ton of explosives in each, and noting the effect of the explosion, more particularly with regard to the projection of debris. The types of buildings I would suggest to be experimented with are: (1) the expanded metal with a cement plaster; (2)—if I can procure the details—the German specially reinforced concrete; (3) a log magazine; and (4) and (5), any particular types which the committee think desirable to test. In carrying out the experiments, I think the explosive should be placed at one end of the magazine, leaving as much air space as possible between the explosive and the far end, the idea being that the explosive which is close to the wall will shatter that wall, but it is not at all certain that the wall at the far end will be equally shattered. When these experiments are being carried out, particularly with regard to expanded metal and reinforced concrete, it might be advisable to see if the expanded metal and iron in the construction of reinforced concrete could not be utilized to protect the buildings from lightning. The other main point that the committee should bear in mind is that the magazine should be reasonably secure against unlawful entry, and also that the cost of construction should be as economical as possible.

Mr. James J. Riley, *Vice-President, Northern Explosives Company, Montreal.*—Will Captain Desborough be good enough to outline to us his views on an ideal construction for a powder factory? Probably some of us have to do a little building even this autumn or before the new legislation will be operative, and we would like to have Captain Desborough's ideas of what we should strive for.

Captain Desborough.—I am afraid that is too big a proposition.

Mr. Daniel Smith, *President of the Ontario Powder Company, Kingston.*—I should like to ask Captain Desborough if he has had much experience in brick magazines. I have always been of the impression that brick is the best material for such a building, because if an explosion takes place the brick is pulverized into dust. If the magazine is constructed of stone the explosion will scatter it like cannon balls. I have seen magazines where the door of the magazine, made of iron, was used as a target. A brick wall one foot thick will keep any bullet out. I do not know so much about iron and concrete.

Captain Desborough.—In England all our magazines, except floating magazines, are made either of stone work or brick work. We have had only two occasions in the last forty years in which explosions have occurred inside a magazine. In one case the magazine was filled with ten tons of sporting powder, and it burned away harmlessly. In the other case the magazine contained a ton of black powder and 150 pounds of gelignite. In this case there was a very violent explosion, and bricks were projected a considerable distance.

Mr. SMITH.—I know of only one case, which occurred in Brockville a number of years ago, where there was an explosion in a small factory. In that instance the brick chimney was pulverized into dust, while the stones in the building were thrown all over the field.

Captain DESBOROUGH.—I have the experience of only one magazine. There was another case where the explosive was stored in a concrete building belonging to the British Government, near Woolwich, in which an explosion occurred; but the magazine was divided into six compartments by very substantial concrete walls. The explosion occurred in one of the compartments, and pulverized the concrete in its immediate neighbourhood. The further walls of the other compartments were projected in blocks, some of them weighing half a ton, a distance of 700 or 800 yards, so it seems that the ordinary concrete is a very bad form of construction. I will try and find a report of the experiments I mentioned the other day, which the Germans had been making with specially reinforced concrete. If I can procure it I shall send a copy of it here. I first saw a short abstract of it in the Journal of the Society of Chemical Industry in England. I may say I am a very great believer in putting earth banks around magazines. They prevent a good deal of the debris being projected, and also very considerably arrest the wave arising from an explosion. We heard, I think it was last week, of an experience with a magazine in British Columbia which was built of logs, and surrounded with, I think, about two feet of earth. This was in the middle of a forest fire where everything else was absolutely wiped out, but the magazine remained, and the explosive inside was not damaged in any way, not even by the heat of the fire passing over the roof.

Mr. SMITH.—We have had some experience with several magazines in this new territory to the north. For instance, at Sudbury, twelve or fifteen years ago, a company had a magazine built of logs and covered with earth. A fire came and the man fought it, and it was safe so long as the fire did not touch it. Being covered with earth, it was protected.

Captain DESBOROUGH.—I do not like to tie you down to any hard and fast structure. A magazine which would be suitable in one place might be unsuitable in another. The object I have tried to attain in assisting to draft this Bill is to include as little hard and fast regulation in the Act as possible, but to have all the regulations administered by Order-in-Council, so as to allow plenty of scope for differences of conditions or material.

Mr. J. MURRAY WILSON, *Manager Hamilton Powder Company, Quebec.*—Last week Mr. Drackett, of the Standard Explosives Company, asked if a plant were located in heavy bush, whether that would count as a natural protection instead of embankments, and you replied that there was no guarantee that the timber protection would be there permanently, that if the timber should be destroyed there would be no protection afforded, and that, that is why timber is not taken into account in connexion with measuring distances. As soon as the underbrush is cleared away, so that there is no danger from fire, I think trees are the very best protection. You agreed that they are, and I do not think any explosive factory would deliberately clear away trees which are so good a protection. The trees grow larger every year, and are even a better protection than embankments. I think trees ought to be taken the same as mounds or hills—should be taken as equivalent to an embankment.

Captain Desborough.—I agree that trees do intercept a great amount of debris projected by an explosion. If Mr. Wilson were always managing a factory so protected it might possibly be advisable to take into consideration the fact that trees are there. On the other hand, there are a number of factory managers who dislike trees very much. They say that they prefer to have the buildings quite open, where they can see what is going on. I do not think there is much in that myself, but there are people who do hold those opinions.

Mr. H. R. Drackett, *Superintendent Standard Explosives Company, Vaudreuil.*—Would not a mound shut off the buildings from view very much the same way as timber? In fact, if the mound were on all sides it would perhaps shut it off still more.

Captain Desborough.—The mound does shut off the buildings from view, but does not shut off the ground between the buildings, and the idea is that the manager of the factory wants to see when an explosive is being transported from one building to another. There is another point about trees, how are you going to settle what growth of trees will be accepted?

Mr. Drackett.—I should think from what you have said that the Act will be administered by the head of the department, and that would be a matter for his judgment in each case, of course. Last week I asked some questions about the use of timber growth as a protection, and I find that our timber growth has been standing within the memory of the oldest inhabitant, and probably will stand for some generations, because we are very careful of our timber growth and nurse it along at all times.

Captain Desborough.—Then if the trees were taken into consideration I suppose you would see no objection to inserting a clause in the license that the distance should only be considered adequate so long as the trees were standing.

Mr. Drackett.—Certainly that would be accepted, I think. We would not expect to take any advantage of the fact that where we have timber growth we could cut it down and do away with our protection.

Captain Desborough.—Timber is getting more and more valuable.

Mr. Drackett.—If we had to erect mounds it would be quite an expense for us where we have already a very efficient protection, because our ground is all rock. We would have to bring in enough dirt from some outside point to make mounds there.

Captain Desborough.—I was principally referring to magazines when I spoke of mounding, and not to working buildings. What was really in my mind was the outlying magazines, what I should call distributing magazines.

Mr. Drackett.—In a case like that the greatest danger is they are considered to be outside the buildings.

Captain Desborough.—I agree.

Mr. Drackett.—In that case, perhaps, the timber would be a source of danger through fire.

Captain Desborough.—I quite agree.

Mr. Drackett.—But in construction it is altogether a different matter, it seems to me.

Mr. C. A. McPherson, *Ontario Powder Company, Kingston.*—It seems to me that trees surrounding a magazine in the outlying districts would serve to keep the public at a distance, and to keep private dwellings away, so it occurs to me that trees would be a very good protection, not only as a barrier against falling debris, but as a means of keeping people from building close to the magazine. It might be well to consider it in that respect.

Captain DESBOROUGH.—Yes, except I do not think it was ever suggested that the existence of trees would be a bar to the establishment of a magazine. I think we are at cross purposes.

Mr. MCPHERSON.—It occurs to me that while trees are considered a good natural barrier, they should be regarded also as a barrier to the building of houses nearer the magazines.

Captain DESBOROUGH.—As far as dwelling houses are concerned a magazine should only be allowed to exist, containing a specified quantity, so long as the distance required between the magazine and dwelling houses is maintained. If a property owner had a right to build a house alongside a magazine, and proceeded to build it, then the magazine license would become extinct.

Mr. DRACKETT.—That raises a very important point. For instance, a distributing magazine might be built in some district in conformity with the table of distances; that being the case would the owner of the magazine have any guarantee that your bureau would protect him from the encroachment of dwellings?

Captain DESBOROUGH.—No.

Mr DRACKETT.—Suppose we put up a magazine for explosives and some one undertakes to build near it, I suppose the only way we could protect ourselves would be by purchasing the land near the magazine to prevent any one coming in.

Captain DESBOROUGH.—As a rule, the effect of building a magazine is to prevent the erection of other buildings near the place.

Mr. DRACKETT.—It has not always been the case. I think Mr. Smith could give you some light on that point. We were just discussing it last night. If you have fifty tons in a magazine, you must have a distance of 850 yards. Is that correct?

Captain DESBOROUGH.—If you get the consent of the occupier the full distance is 850 yards, but if you have an earth bank between the magazine and the dwelling house the distance may be reduced to 425 yards, or if there is a substantial natural feature between, then the distance would be about 216 yards.

Mr. DRACKETT.—Say we do not receive permission, we must, therefore, put our buildings 850 yards from other buildings. That means a square mile of property.

Captain DESBOROUGH.—It would be necessary then to put up an earth bank, which would reduce the distance.

Mr. DRACKETT.—That would still be half a mile.

Captain DESBOROUGH.—I do not quite see how to get around that. The way our people get around it is, they use a fairly large number of small magazines—20-ton magazines. You must remember in England we are very crowded, and it is difficult to get a site for a magazine at all, but still we manage to use 30,000,000 pounds of explosives every year, and all that is kept at specified distances. I do not think in practice you will find the difficulty you anticipate.

Mr. SMITH.—A few years ago we built a magazine in Cobalt, when the mines were first discovered there, and we cut a road about half a mile into the woods and built a log magazine covered with sheet iron, banked it, and fixed it up as we thought was right. That autumn the discovery of silver was made known generally. Miners went there in flocks, and went in by our road and built a town near the magazine. A bush fire came. They did not pay much attention to it until it got near the magazine, and then they made tracks down the railway. The country being new, and there being veins in the rock, leaves accumulated in them and the fire followed them up, and ran under the magazine and set it off. You have heard of the explosion, I presume?

Captain DESBOROUGH.—Yes.

Mr. SMITH.—In a mining district like Sudbury, you cannot buy a large block of land—the Ontario Government would not sell a mile square—and the consequence is we could not build a magazine there where it is quite essential. The quantities stored vary. Sometimes we have to carry a larger stock than at other times in those isolated places, and if we should have a large quantity it would be necessary to move the magazine farther away than when a small quantity is stored. In that event it would be necessary to have the magazine on wheels or runners.

Captain DESBOROUGH.—Cobalt cannot be described as a flat plain, and I am quite sure there are many hollows in the ground that would enable you to maintain a quarter of these distances. I think, possibly, Cobalt may be an exception. Perhaps it would be better for Canada if it were not, but you cannot expect to have tremendous developments in such a rich country in very many places.

Mr. SMITH.—You were speaking of trees as a protection. We find that the trees are a great protection, not only against flying debris, but also against carrying the sound. If an explosion occurs in such a place the trees around it throw the sound up. For instance, if you see a train approaching, and stand behind a clump of bushes until it passes, you do not hear much sound.

Captain DESBOROUGH.—I quite recognize the very great value of having the protection of trees.

Mr. SMITH.—Our factory stands in a very nice clump of trees. We have had a couple of explosions there, and I consider the trees afforded very good protection. It is the wave that does the damage, the movement of air, and the trees carry the waves upward.

Mr. LIONEL KENT, *the Energite Explosives Company, Montreal.*—Mr. Smith's remarks on the subject of the advisability of having trees surrounding magazines and factory buildings recall to my mind the differences in point of view taken by some of the municipalities on that subject. Our factory is situated in the township of Bucke, near Haileybury. Under the municipal regulations there we are not allowed to have trees or brush within some twenty rods of any of our buildings or magazines, and for that very reason we have been compelled to clear them away, the danger arising from bush fires in that district not being considered by any means insignificant. Before getting away from the subject of the construction of magazines, I notice Captain Desborough, that you make mention of sheet-iron magazines as having been adopted in England or in use there.

Captain DESBOROUGH.—We do use them in England, but every one I have mentioned them to here, says that, owing to climatic conditions, they are unsuitable. I do not see the slightest objection to using corrugated iron buildings in a certain way for magazine construction.

Mr. Kent.—The only objection you have heard is that climatic conditions render them objectionable at certain seasons of the year?

Captain Desborough.—Unwise.

Mr. E. A. LeSueur.—You mentioned 850 yards as the distance required for a magazine containing not more than 50 tons.

Captain Desborough.—With the consent of the occupier.

Mr. LeSueur.—Without the consent of the occupier what would the distance be?

Captain Desborough.—Three thousand five hundred yards, that is unmounded, but it is almost inconceivable that you would find 3,500 yards of flat country in the Sudbury district.

Mr. McPherson.—Some mention was made at our last meeting of a revised table of distance. I do not happen to have one of those tables. Is there any probability that the revised tables will be adopted?

Captain Desborough.—I cannot tell you what the Dominion Government will do in the matter, but I think that I may say this, that the new table is produced by the manufacturers of explosives. I do not doubt their integrity in the least, but one must remember they are very interested parties and, therefore, before one accepts such a table one would have to be very well satisfied that the distances were adequate. I may say, in the new revised table sent to me it was expressly stated that the new distances did not protect any building against projection by debris. It is very nice from the manufacturers' point of view; but if the Government sanctioned such conditions as might occur similar to what did occur in Hull, I think the Government would have a very unpleasant time, and rightly. The existing table of distances has been adopted by the bulk of the European countries, by South Africa, by Australia, and by India, and if the new one were adopted, reducing these distances about 75 per cent straightway, I think it would be a very bold step to take.

Mr. McPherson.—In your opening remarks you suggested that a committee should be formed of three Government officials and three representatives of the explosives trade, for the purpose, apparently, of experimenting on this question. The present table, therefore, would probably be adopted temporarily until such time as a new table might be arranged.

Captain Desborough.—My view was not so much to deal with the table of distances as to afford information about preventing the projection of debris. Remember in this country your dwelling houses, outside of the cities, are almost entirely frame houses. These are much more susceptible to damage than buildings of stone or brick which you find in other countries. Therefore it is absolutely essential to take such steps as you can to minimize the damage which would occur from debris in case of an explosion. I would not like to base the distances on experiments with one ton of explosives—I would not like to say that it would indicate what might happen if 50 or 100 tons of explosives were exploded. I do not think the manufacturers would care to furnish 100 tons to be exploded at one time; it would be an expensive experiment to carry out.

Mr. McPherson.—The Government might co-operate and furnish the explosives. It occurred to me that up to the quantity exploded it might be well to have a revised table in mind, to govern such quantities as might be experimented with.

Captain Desborough.—You may be very wealthy people out here, but if you are going to use enough explosives to make tests on a large scale, I think you will find it very expensive.

Mr. McPherson.—Up to one ton was suggested.

Captain Desborough.—That is a very small amount.

Mr. McPherson.—It would be interesting to manufacturers to have experiments on a large scale. Apart from our magazine, and perhaps one other building on the works, we would not expect to have 100 tons in any one of the buildings. Then it would be interesting to us to know just what distances might be considered safe.

Captain Desborough.—I have been endeavouring to get the English Government to carry out such experiments for the last eight years, and have failed to persuade them. I mentioned it this morning in the hope that you people would be ready to co-operate with the Dominion Government. I think the experiments would be most valuable, particularly if carried out in a reasonable way, keeping economy in view.

Mr. McPherson.—Economy would be, of course, one determining factor. For instance, if we have regulations put into force here which will mean that we will have to transport our material back and forth, let us say a quarter of a mile between the different buildings on the work, it means that our finished product is going to cost a great deal more than the same explosive manufactured in the United States, where the regulations may be entirely different. I do not know if they are. Supposing our cost is increased by even a fraction of a cent in the pound, where we have certain markets where we come into competition very keenly with the United States dynamite, I imagine in those conditions we might be entirely shut out.

Captain Desborough.—If my recommendation is adopted no United States explosive will come into Canada, except by virtue of an importation license. The United States manufacturer will be required to have his explosive authorized in the ordinary way. Any explosive coming into Canada will be held in bond until samples have been examined by the chemical officers of the new department, and it will not be released for distribution until the chemical advisers have reported favourably on the samples taken by the customs officers.

Mr. McPherson.—I have reference more especially to another of our colonies where there is no protection or duty of any kind, and where we have to compete with United States dynamite. They probably will not have any regulations of this kind, but the explosives used there will be either Canadian or American. If we are handicapped to the extent of even a small fraction of a cent we will be cut out of that market, which we consider peculiarly our own, so that if you can in any way reduce the distance between buildings on the works, it is a very important point to the manufacturers where others may have an advantage in the trade. I merely mention it in order that these questions may be taken into consideration.

Captain Desborough.—I have here the intra-table of distances which we use. The distances are very much smaller inside the factory than in relation to buildings outside. For ordinary blasting explosives, if a building is mounded you can have 50,000 pounds at 75 yards. I do not think there are many working buildings where you will want anything near 50,000 pounds. The distance for 2,000 pounds, if mounded, is 50 yards.

Mr. RILEY.—What is the distance for 5,000 pounds?

Captain DESBOROUGH.—The curve is very steep between 2,000 and 10,000, but you can have 10,000 pounds mounded at 55 yards.

Mr. RILEY.—And half of that?

Captain DESBOROUGH.—Five thousand would come between 55 and 50 yards.

Mr. MCPHERSON.—There is one question which came up in connexion with our last discussion, that is, the sampling of new importations. We are not interested in that, so I do not need to discuss it. I do not think we quite understand each other on the question of this licensing. As I understand it, you stated that any powder imported from the United States would be subject to a license. It is a question of cost rather than license that would determine where the trade would eventually lie.

Captain DESBOROUGH.—I do not think you will find a government in the world that will grant a license without extracting a fee, and probably the fee will be made proportionate to the quantity of explosives imported.

Mr. MCPHERSON.—The Ontario Powder Company did not receive the documents which were to have been sent to them. I believe they were mailed, but we were obliged to leave Kingston probably before they arrived, so we have had very little time to study the points touched on last week. In regard to the number of employes in the different buildings, I notice you mention here the rule in England at the present time, or is it merely the conditions you have found in Canada?

Captain DESBOROUGH.—As regards the limitations?

Mr. MCPHERSON.—The number of employes in a building.

Captain DESBOROUGH.—That is in England. The number is generally limited to four, but that is exclusive of what we call runners; those are men who are not producers and whose business it is to convey explosives from one building to another, and, of course, exclusive of foremen.

Mr. MCPHERSON.—At our last meeting you made some remarks with reference to the applicant drafting a license. I do not just understand what that means.

Captain DESBOROUGH.—It means the occupier of the factory. He has theoretically to produce a draft of the license and bring it to the authorities and ask them to confirm the license. The explosives department in England have so much greater experience in the way of drafting licenses that they practically draft the license with the occupier of the factory. It is merely a friendly arrangement; it saves trouble to the occupier of the factory.

Mr. MCPHERSON.—That seems the natural course and it must necessarily resolve itself into that.

Captain DESBOROUGH.—The essential part of a license is the plan, which shows the distribution of the buildings on the site. I may say I have here a dummy license which we use in England, and which you might like to have a look at. I am not proposing that it should be exactly the same for Canada.

Mr. McPherson.—On page 8 of the report of last week's meeting mention is made of regulations to be made by the Railway Commission for transportation by rail, and regulations for the transportation by road, and by water.

Captain Desborough.—What I said was that it was not proposed to interfere with the transportation by railway, as that was already governed by the Railway Commissioners' regulations, but I did think the Federal Government should make general regulations regarding transportation by water, and by wagon road. There was a very bad accident in one of the cities of the United States through bad stowage on a cart. Two cases of dynamite were dropped off a cart and an electric street car ran into them. You want to protect the public from bad stowage, and what we propose is that general regulations should be made providing that stowage should be satisfactory.

Mr. McPherson.—Subject to a chance inspection at any time, that is, to one you never know. In some cities, I understand the regulations are such that if you want to remove powder from a magazine you have to apply to the Chief of Police, who sends an officer to accompany the load. That means not only expense, but inconvenience.

Captain Desborough.—And a certain amount of friction, too.

Mr. McPherson.—A regulation of that kind in this country would be tremendously resented, and in the end might not be workable.

Captain Desborough.—You think a general regulation would be a mistake?

Mr. McPherson.—A general regulation might be satisfactory, but to stipulate that an officer in uniform must accompany the carter, as is required in some cities, would never do.

Mr. Smith.—Quebec, for instance.

Captain Desborough.—We have nothing of that sort in England. All our regulations are really to require proper stowage; that is the gist of the regulations, and also to prevent gasoline and similar things being conveyed with explosives. The difficulty here is that many of the municipal authorities have power to regulate matters. In one instance it has come to my knowledege that they have insisted upon every vehicle conveying explosives being provided with rubber tires. That is not a thing which I should have thought necessary, but at present apparently they have the power to do so. My feeling is this, if you can get general regulations it will be much more satisfactory to you and to the public.

Mr. McPherson.—Major Riley at our last meeting in connexion with the supervision of the use of explosives suggested that a course might be followed something like the one followed by the Agricultural Department, that is, sending out instructors. That reminds me of the system pursued with respect to the inspection of milk. As a matter of fact, the inspection of milk does not occur every day, or periodically, but the produce of every dairy is subject to inspection at any time. In the same way a rule might be adopted that the whole system of stowage is subject to inspection around the corner at any place, and in that way people would be more careful, and such inspection would be more effective than any other.

Captain Desborough.—To get that inspection you must have inspectors appointed, and it seems to me to be largely a question of money.

Mr. McPherson.—The local police might co-operate.

Captain DESBOROUGH.—If their co-operation could be obtained. That is what is done in England. The entire supervision of conveyance is absolutely in the hands of the police in England.

Mr. MCPHERSON.—On page 10 of the report of our last meeting I find a reference to accidents from frozen explosives. That comes back to what I mentioned the other day, the question of accidents at the place of use. I do not think we have accidents from frozen explosives at the factory.

Captain DESBOROUGH.—No, that refers only to the use.

Mr. MCPHERSON.—If an explosive is used in the frozen condition at the point of use, that is where the inspection should be; you cannot blame the manufacturer. Then again, the statement is made that accidents happen from the use of weak or poor caps. That no doubt is true, but on investigating at the point of consumption our experience has been that most of the accidents we have been able to trace have been due to improper loading, or probably carelessness in preparing their charges. They may have one cartridge in the bottom of the hole, and a large space between that cartridge and the next one, the consequence being that the top cartridge would go off without exploding the lower one. Then when they come along with their picks and shovels they find the lower cartridge unexploded. That is not due to inferior dynamite, but to improper loading.

Captain DESBOROUGH.—I have studied the use of explosives for some years, and I would not be wrong in saying that 80 per cent of the accidents which occur in use are due to sheer foolishness on the part of the operator.

Mr. A. E. BLOOD, *Bureau Safe Transportation of Explosives, New York and Toronto.*—I should like to touch on a point brought up with regard to the transportation of explosives by team through cities. I do not think there are regulations at the present time that fully cover the matter, and that is, the transportation of blasting caps and high explosives on the same wagon. Without giving any offense I should like to say that that practice is pretty general among the representatives of the manufacturers in Canada. It seems to be a point that has been overlooked entirely. They have perhaps certain days of the week in which they want to deliver their shipments to the railways, and also deliver to the local works throughout the district, and it is almost entirely the practice to load the whole business in one wagon, and make the deliveries just as a groceryman would deliver his groceries in the morning.

Captain DESBOROUGH.—I think the regulations, if they were enforced, would stipulate that caps should not be conveyed with explosives.

Mr. BLOOD.—What I am asking is that the manufacturers discontinue the practice before the legislation is passed. I leave it in their hands.

Mr. CORKILL.—Would that have reference to the transportation of explosives from the magazines to the mine itself, or is it chiefly transportation in cities?

Captain DESBOROUGH.—My idea is, it should be where the explosive can constitute a danger to the general public, but when the explosive goes on to the mine premises, then the mine owner is responsible for it. As a matter of fact, these general regulations should be only what one might call common sense, and the mine owner would be well advised to carry out the same regulations when the explosive is on his own property.

Mr. Corkill.—I quite agree with you as to the reckless manner in which explosives are transported. I know of a great many cases that were really dangerous. One happened in Cobalt. The teamster had taken his load of dynamite, and at noon time he happened to be opposite a public school. He allowed his load to remain there with children playing around it for over an hour. Such a thing should be stopped.

Captain Desborough.—One of the regulations we have is that the man in charge of the team should not smoke when passing through a town or village. That could not hurt any one, and still it is a most important precaution to take.

Mr. LeSueur.—The minimum carload of dynamite is ten tons—that means about eight tons of actual dynamite. Magazines are built for containing one of these shipments, and it occurred to me that it might not be too much, if the Government thought it would alter their views about the table of distances, if the manufacturers would supply not merely ten tons, but two or three lots of ten tons each to experiment with the different types of magazines, with a view to finding out whether there was any possible danger from debris from a well constructed magazine without rubble in its walls, at distances such as the British table of distances gives. Do you not think that the data obtained from such experiments should have great weight in determining the distance that a magazine containing not more than ten tons might be located from the nearest dwelling?

Captain Desborough.—A practical experiment is just what I was suggesting, only I was too modest. I stipulated for one ton, and you are stipulating for 10 to 100 tons.

Mr. LeSueur.—The matter is of such vital importance and involves such an investment in land that the expense would be warranted; but no one concerned might wish to incur the expense from which others who did not share it would derive as much benefit as himself. I should think there would be no trouble gett'ng several times ten tons from the manufacturers if they would club together.

Captain Desborough.—It is an excellent idea. What I suggest is to carry out the experiment with two kinds of explosives. Take ordinary black powder for one, having a low velocity, and for the other an explosive which has the greatest speed of detonation, something like 60 per cent dynamite, and then if you have the two extremes of velocity of explosion, you can be sure what will happen with intermediate explosives.

Mr. J. Murray Wilson, *Hamilton Powder Company, Quebec.*—I would be on the economical side. The mine manager can always tell how much a ton of explosive will do in the way of work. He can tell if the explosive is weak or strong. We can tell in the laboratory whether the explosive is weak or strong. Why not make small magazines as you suggest, say only about 6 feet square, and instead of exploding ten tons, explode a decimal quantity of that, or say ten pounds, and you could have a number of experiments to show where the debris goes.

Captain Desborough.—In actual practice we have made these tests and have registered results. We have found the curve for small quantities does not give a very good idea of how the curve will go as the quantities increase. It changes very rapidly, and I would not like to base a new table of distances on experiments carried out with small quantities.

Mr. Wilson.—I am speaking more of the quality of walls so as to get the best type of wall for a magazine in the event of an explosion. It would only be a comparative test.

Captain Desborough.—Only a comparative test at best, but I think if done without undue expenditure to the country half a ton or a ton should be used, and it would be better still if you made tests with larger quantities. It would be more satisfactory to every one. One does not really know what pressure would obtain with large quantities. The only time in which I have attempted to measure pressure was firing a charge of 75 per cent dynamite in a cannon. We used copper crusher gauges, and the result of these tests gave us say 100 tons to the square inch. I do not give those figures as at all accurate. We do not know what happens to copper after that pressure. The other system of measuring pressures was in vacuo. I do not think those experiments were worth anything.

Mr. Corkill.—I have not had an opportunity of reading the recommendations of Captain Desborough very carefully, but in glancing over them hurriedly, I do not see anything in reference to the inspection of fuses. Is it your idea not to have these inspected?

Captain Desborough.—I had thought of that, but I may say in this paper I have only touched on very general principles. I thought whether it was advisable to have a test for fuse was a matter which could be considered when the Act has passed through Parliament. The South African government has a very elaborate system of testing safety fuse, and they tell me it has been of very great benefit to them. In England we have no test of fuses, and I do not know whether the fact of not having a test has led to any increase of accidents. If there is a demand for a test, it would be a very good thing to have it.

Mr. Corkill.—My experience inspecting mines the last five years leads me to believe that there should be an inspection of fuse, and that fuses should be regulated so that the burning speed should be within certain limits. There are at the present time many makes of fuse sold in Ontario, and they are not of the same burning speed. Of course there is not a great deal of difference, but sometimes there is a difference which might lead to accidents. Another case is where we have a so-called quick fuse. Of course I do not think that is responsible for a great many of the accidents that occur. In fact, in a number of accidents I have investigated from the so-called quick fuse I have always found something else, but the miners all call it quick fuse if they happen to be caught. Still I have affidavits from fairly reliable miners that their fuse did in some cases burn faster than was safe. I have never yet in my own experience seen it, but still there is a possibility of it.

Captain Desborough.—You can reproduce it experimentally very simply with a pair of pliers.

Mr. Corkill.—I think in drafting the Bill there should be some regulations for the inspection of fuse. I have read with much interest the South African Act with regard to that, and I was very much impressed with it.

Captain Desborough.—The real difficulty, even in South Africa, is that fuse changes so much after storage. If you have a hard and fast rate of burning you may condemn fuse because it has got a little bit slower and just outside your limits.

Mr. CORKILL.—It is a very hard thing to regulate the storage of fuse. Most people when they get a box of fuse in a store put it near a stove, and soon it will be unfit for use.

Captain DESBOROUGH.—Personally I should prefer electric firing if I wanted to be very accurate about the time of burning.

Mr. CORKILL.—That brings up another thing. During the last six months we have had some electric time fuse that should be tested thoroughly by the new department before it is allowed to be sold, the same as any new explosive, and regulations framed accordingly; because no one knew anything about this new fuse. The miners had to experiment, themselves, with it. I do not know if we have had any fatal accident from it, but there is the possibility.

Captain DESBOROUGH.—My view of the new department is this, really, that explosives will be examined by the chemist solely with two objects in view, one to eliminate explosives which are unduly sensitive to friction and percussion, and the other to ensure that the explosives possess a reasonable degree of chemical stability. As regards the regularity, it would be a very difficult thing indeed to frame regulation to ensure it, and I think all one can do, anyway for the present, is to have a testing department of the new bureau opened to carry out experiments for the users of explosives. If a user wants to try a new explosive, I think it ought to be open to him to send it to the testing station, and let the authorities there give him such information as they can about its explosive qualities, such as speed of explosion possible, of kinetic energy, and other kindred matters, but I am rather averse to regulating what I may call the physical qualities of explosives.

Mr. CORKILL.—What about the gas? Is not that a point you are very strict about?

Captain DESBOROUGH.—It is a very difficult question to take up. We have discussed it a great deal in England, but except so far as coal mine explosives are concerned, we do not attempt to regulate it. Practically all explosives give off deleterious gases. Some are very much worse than others, depending on the completeness of their detonation. If the detonation is not complete, you get worse gases. Other explosives will give other gases if you light them. It is a question of degree. It is very difficult to regulate explosives so far as their fumes go. If you say they shall not give more than a certain percentage of carbon monoxide, a manufacturer will say, and reinforce it with experiments; under the conditions he carries on the experiment, the explosives are right. Then you have to blame the detonator. The maker of the detonator will say the detonator is all right, and the explosive all wrong.

Mr. CORKILL.—Should you not say that the amount of carbon monoxide should not exceed a certain quantity. We have had considerable trouble with gases, and a number of men have been asphyxiated.

Captain DESBOROUGH.—We have fired explosives from cannon, one case tamped, another case not tamped. You get absolutely different substances from the combustion. It leaves a loop hole open in this way, that the manufacturer of the explosives will quite rightly say this hole was not properly tamped, therefore you did not get the necessary confinement and did not get the final products of the explosion. It is impossible to prove it one way or the other, and you simply set people at loggerheads without any advantage.

Mr. CORKILL.—In the case of new explosives, there should be some regulation with regard to deleterious gases, carbon monoxide in particular.

Captain DESBOROUGH.—All you can do is to try to ensure that the quality of the explosives will be good. The whole question of detonation is such a very involved one that it is very difficult to frame any regulations which would meet your point.

Mr. CORKILL.—I see also here, with reference to detonators, you state it is very difficult to have a system of inspection.

Captain DESBOROUGH.—Not so much a system of inspection as formulating a test by which you compare different patent detonators.

Mr. CORKILL.—I think the regulations should be that weak detonators should be prohibited from sale altogether.

Captain DESBOROUGH.—I think the manufacturers here have agreed that there is no objection to specifying the minimum amount of explosives which must be present in a detonator of a particular number; that is, that a No. 6 detonator means that it contains one gramme of fulminate composition.

Mr. CORKILL.—I think the only way you can keep most of the miners from using inferior detonators is not to let them be manufactured.

Captain DESBOROUGH.—The other difficulty is this, it is very hard to persuade the user of explosives that it is false economy to use a cheap detonator.

Mr. CORKILL.—I have been trying to do that for five years and have not succeeded.

Mr. LESUEUR.—The No. 3 is the standard detonator in Canada, and in a country as cold as Canada I think it is not right.

Mr. CORKILL.—I must disagree with you. In mines they generally use a No. 6.

Mr. LESUEUR.—For construction work the No. 3 seems to be almost exclusively used, except for electric exploders, where they sometimes get double strength, which means No. 6.

Mr. MCMASTER.—I regret exceedingly that I am not, on account of want of knowledge, able to speak of the practical working of powder factories, or the technical parts. While I am sure we all are in sympathy with the desire to protect life and property, there is, of course, the commercial side of the question which has to be considered. Mr. McPherson raised an important point. He suggested that in any neutral market which the Canadian manufacturer might reach, it would be naturally a disadvantage to subject the producer in this country to onerous conditions in competition with manufacturers to the south of us. That is something we must ask the Government to take into consideration, because there is no question the climatic conditions here are somewhat different to those in Captain Desborough's country, and I have no doubt that has been taken into consideration by the Captain. In regard to the Orders-in-Council, if I understand the Captain correctly, he does not want to make hard and fast rules. I have had experience of Orders-in-Council in the past where interests have been affected. If the parties interested could have knowledge of what was intended to be enforced before the Orders-in-Council go into effect, it would be better.

Captain DESBOROUGH.—I go further than that; I say I think it should be absolutely necessary, but you must not take what I say as binding the Government.

Mr. McMaster.—I understand that. I should like very much if I were in a business which would be affected by Orders-in-Council, to be treated in that way. When you were speaking about the size of magazines on the other side of the Atlantic, there came to my mind the question of climatic conditions which do not exist here—that is, where large quantities have to be put into magazines at certain seasons of the year, and storage quantities must necessarily be larger.

Captain Desborough.—There is another reason for establishing small magazines; otherwise you could not maintain the distance from dwelling houses. We have a few magazines, of 200 tons capacity, but they are invariably old hulks moored in the Thames, or the Mersey, or other similar places, and it is because they cannot comply with the table of distances that they use these old hulks. They find them a great advantage now that they have adopted them.

Mr. McMaster.—I may say we shall be very glad to co-operate in making the tests suggested.

Mr. Riley.—I notice in the title of the Act there is no reference to regulating the use of explosives in any way. I presume it is intended to adopt Mr. Gibson's suggestion the other day, that this Act will only govern explosives in the hands of manufacturers, and once they become a usable commodity the provincial or municipal regulations will govern. There must be places where there are no such regulations, and I think with Mr. Corkill that the users—that is Mike and Tony at the end of the dump—must be protected from themselves to a certain extent regarding the quality of explosives and the caps and the detonators. If you could put in this Act certain general regulations applying to the transportation of explosives by wagon, and the use of explosives, these regulations to be framed by Captain Desborough, and other trained people, it would be a very great guide for local aldermen and others who know nothing at all of the conditions, and yet have to frame municipal regulations that they feel called upon to make. If you had some such general regulations for transport and use in the Act, or in the Order-in-Council in some way it would be a good model for the local people to adopt, and would tend to make the legislation on this matter uniform from one end of the country to the other.

Captain Desborough.—So far as transportation is concerned, I propose, if it is legal, that power should be taken to regulate the general transportation throughout the country. As far as the use is concerned I have recommended, again if it is legal, that the use of explosives in places which are not already governed by the Provincial Mines and Quarries Act should be governed by general regulations framed by the new department, but, of course, the question of legality is one which is difficult to settle, and has not been threshed out yet.

Mr. Riley.—I should like to emphasize that point, and also that I do not believe in trying to accomplish everything by legislation—that a certain amount of education should be undertaken by the Mines Department, such as other departments of the Government undertake. Another point I should like to have borne in mind—I notice the proposition is to adopt the American Bureau's regulations—to try and get from the railways better terms for the transportation of explosives than we can at present, because we have to pay for 5,000 pounds whether we ship that amount or less. I know as a matter of fact that this causes the smuggling of explosives on passenger trains to a certain extent. People carry them on the trains when they should not. If we could ship, as they do in the United States, a box of explosives at a time it would be a good thing. It is a question which I should like you to bear in mind. I should like Captain Desborough to tell us also, from his experience in England, what protection the manufacturers have from the encroachment of dwellings around their factories. Does the proposed legislation mean that we have to bank up the whole of our factory with a mound to keep people from coming in on us, or that we must go a certain distance away from the border of our property before we put up any buildings?

Captain Desborough.—In practice in England the bulk of the factories have no fence around them, but they put up a notice to trespassers, and that notice is statutory. If a man is found trespassing on the property he can be apprehended and prosecuted.

Mr. Riley.—I did not mean that so much. Suppose we have a building located in accordance with the table of distances, and some one comes and puts up a building close to us, have we to go so much farther back?

Captain Desborough.—Yes, you would, but in England it is always arranged by mutual agreement between the occupier of the land and the occupier of the factory.

Mr. Riley.—The intra-table of distances is a very important matter with us, even in small works like ours. The winter before last we had a man with a horse and snow plough, and two shovellers at work all winter. This contributes to our cost above the cost of production in more southern climates, and if we have the additional distance to shovel the snow, the cost will be increased proportionately.

Captain Desborough.—I do not think you will find practically that it will make any difference. In your factory I believe there are greater distances than we require.

Mr. Riley.—That is the cause of a good deal of the trouble. I should like to ask the Captain what is the ideal factory construction that we should work towards.

Captain Desborough.—I do not wish to accede to your request, because I do not know your Canadian winter, and what is suitable to us is not necessarily suitable to you. Throughout, my feeling has been not to lay down things hard and fast—to try and have as much elasticity as you possibly can. Of course there is the general principle that the working buildings should be of light construction, and that in a magazine the greater danger comes from without, and therefore, you must make the magazine more or less solid.

Mr. Kent.—According to Major Riley's intra-factory distance reference, it was said last week, by some one, that perhaps you will allow us five years, or recommend to the Government that the period allowed to factories existing to-day, under certain conditions, to conform to the new regulations covering distance, should be five years.

Captain Desborough.—I have noted that, but you must understand I cannot possibly bind the Government to any course. All I can tell them is what the feeling of the explosives trade is.

Mr. Kent.—You would not care to commit yourself to saying what your probable recommendation would be touching that point?

Captain Desborough.—I have had a conversation with Mr. Templeman on the subject, but I really am not at liberty to tell you what he said to me. I told him that in England we treated the existing factories too leniently.

Mr. Kent.—Yes, and you cited an instance.

Captain Desborough.—And as a compromise you should be given a certain time limit. What his views are on the matter I really cannot tell you.

Mr. Kent.—Is it anticipated that the legislation which will result from your recommendations will influence in any way, or modify, or affect the existing railway transportation regulations?

Captain Desborough.—What I have suggested is that the control of transportation by rail should be solely in the hands of the railway commissioners—in fact no one has power to take it out of their hands. I have no doubt they will co-operate with the new department, and in that, of course, the main difference between what exists at the present time and what will exist in the future, will be that the control of the type of explosive which is conveyed will rest in the hands of the Dominion Government instead of the private bureau in New York.

Mr. Kent.—That may or may not add to the transportation restrictions as they are at present.

Captain Desborough.—I can only repeat that I think, for the present, the regulations will remain absolutely as they are.

Mr. Kent.—I should like to ask Mr. Blood if it has been actually demonstrated, frequently, or unfrequently, where shipping detonators by wagon, by rail, by boat, or otherwise, with dynamite or other explosives, is practised, when those detonators have been properly, carefully, and intelligently packed—if it has been demonstrated that the danger is increased to any extent?

Captain Desborough.—I should think it is a matter of common sense that if you put detonators close to your dynamite you must have greater danger of explosion.

Mr. Blood.—I should like to put it in this way: a short time ago in the Province of Quebec, there were two teams unloading a carload of 600 cases of dynamite. The teams were on their way to the magazine. The first team in turning a corner very nearly collided with a sleigh in which a party was out riding. The second driver was negligent and did not notice that the first team had stopped until the pole of his wagon struck the front wagon, perforated it, and passed through four or five boxes of cartridges and scattered some of them on the street. It might just as well have been a box of detonators and caused an explosion. I understand not long ago a horse ran away in the city of Ottawa and scattered dynamite along five or six blocks, and shortly afterwards a child picked up a detonator and pricked it with a pin, and it exploded in his hands. I have heard that, I do not know if it is true.

Mr. Kent.—I admit that it is a matter of common sense that if there are detonators with other explosives the danger is increased to a certain extent; but it is equally a matter of common sense that if there are two cases of dynamite, or three cases, the danger is increased by the difference in the quantity of explosives in any given place or at any given point. What I asked you to tell me was if it had been demonstrated, to your knowledge; or can you cite any instance from your own experience of accidents, or serious explosions, resulting from the detonation of caps carefully packed and transported with dynamite?

Captain DESBOROUGH.—I cannot tell you, because in England it is absolutely prohibited.

Mr. KENT.—Infractions of that regulation are not heard of?

Captain DESBOROUGH.—No, it is absolutely prohibited, and I do not think any manufacturer would want to do it.

Mr. BLOOD.—It is prohibited in the United States and Canada. I have known violations through ignorance, but I do not know of accidents which could be directly traced to the violation.

Mr. MCPHERSON.—I have here before me the form of license submitted to us to-day. I understand from the various paragraphs here that you must first obtain permission to apply for a license.

Captain DESBOROUGH.—I did not really mean the first two or three pages to refer to you. I was just showing you the terms of the license. Of course, to an actual license a plan would be attached.

Mr. MCPHERSON.—I see provision made in the license for the testing of clothing of workmen employed. That such clothing shall be of non-inflammable material. That would mean only clothing of that character should be used—there is no uniform clothing required?

Captain DESBOROUGH.—We have a small apparatus for testing clothing. What we want to eliminate is thin cotton, particularly in black powder factories. Our experience has been in explosive factories where the main danger is from fire as opposed to explosion, it is very important that the workmen should wear relatively non-inflammable clothing.

Mr. DRACKETT.—I have seen an abstract of a report from German experiments on fireproof clothing. The abstract shows that the experiments developed that fireproof clothing is of no use.

Captain DESBOROUGH.—I do not know what the German fireproof clothing is, but I know we have had a considerable number of lives saved by its use in England. It is absolutely beyond question.

Mr. DRACKETT.—That is in connexion with black powder?

Captain DESBOROUGH.—I do not refer to any particular cloth. Most of our people wear closely woven woollen clothing. What you want is when the actual source of fire is removed the material will not go on burning. Our system of testing is to place the cloth on a frame about a foot square and standing about six inches above the table. Then underneath the centre, in a pan, we use cordite and ignite a definite quantity of it, which burns for a definite time, and makes a big flame. If the flame does not pass through the clothing, and the clothing does not carry fire after the explosive is burned out, we consider the clothing sufficiently satisfactory.

Mr. DRACKETT.—How long a flame is that as to time—very short?

Captain DESBOROUGH.—I should think somewhere about a minute.

Mr. DRACKETT.—I have tried clothing for black powder. It does not seem to stand up that way.

Captain DESBOROUGH.—If you come to England I can show you plenty of samples which stood the test very well.

Mr. DRACKETT.—You spoke of floating magazines; are the distances different for floating magazines?

Captain DESBOROUGH.—We consider, as far as floating magazines are concerned, so long as the explosive is kept below the water line, that counts as very adequate mounding, and you get favourable distances. As a rule, from the configuration of the bank of the river, or whatever it may be, you may consider you have natural features of the ground intervening, and, therefore, the distances are probably reduced by three-quarters.

Mr. DRACKETT.—I suppose it depends on the judgment of the inspector.

Captain DESBOROUGH.—Yes, it is left to the judgment of the inspector. What struck me was they might be of great use here on the west coast of Canada. I was not thinking of the east coast at all.

The CHAIRMAN.—Before adjournment I want to make the remark that the proceedings of this meeting will be published, and copies sent as early as possible, as was done in connexion with the first meeting.

Mr. MCMASTER.—I wish to express the thanks of the meeting to Captain Desborough for his kindness in allowing the gentlemen here to express their views on the subject of the proposed legislation. I am sure all of us agree that we are very much obliged to him for the opportunity. (Applause).

The CHAIRMAN.—I am inclined to think that all the difficulties in carrying out the Bill will be matters of administration. The Bill itself will be an exceedingly short one. Therefore, it will require at the head of the division of the Mines Branch a man of great ability, judgment, and practical knowledge. Since the new regulations will be made by Order-in-Council I think that in the matter of these regulations plenty of opportunity should be given to manufacturers, and all concerned, to express their views. I myself would be strongly in favour of having nothing done without advice and consultation with the parties who are concerned.

Mr. MCMASTER moved that a vote of thanks be extended to Dr. Eugene Haanel, Director of Mines, and to Captain A. P. H. Desborough, Inspector of Explosives, from the Home Office, London, England, for their consideration in calling this Conference, and for the explanation of their recommendation, which Captain Desborough proposes to make in his report to the Minister of Mines. The motion was carried with acclamation, and the proceedings terminated.

APPENDIX III

(Copy)

3rd Session, 11th Parliament, 1 George V, 1910-11.

THE HOUSE OF COMMONS OF CANADA.

BILL 79.

An Act to regulate the manufacture, testing, storage and importation of Explosives.

HIS Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

SHORT TITLE.

1. This Act may be cited as *The Explosives Act.* Short title.

INTERPRETATION.

2. In this Act, unless the context otherwise requires,— Definitions.

(*a*) "Department" means the Department of Mines; "Department."

(*b*) "Minister' means the Minister of Mines; "Minister."

(*c*) "authorized explosive" means any explosive the manufacture of which has been authorized under this Act; "Authorized explosive."

(*d*) "explosive" means and includes gunpowder, blasting powder, nitro-glycerine, gun cotton, dynamite, blasting gelatine, gelignite, fulminates of mercury or of silver, fog and other signals, fireworks, fuses, rockets, percussion caps, detonators, cartridges, ammunition of all descriptions, and every other substance, whether chemical compound or mechanical mixture, which has physical properties similar to those of the substances above mentioned, and every adaptation or preparation of everything above named; "Explosive."

(*e*) "factory" means and includes any building, structure, or premises in which the manufacture or any part of the process of manufacture of an explosive is carried on, and any bu lding or place where any ingredient of an explosive is stored during the process of manufacture; "Factory."

(*f*) "inspector" means and includes the chief inspector of explosives, an inspector of explosives, a deputy inspector of explosives, and any other person who is directed by the Minister to inspect an explosive or explosive factory or magazine, or to hold an inquiry in connexion with any accident caused by an explosive; "Inspector."

"Magazine." (g) "magazine" means and includes any building, storehouse, structure, or place in which any explosive is kept or stored; other than at or in and for the use of a mine or quarry in a Province in which provision is made by the law of such Province for the efficient inspection of mines and quarries;

"Occupier." (h) "occupier" means any person who operates a factory for manufacturing explosives, or is the manager of or in charge of such factory, or who is the occupant of or uses a magazine for the storage of explosives;

"Regulations." (i) "regulations" means any regulations made by the Governor in Council under the authority of this Act;

"Safety cartridges." (j) "safety cartridges" means cartridges for guns, rifles, pistols, revolvers, and other small arms, of which the case can be extracted from the small arm after firing, and which are so closed as to prevent any explosion in one cartridge being communicated to other cartridges.

Departments exempted. **3.** This Act does not apply to the Department of Militia and Defence or the Department of Naval Service.

IMPORTATION, MANUFACTURE, AND USE.

Explosives prohibited unless authorized. **4.** Except as herein provided, no person shall have in his possession, or import, store, use, or manufacture, whether wholly or in part, or sell, any explosive unless such explosive has been declared by the Minister to be an authorized explosive.

Small quantities excepted. **5.** Nothing in this Act shall apply to the making of a small quantity of explosive for the purpose of chemical experiment, and not for practical use or sale.

Certain process prohibited. **6.** Except in so far as may be permitted by regulations made under this Act, no person except in licensed, manufacturing factories, shall carry on any of the following processes, namely: of dividing into its component parts, or otherwise breaking up or unmaking, any explosive; of making fit for use any damaged explosive; or of remaking, altering, or repairing any explosives; provided that this section shall not apply to the process of thawing explosives containing nitro-glycerine, if a proper apparatus or thawing-house is used.

LICENSES AND PERMITS.

Licenses. **7.** The Minister may issue licenses for factories and magazines, and no one shall manufacture, either wholly or in part, or store explosives except in licensed factories and magazines.

Permits for importation. **8.** The Minister may issue permits for the importation of authorized explosives, and no one shall import any explosive into Canada without such permit; provided, however, that nothing in this section shall prevent any explosive from being transported through Canada by railway in bond, if such transportation is made in a manner authorized by *The Railway Act* or any regulation or order made thereunder. (Transport in bond.)

9. The Minister may, on application, and on payment of the prescribed fees, issue a special permit to import, for the purpose of chemical analysis or scientific research, an amount not exceeding two pounds of any explosive specified in such permit. Special permits

10. Applications for factory or magazine licenses shall be made in such form and manner as are prescribed by regulation, and the application shall be accompanied by,— Application for license.

(*a*) a plan, drawn to scale, of the proposed factory or magazine, and of the land on which such factory or magazine is situated, and also of the lands adjacent thereto on which buildings are erected, with the uses to which such lands and buildings are now put. Such plan to have the exact distances between the several buildings marked thereon; Plan of factory and premises.

(*b*) a description of the situation, character, and construction of all buildings and works connected with the factory or magazine, and the maximum amount of explosive to be kept in each building; Description.

(*c*) a statement of the maximum number of persons to be employed in each building in the factory or magazine; Statement of employes.

(*d*) any information or evidence which the Minister may require; Required information.

(*e*) in the case of an application for a factory license, a statement of the maximum amount of explosive, and of ingredients thereof wholly or partially mixed, to be allowed at any one time in any building, machine, or process of the manufacture, or within the distance from such buildings or machine which is limited by regulation: Statement of maximum amount and ingredients

(*f*) a statement of the nature of the processes to be carried on in the factory and in each part thereof, and the place at which each process of the manufacture, and each description of work connected with the factory is to be carried on, and the places in the factory at which explosives and anything liable to spontaneous ignition, or inflammable or otherwise dangerous, are to be kept. Statement of processes and position of explosives.

11. No license shall be granted for any factory or magazine hereafter established within the limits of, or within one mile of the limits of, any city, town or incorporated village, or elsewhere except with the approval of the municipal corporation or other local authority having jurisdiction, or the Government of the Province, if in a Province, and in territory where there is no local authority having jurisdiction, and also with the consent of the Minister. Consent of municipality and Minister before license granted.

12. The Minister may, on application and on payment of such fees as are prescribed by regulation, issue a permit to manufacture for experimental purposes or for testing and special blasting operations only, and not for sale, any new explosive, upon such conditions and subject to such restrictions as are fixed by the Minister. Permits for experiments, and testing new explosives

13. The owner or occupier of a factory or magazine shall not make any material alteration or addition to a licensed factory or magazine, or rebuild any part thereof, until he has obtained a permit from the Minister; and before such permit may be granted he shall submit such plans and other information and evidence as the Minister may require. Permit for alteration or addition to factory.

Change of owner or occupier.

Notice to Minister.

Penalty

14. A factory or magazine license shall not be affected by any change in the person of the owner or occupier of the factory or magazine; but notice thereof, with the address and calling of the new owner or occupier, shall be sent by the owner to the Minister within three months after such change, and in default thereof, the new owner and occupier shall each be liable to a penalty not exceeding one hundred dollars for every week during which such default continues.

License for factory now in operation.

Proviso.

15. In the case of a factory now in operation or a magazine now in existence, no license shall be required until the first day of January, one thousand nine hundred and sixteen; provided, however, that if the owner or occupier of such factory or magazine desires to make any material alteration in or addition to such factory or magazine, or to rebuild the same or any part thereof, he shall comply with the provisions of section 13 of this Act.

Application for continuing certificate.

Particulars.

2. The owner or occupier of any such factory or magazine shall, within three months after the passing of this Act, make application to the Minister for a continuing certificate, stating in such application his name and address and the situation of the factory or magazine, and shall supply such particulars and information respecting the same as the Minister may require; and the applicant shall, thereupon, be granted a continuing certificate in such form as may be prescribed by the Minister, and such factory or magazine shall thereupon be deemed to be duly authorized to manufacture and store explosives.

Powers of Minister in case of special danger.

3. Notwithstanding anything in this section, the Minister may require the owner or occupier of any factory or magazine to stop using, or to use only under and subject to conditions to be specified by him, any building, structure, or premises which, from its situation or from the nature of the processes carried on therein, constitutes, in his opinion, a special danger.

INSPECTORS.

Appointment of inspectors.

16. The Governor in Council may appoint a chief inspector of explosives, one or more inspectors of explosives, one or more deputy inspectors of explosives, and a chemist of explosives.

Powers of inspectors.

17. An inspector may, at any time, visit and inspect any factory, magazine, and premises where any explosive is being manufactured or stored, or where he has reason to suspect any explosive is being manufactured or stored, and to open and examine any package that he may there find; and the owner and occupier of such factory, magazine, and premises, shall afford such inspector every facility to make such inspection full and complete, and shall supply the inspector with any information that he may require, other than information relating to the cost of manufacturing any explosive.

May require samples.

2. An inspector may require the owner or occupier of any factory, or magazine, where any explosive is manufactured or stored, or any person employed in any such place, to give him such samples as he may require of any substance therein, whether in the state of raw material, material in course of manufacture, or manufactured material, which the inspector believes to be an explosive, or to be an ingredient from which an explosive may be manufactured.

3. An inspector may, at any time, open or cause to be opened any package or store of material of whatsoever nature, which he believes to contain explosives or ingredients for the manufacture of explosives. May open packages.

INQUIRIES INTO EXPLOSIONS.

18. The Minister may direct an inquiry to be made whenever any accidental explosion of an explosive has occured, or when any accident has been caused by an explosive, and the person authorized by the Minister to conduct such inquiry shall have all the powers and authority of a commissioner appointed under Part I of *The Inquiries Act*. Inquiry into accidents.

2. This section shall not apply, however, where an accident has been caused by an explosion of an explosive occuring in any mine or quarry, or metallurgical work in any Province in which provision is made by the law of such Province for a proper and thorough investigation and inquiry into the cause of such accident. Exemption: where covered by Provincial legislation.

REGULATIONS.

19. The Governor in Council may make regulations— Regulations.

(*a*) for classifying explosives, and for prescribing the composition, quality, and character of explosives; Classify explosives.

(*b*) prescribing the form and duration of licenses, permits, and certificates issued under this Act, the terms and conditions upon which such licenses, permits, and certificates shall be issued, and the fees to be paid therefor; Licenses, permits, and certificates.

(*c*) for regulating the importation, packing, and handling of explosives, and the transportation of explosives otherwise than by railway; Importation, packing, and transportation.

(*d*) for inquiries into the accidental explosion of explosives, and any accident caused by explosives; Inquiries into accidents.

(*e*) for the taking of samples of explosives required for examination and testing, and for the establishing of testing stations, and of the tests and other examinations to which explosives shall be subjected; Samples. Testing.

(*f*) prescribing the manner in which an explosive shall be tested and examined before it is declared to be an authorized explosive, and for determining to what examinations and tests authorized explosives shall be subject; Authorized explosives.

(*g*) to be observed by inspectors and other officers and employes charged with any duty under this Act, or under any regulations made thereunder; Inspectors and officers.

(*h*) relating to the construction and management of factories and magazines; Factories.

(*i*) for the safety of the public and of the employes at any factory or magazine, or any person engaged in the handling, or packing of explosives, or the transportation of explosives otherwise than by railway; Safety of public and employes.

(*j*) governing the establishment, location, and maintenance of factories and magazines, and the manufacture and storage of explosives; Location and manufacture.

(*k*) for the more effective carrying out of this Act. Operation of Act.

2. All regulations made under this Act shall be published in *The Canada Gazette*, and upon being so published they shall have the same force as if they formed part of this Act. Publication.

OFFENCES AND PENALTIES.

Obstruction of entry and examination by inspector.

20. Every person who fails to permit an inspector to enter upon any property, and to inspect, examine, or make inquiries in pursuance of his duties, and every person who fails to comply with any order or direction of such inspector, in pursuance of the requirements of this Act, or any regulation made thereunder, or who, in any manner whatsoever, obstructs such inspector in the execution of his duties under this Act, shall be liable to a penalty not exceeding five hundred dollars and costs.

Penalty.

Manufacturers objections to Inspectors ruling referable to Minister for adjudication.

2. Any manufacturer who takes exception to the ruling of an inspector, before such ruling or before the penalty provided for in subsection (1) one of this section is enforced, as the case may be, may have the facts upon which such ruling is based submitted to the Minister for his consideration and decision.

Trespassing upon premises.

21. Every person who enters without permission or lawful authority, or otherwise trespasses upon any factory or magazine, shall, for every offence, be liable to a penalty not exceeding fifty dollars and costs, and may be forthwith removed from such factory or magazine by any constable, or by any person employed at such factory or magazine.

Penalty.

Causing explosion or fire.

22. Every person who commits any act which is likely to cause an explosion or fire in or about any factory or magazine, shall be liable to a penalty not exceeding five hundred dollars and costs.

Penalty.

Possession, sale, manufacture, or importation of unauthorized explosive.

23. Every person who, by himself or his agent, has in his possession, sells, offers for sale or manufactures or imports any unauthorized explosive within the meaning of this Act shall, for a first offence, be liable to a penalty not exceeding two hundred dollars and costs, or to imprisonment for a term not exceeding three months, or to both penalty and imprisonment, and for each subsequent offence shall be liable to a penalty not exceeding five hundred dollars and costs, and not less than fifty dollars and costs, or to imprisonment for a term not exceeding six months, or to both penalty and imprisonment.

Penalty.

Contravention of Act.

24. Every person who violates any provision of this Act for which a penalty has not been provided, or any regulation made thereunder, shall, for a first offence, incur a penalty not exceeding two hundred dollars and costs, and for each subsequent offence a penalty not exceeding five hundred dollars and costs.

Penalty.

Recovery of penalties.

25. Every penalty and forfeiture may be recovered in a summary manner under the provisions of Part XV of *The Criminal Code*.

COMMENCEMENT OF ACT.

Commencement of Act.

26. This Act shall come into force on a day to be fixed by proclamation of the Governor in Council.

INDEX

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

V

W

Y

Z

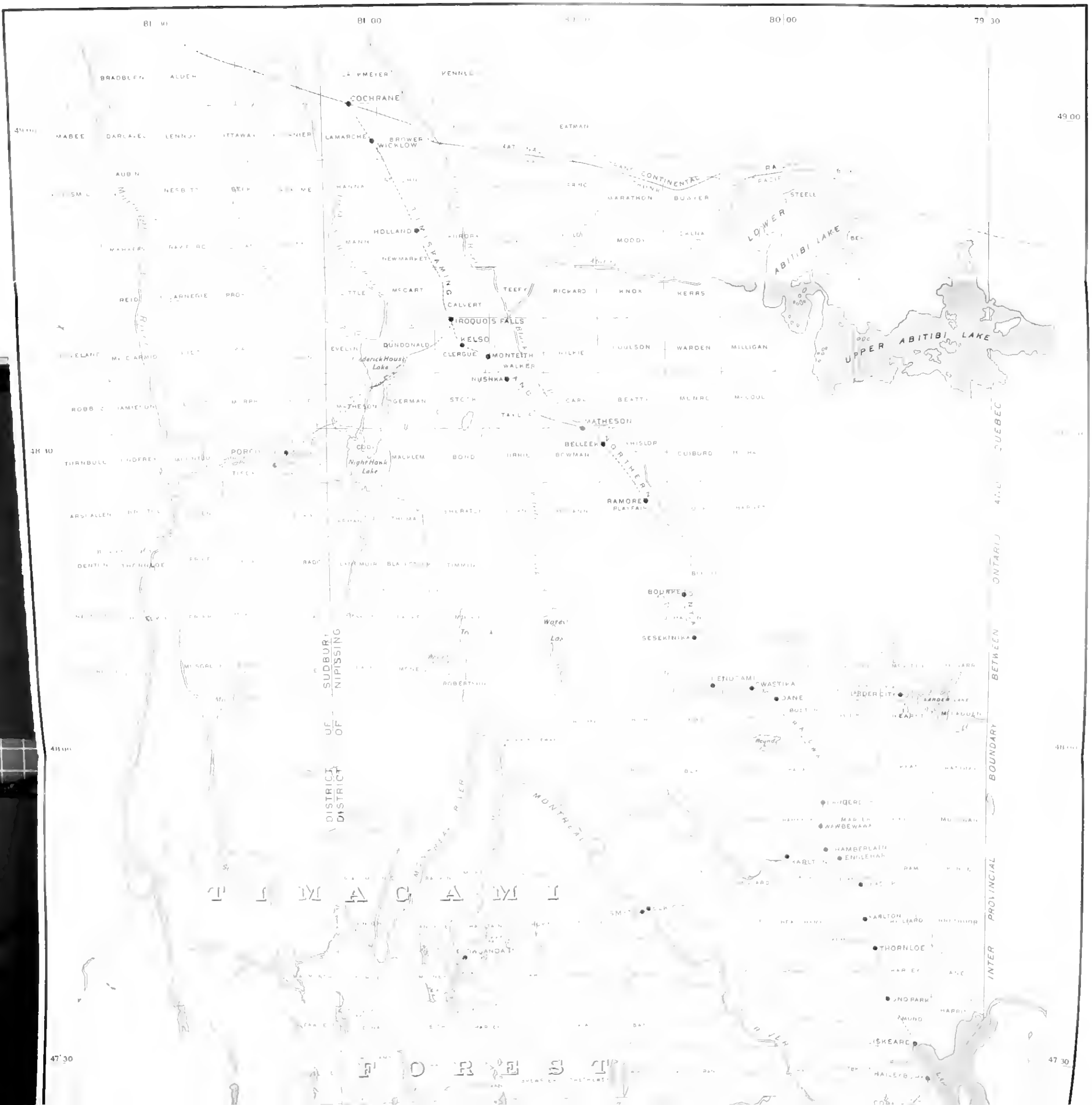
CANADA

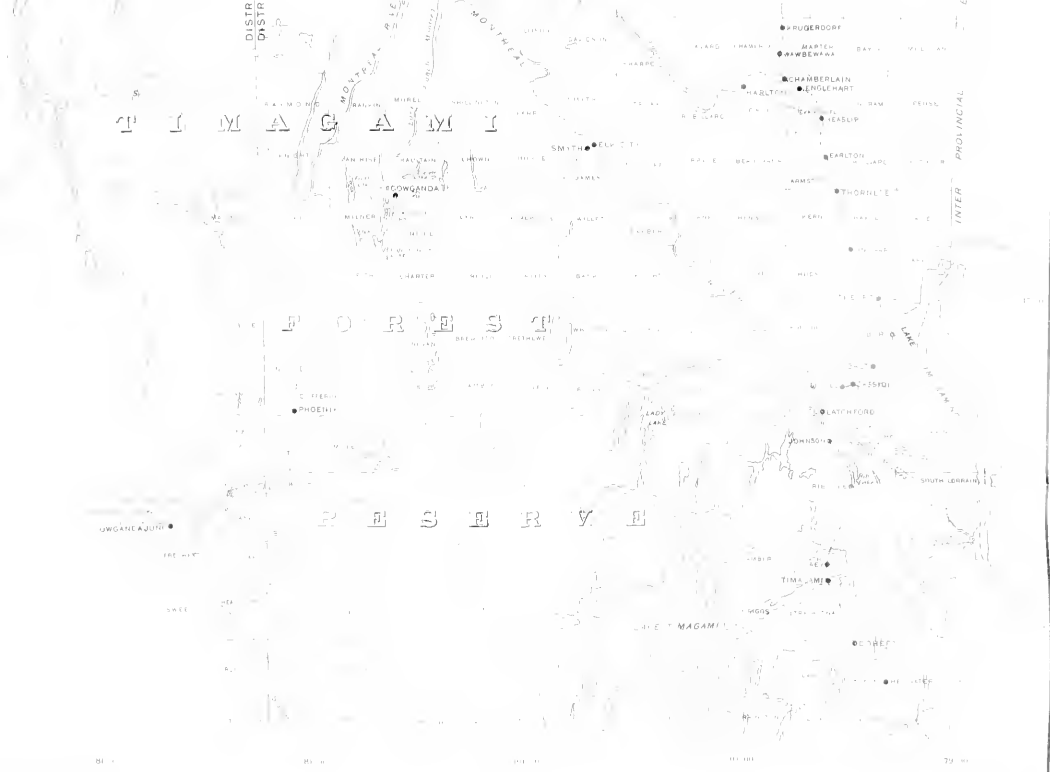
DEPARTMENT OF MI

MINES BRANCH

HON W. TEMPLEMAN, MINISTER, A.

EUGENE HAANEL





No. 94

MAP SHOWING
COBALT, GOWGANDA, SHININGTREE,
AND PORCUPINE DISTRICTS

CANADA
DEPARTMENT OF MINES
MINES BRANCH

HON. W. TEMPLEMAN, MINISTER; A. P. LOW, LL.D., DEPUTY MINISTER; EUGENE HAANEL, PH.D., DIRECTOR.

REPORTS, AND MAPS OF ECONOMIC INTEREST.

PUBLISHED BY THE

MINES BRANCH

REPORTS

1. Mining Conditions of the Klondike, Yukon. Report on—by Eugene Haanel, Ph.D., 1902.
2. Great Landslide at Frank, Alta. Report on—by R. G. McConnell and R. W. Brock, M.A., 1903.
3. Investigation of the different electro-thermic processes for the smelting of iron ores, and the making of steel, in operation in Europe. Report of Special Commission—by Eugene Haanel, Ph.D., 1904. (Out of print).
4. Rapport de la Commission nommée pour étudier les divers procédés électro-thermiques pour la réduction des minerais de fer et la fabrication de l'acier employés en Europe. (French Edition), 1905. (Out of print).
5. On the location and examination of magnetic ore deposits by magnetometric measurements. Eugene Haanel, Ph.D., 1904.
7. Limestones, and the Lime Industry of Manitoba. Preliminary Report on—by J. W. Wells, 1905.
8. Clays and Shales of Manitoba: their Industrial Value. Preliminary Report on—by J. W. Wells, 1905. (Out of print).
9. Hydraulic Cements (Raw Materials) in Manitoba; Manufacture and Uses of. Preliminary Report on—by J. W. Wells, 1905.
10. Mica: its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (Out of print).
11. Asbestos: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (Out of print: see No. 69)
12. Zinc Resources of British Columbia and the Conditions affecting their Exploitation. Report of the Commission appointed to investigate—by W. R. Ingalls, 1905.
16. Experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Final Report on—by Eugene Haanel, Ph.D., 1907.
17. Mines of the Silver-Cobalt Ores of the Cobalt district: Their Present and Prospective Output. Report on—by Eugene Haanel, Ph.D., 1907.
18. Graphite: Its Properties, Occurrence, Refining, and Uses—by Fritz Cirkel, M.E., 1907.
19. Peat and Lignite: Their Manufacture and Uses in Europe—by Erik Nyström, M.E., 1908.
20. Iron Ore Deposits of Nova Scotia. Report on (Part I)—by Dr. J. E. Woodman.
21. Summary Report of Mines Branch, 1907–8.
22. Iron Ore Deposits of Thunder Bay and Rainy River districts. Report on—by F. Hille, M.E.
23. Iron Ore Deposits, along the Ottawa (Quebec side) and Gatineau rivers. Report on—by Fritz Cirkel, M.E.

24. General Report on the Mining and Metallurgical Industries of Canada, 1907–8.
25. The Tungsten Ores of Canada. Report on—by Dr. T. L. Walker.
26. The Mineral Production of Canada, 1906. Annual Report on—by John McLeish, B.A.
27. The Mineral Production of Canada, 1908. Preliminary Report on—by John McLeish, B.A.
28. Summary Report of Mines Branch, 1908.
29. Chrome Iron Ore Deposits of the Eastern Townships. Monograph on—by Fritz Cirkel, M.E. (Supplementary Section: Experiments with Chromite at McGill University—by Dr. J. B. Porter).
30. Investigation of the Peat Bogs and Peat Fuel Industry of Canada, 1908. Bulletin No. 1—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
31. Production of Cement in Canada, 1908. Bulletin on—by John McLeish, B.A.
32. Investigation of Electric Shaft Furnace, Sweden. Report on—by Eugene Haanel, Ph.D.
42. Production of Iron and Steel in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
43. Production of Chromite in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
44. Production of Asbestos in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
45. Production of Coal, Coke, and Peat in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
46. Production of Natural Gas and Petroleum in Canada during the calendar years 1907 and 1908. Bulletin on—by John McLeish, B.A.
47. Iron Ore Deposits of Vancouver and Texada islands. Report on—by Einar Lindeman, M.E.
55. Report on the Bituminous, or Oil-shales of New Brunswick and Nova Scotia; also on the Oil-shale Industry of Scotland—by Dr. R. W. Ells.
58. The Mineral Production of Canada, 1907 and 1908. Annual Report on—by John McLeish, B.A.
59. Chemical Analyses of Special Economic Importance made in the Laboratories of the Department of Mines, 1906–7–8. Report on—by F. G. Wait, M.A., F.C.S. (With Appendix on the Commercial Methods and Apparatus for the Analysis of Oil-shales—by H. A. Leverin, Ch.E.)
62. Mineral Production of Canada, 1909. Preliminary Report on—by John McLeish, B.A.
63. Summary Report of Mines Branch, 1909.
67. Iron Ore Deposits of the Bristol Mine, Pontiac county, Quebec. Bulletin No. 2—by Einar Lindeman, M.E., and Geo. C. Mackenzie, B.Sc.

Schedule of Charges for Chemical Analysis and Assays.

68. Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—by Dr. Eugene Haanel.
69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel, M.E. (Second Edition, enlarged).
71. Investigation of the Peat Bogs, and Peat Industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's Paper on Dr. M. Ekenberg's Wet-Carbonizing Process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet entitled 'A Solution of the Peat Problem,' 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. Anrep, Peat Expert. (Second Edition, enlarged).
79. Production of Iron and Steel in Canada during the calendar year 1909. Bulletin on—by John McLeish, B.A.
80. Production of Coal and Coke in Canada during the calendar year, 1909. Bulletin on—by John McLeish, B.A.
82. Magnetic Concentration Experiments. Bulletin No. 5—by Geo. C. Mackenzie.
83. An investigation of the Coals of Canada with reference to their Economic Qualities: as conducted at McGill University under the auspices of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., and R. J. Durley, Ma.E.
84. Gypsum Deposits of the Maritime Provinces of Canada—including the Magdalen islands. Report on—by W. F. Jennison, M.E.

85. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials during the calendar year 1909. Bulletin on—by John McLeish, B.A.
88. The Mineral Production of Canada 1909. Annual Report on—by John McLeish, B.A.
89. Reprint of Presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Eugene Haanel, Ph.D.
90. Proceedings of Conference on Explosives.
92. Investigation of the Explosives Industry in the Dominion of Canada, 1910. Report on—by Capt. Arthur Desborough. (Second Edition).
93. Molybdenum Ores of Canada. Report on—by Dr. T. L. Walker.
102. Mineral Production of Canada, 1910. Preliminary Report on—by John McLeish, B.A.
103. Mines Branch Summary Report, 1910.

IN THE PRESS.

100. The Building and Ornamental Stones of Canada. Report on—by Professor W. A. Parks.
104. Catalogue of Publications of Mines Branch, from 1902 to 1911; containing Tables of Contents and List of Maps, etc.
110. Western Portion of Torbrook Iron Ore Deposits, Annapolis county, N.S. Bulletin No. 7—by Howells Fréchette, M.Sc.
111. Diamond Drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with Introductory by A. W. G. Wilson, Ph.D.
114. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada, 1910. Bulletin on—by John McLeish, B.A.
115. Production of Iron and Steel in Canada during the calendar year 1910. Bulletin on—by John McLeish, B.A.
116. Production of Coal and Coke in Canada during the calendar year 1910. Bulletin on—by John McLeish, B.A.
117. General Summary of the Mineral Production in Canada during the calendar year 1910. Bulletin on—by John McLeish, B.A.
118. Mica: Its Occurrence, Exploitation, and Uses. Report on—by Hugh S. de Schmid, M.E.

IN PREPARATION.

91. Coal and Coal Mining in Nova Scotia. Report on—by J. G. S. Hudson.

MAPS.

6. Magnetometric Survey, Vertical Intensity: Calabogie mine, Bagot township, Renfrew county, Ontario—by E. Nyström, M.E., 1904.
13. Magnetometric Survey of the Belmont Iron Mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, B.Sc., 1905.
14. Magnetometric Survey of the Wilbur mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, B.Sc., 1905.
15. Magnetometric Survey, Vertical Intensity: Iron Ore Deposits at Austin brook, Bathurst township, Gloucester county, N.B.—by E. Lindeman, M.E., 1906.
33. Magnetometric Survey, Vertical Intensity: Lot 1, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, M.Sc., 1909.
34. Magnetometric Survey, Vertical Intensity: Lots 2 and 3, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, M.Sc., 1909.
35. Magnetometric Survey, Vertical Intensity: Lots 10, 11, and 12, Concession IX, and Lots 11 and 12, Concession VIII, Mayo township, Hastings county, Ontario—by Howells Fréchette, M.Sc., 1909.
36. Survey of Mer Bleue Peat Bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
37. Survey of Alfred Peat Bog, Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
38. Survey of Welland Peat Bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.

39. Survey of Newington Peat Bog, Osnabruck, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.

40. Survey of Perth Peat Bog, Drummond township, Lanark county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.

41. Survey of Victoria Road Peat Bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.

48. Magnetometric Map of Iron Crown claim at Klaanch river, Vancouver island, B.C.—by Einar Lindeman, M.E.

49. Magnetometric Map of Western Steel Iron claim, at Sechart, Vancouver island, B.C.—by Einar Lindeman, M.E.

50. Vancouver island, B.C.—by Einar Lindeman, M.E.

51. Iron Mines, Texada island, B.C.—by E. H. Shepherd, C.E.

52. Sketch Map of Bog Iron Ore Deposits, West Arm, Quatsino sound, Vancouver island, B.C.—by L. Frank.

53. Iron Ore Occurrences, Ottawa and Pontiac counties, Quebec, 1908—by J. White, and Fritz Cirkel, M.E.

54. Iron Ore Occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel, M.E.

57. The Productive Chrome Iron Ore District of Quebec—by Fritz Cirkel, M.E.

60. Magnetometric Survey of the Bristol mine, Pontiac county, Quebec—by Einar Lindeman, M.E.

61. Topographical Map of Bristol mine, Pontiac county, Quebec—by Einar Lindeman, M.E.

64. Index Map of Nova Scotia: Gypsum—by W. F. Jennison, M.E.

65. Index Map of New Brunswick: Gypsum—by W. F. Jennison, M.E.

66. Map of Magdalen islands: Gypsum—by W. F. Jennison, M.E.

70. Magnetometric Survey of Northwest Arm Iron Range, Lake Timagami, Nipissing district, Ontario—by Einar Lindeman, M.E.

72. Brunner Peat Bog, Ontario—by A. Anrep, Peat Expert.

73. Komoka Peat Bog, Ontario—by A. Anrep, Peat Expert.

74. Brockville Peat Bog, Ontario—by A. Anrep, Peat Expert.

75. Rondeau Peat Bog, Ontario—by A. Anrep, Peat Expert.

76. Alfred Peat Bog, Ontario—by A. Anrep, Peat Expert.

77. Alfred Peat Bog, Ontario: Main Ditch profile—by A. Anrep.

78. Map of Asbestos Region, Province of Quebec, 1910—by Fritz Cirkel, M.E.

86. Map showing general distribution of Serpentine in the Eastern Townships—by Fritz Cirkel, M.E.

94. Map showing Cobalt, Gowganda, Shiningtree, and Porcupine districts—by L. H. Cole, B.Sc.

95. General Map of Canada showing Coal Fields. (Accompanying report No. 83—by Dr. J. B. Porter).

96. General Map of Coal Fields of Nova Scotia and New Brunswick. (Accompanying Report No. 83—by Dr. J. B. Porter).

97. General Map showing Coal Fields in Alberta, Saskatchewan, and Manitoba. (Accompanying Report No. 83—by Dr. J. B. Porter).

98. General Map of Coal Fields in British Columbia. (Accompanying Report No. 83—by Dr. J. B. Porter).

99. General Map of Coal Field in Yukon Territory. (Accompanying Report No. 83—by Dr. J. B. Porter).

106. Austin Brook Iron Bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman, M.E.

107. Magnetometric Survey, Vertical Intensity: Austin Brook Iron Bearing district—by E. Lindeman, M.E.

108. Index Map showing Iron Bearing Area at Austin Brook—by E. Lindeman, M.E.

109. Sections of Diamond Drill Holes in Iron Ore Deposits at Austin Brook—by E. Lindeman, M.E.

IN THE PRESS.

112. Sketch plan showing Geology of Point Mamainse, Ont.—by Professor A. C. Lane.

119–137. Mica: Townships maps, Ontario and Quebec—by Hugh S. de Schmid, M.E.

138. Mica: Showing location of Principal Mines and Occurrences in the Quebec Mica Area—by Hugh S. de Schmid.

139. Mica: Showing Location of Principal Mines and Occurrences in the Ontario Mica Area—by Hugh S. de Schmid.

140. Mica: Showing Distribution of the Principal Mica Occurrences in the Dominion of Canada—by Hugh S. de Schmid.

141. Torbrook Iron Bearing District, Annapolis county, N.S.—by Howells Fréchette, M.Sc.

IN PREPARATION.

113. Holland Peat Bog, Ontario—by A. Anrep, Peat Expert.