MUNITION RESOURCES COMMISSION

CANADA

HON. COL. THOS. CANTLEY, *Chairman*
GEO. C. MACKENZIE, *Secretary*

FINAL REPORT
OF
THE WORK OF THE COMMISSION

November, 1915, to March, 1919
inclusive

1920

TORONTO

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TORONTO

TO HIS EXCELLENCY VICTOR CHRISTIAN WILLIAM, DUKE OF DEVONSHIRE, MARQUIS OF HARTINGTON, EARL OF DEVONSHIRE, EARL OF BURLINGTON, BARON CAVENDISH OF HARDWICKE, BARON CAVENDISH OF KEIGHLEY, K.G., P.C., G.C.M.G., G.C.V.O., ETC., ETC., GOVERNOR GENERAL OF CANADA.

May it please your Excellency:

The undersigned has the honour to lay before your Excellency the Final Report of the Munition Resources Commission.

Respectfully submitted,

THOMAS CANTLEY,
Chairman.

SIR:

I have the honour to transmit herewith the Final Report of the Munition Resources Commission.

This contains a compilation of interim reports made to the Prime Minister from time to time, also descriptions of the field work and various investigations undertaken by the Commission.

Only the more important material is included in this report. The files of the Commission, containing much additional information, have been deposited with the Mines Branch, Department of Mines, where they are available for reference.

Certain special reports made by officers of the Geological Survey at the request of the Commission have been published by that branch of the Department of Mines.

I have the honour to be, Sir,
Your obedient servant,
GEORGE C. MACKENZIE,
Member and Secretary.

Hon. COLONEL THOMAS CANTLEY,
Chairman,
Munition Resources Commission.

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ERRATA

Page 9. Line 9 from top, for "J. Blizzard" read "J. Blizard."

91. Footnote, for "facing p. 94" read "p. 95."

110. Line 6 from bottom, for "Breckinridge" read "Breckenridge."

116. Lines 12 and 15 from bottom, for "Macdonell" read "Macdonnell," also on p. 117, line 15 from top.

126. Line 19 from top, for "C. O. Lindeman" read "C. O. Linderman."

128. Line 15 from top, for "Rosebury" read "Rosebery."

136. Line 20 from bottom, for "paladium" read "palladium."

180. Line 7 from top, for "Vancoueer" read "Vancouver."

184. Line 14 from bottom, for "Brewster's" read "Brewer's."

189. Footnote, for "p. 194" read "p. 193."

191. Footnote, for "p. 195" read "p. 194."

ILLUSTRATIONS.

Orders in Council providing for the appointment of a Commission to make enquiries respecting the supply and sufficiency of war materials required for the production of munitions.

Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 27th November, 1915.

The Committee of the Privy Council have had before them a report, dated 24th November, 1915, from the Right Honourable Sir Robert Laird Borden, the Prime Minister, stating that representations have been made to him urging the importance and desirability of an inquiry respecting the supply and sufficiency of raw materials in Canada required for the production of munitions of war and as to the best method of conserving the same.

The Prime Minister observes that the proposed inquiry involves considerations of an urgent nature and that it should be made forthwith.

The Committee, on the recommendation of the Right Honourable Sir Robert Laird Borden, the Prime Minister, advise that for the purpose of such inquiry, the following gentlemen be, under the provisions of Part I of the Inquiries Act, appointed Commissioners, viz.:—

Col. Thomas Cantley, of New Glasgow, Province of Nova Scotia, Manufacturer, Chairman;

Robert Hobson, of the City of Hamilton, Province of Ontario, Esquire, Manufacturer;

George C. Mackenzie, B.Sc., of the City of Ottawa, Province of Ontario, Mining Engineer; and

Honourable William C. Edwards, of the City of Ottawa, Province of Ontario, Manufacturer.

(*Sgd.*) RODOLPHE BOUDREAU,
Clerk of the Privy Council.

Certified copy of a Report of the Committee of the Privy Council, approved by His Royal Highness the Governor General on the 30th November, 1915.

The Committee of the Privy Council, on the recommendation of the Right Honourable Sir Robert Laird Borden, Prime Minister, advise, with reference to the Order in Council of 27th November, 1915, appointing, under the provisions of Part I of the Inquiries Act, certain gentlemen as Commissioners to make inquiry respecting the supply and sufficiency of raw materials in Canada required for the production of munitions of war and as to the best method of conserving the same, that the undermentioned gentlemen be added to the personnel of the said Commission, viz.:—

E. Carnegie, Esquire, President of the Electric Steel and Metals Company of Welland, Ontario; and

George W. Watts, of the City of Toronto, Province of Ontario, Esquire, General Manager of the Canadian General Electric Company.

(*Sgd.*) RODOLPHE BOUDREAU,
Clerk of the Privy Council.

Text of the Commission

CANADA

ARTHUR.

[L.S.]

GEORGE THE FIFTH, by the Grace of God, of the United Kingdom of Great Britain and Ireland, and of the British Dominions beyond the Seas KING, Defender of the Faith, Emperor of India.

To all to whom these Presents shall come, or whom the same may in anywise concern,—GREETING:—

W. STUART EDWARDS,
Acting Deputy Minister of Justice,
Canada.

WHEREAS in and by Orders of Our Governor General in Council, bearing date the twenty-seventh and thirtieth days of November, in the year of Our Lord one thousand nine hundred and fifteen (copies of which are hereto annexed) provision has been made for an inquiry by Our Commissioners therein and hereinafter named respecting the supply and sufficiency of raw materials in Canada required for the production of munitions of war and as to the best method of conserving the same.

NOW KNOW YE, that by and with the advice of Our Privy Council for Canada, We do by these Presents nominate, constitute and appoint Thomas Cantley of the Town of New Glasgow, in the Province of Nova Scotia, Manufacturer; Robert Hobson, of the City of Hamilton, in the Province of Ontario, Manufacturer; George Cleghorn Mackenzie, of the City of Ottawa, in the said Province of Ontario, Mining Engineer; the Honourable William Cameron Edwards, of the City of Ottawa, in the Province of Ontario aforesaid, a Member of Our Senate of Canada; Ebenezer Carnegie, of the Town of Welland, in the said Province of Ontario, Esquire; and George W. Watts, of the City of Toronto, in the said Province of Ontario, Esquire; to be Our Commissioners to conduct such inquiry.

To have, hold, exercise and enjoy the said office, place and trust unto the said Thomas Cantley, Robert Hobson, George Cleghorn Mackenzie, William Cameron Edwards, Ebenezer Carnegie, and George W. Watts, together with all the rights, powers, privileges and emoluments unto the said office, place and trust of right and by law appertaining during pleasure.

AND WE, in pursuance of the Statute in that behalf do hereby authorize and empower Our said Commissioners to engage the services of such accountants, engineers, technical advisers, or other experts, clerks, reporters and assistants, as they may deem necessary or advisable, also the services of Counsel to aid and assist Our said Commissioners in the inquiry, and also to have and exercise the other powers specified in Chap. 28, 2 George V, intituled "An Act to amend the Inquiries Act."

AND WE do by these presents nominate, constitute and appoint the said Thomas Cantley, Chairman of such Commission.

AND WE do hereby under the authority of the Revised Statutes respecting Inquiries concerning public matters, confer upon Our said Commissioners the power of summoning before them any witnesses and of requiring them to give evidence on oath, or on solemn affirmation, if they are persons entitled to affirm in civil matters, and orally or in writing, and to produce such documents and things as Our said Commissioners shall deem requisite to the full investigation of the matters into which they are hereby appointed to examine.

AND WE do hereby require and direct Our said Commissioners to report to Our Governor General in Council the result of their investigation together with the evidence taken before them and any opinion they may see fit to express thereon.

IN TESTIMONY WHEREOF, We have caused these Our Letters to be made Patent, and the Great Seal of Canada to be hereunto affixed. WITNESS: Our Most Dear and Entirely Beloved Uncle and Most Faithful Counsellor, Field Marshal, His Royal Highness Prince Arthur William Patrick Albert, Duke of Connaught and of Strathearn, Earl of Sussex (in the Peerage of the United Kingdom); Prince of the United Kingdom of Great Britain and Ireland, Duke of Saxony, Prince of Saxe-Coburg and Gotha; Knight of Our Most Noble Order of the Garter; Knight of Our Most Ancient and Most Noble Order of the Thistle; Knight of Our Most Illustrious Order of Saint Patrick; One of Our Most Honourable Privy Council; Great Master of Our Most Honourable Order of the Bath; Knight Grand Commander of Our Most Exalted Order of the Star of India; Knight Grand Cross of Our Most Distinguished Order of Saint Michael and Saint George; Knight Grand Commander of Our Most Eminent Order of the Indian Empire; Knight Grand Cross of Our Royal Victorian Order; Our Personal Aide-de-Camp; Governor-General and Commander-in-Chief of Our Dominion of Canada.

At Our Government House, in Our City of Ottawa, this twenty-seventh day of November, in the year of Our Lord one thousand nine hundred and fifteen and in the sixth year of Our Reign.

By Command,

THOMAS MULVEY,
Under-Secretary of State.

REPORT OF THE COMMISSIONERS.

OBJECT OF THE COMMISSION

The Commission was appointed for the purpose of instituting an enquiry respecting the supply and sufficiency of raw materials in Canada required for the production of munitions of war, and the best methods of conserving the same.

APPOINTMENT AND DUTIES OF THE SECRETARY

At the first meeting of the Commission, held in Ottawa, December 7, 1915, Mr. G. C. Mackenzie, a member of the staff of the Mines Branch, Department of Mines, was appointed Secretary and instructed to secure suitable offices and the necessary staff required for the discharge of the work undertaken by the Commission.

Through the courtesy of Dr. E. Haanel, Director of the Mines Branch, the Secretary was allowed to retain his own office in the Mines Branch Building, and was also given additional space required from time to time as the Commission's activities developed. The assistance rendered by Dr. Haanel not only allowed the Commission office accommodation free of rental, but facilitated business with the staff of the Department of Mines and placed the Commission within easy and rapid communication with the departmental laboratories.

The duties of the Secretary comprised the keeping of all minutes, records, and accounts in connection with the business of the Commission; the assembling of technical reports on the occurrence and marketing of Canadian minerals required for munition purposes, and the presenting of these reports to the Canadian Government and the Imperial Munitions Board, through the Commissioners. The Secretary also acted in a consulting capacity to the Imperial Munitions Board and to many Canadian manufacturers and mining companies desiring information and assistance relative to mineral supplies.

All information and engineering advice supplied to the public was given free of charge, and in many instances was of considerable value in conserving financial expenditure in exploration of mineral prospects and in development of manufacturing processes.

ACKNOWLEDGMENTS

The large amount of information compiled and distributed was rendered possible by the generous assistance given the Secretary by all members of

the staff of the Department of Mines, the officers of the various Provincial Bureaus, and of the Canadian Mining Institute.

In presenting this Report the Commission desires to express its appreciation of their hearty co-operation in its work since its organization in November, 1915.

The services of the Secretary have been practically monopolized by the Commission for the past four years, and while this interfered to a considerable extent with his usefulness to the Mines Branch, both the Deputy Minister of Mines and the Director of the Mines Branch most generously refrained from making any objections to the time he has devoted to the business of the Commission.

The Commission furthermore desires to thank the Department of Mines for placing the departmental Chemical, Physical, and Ore Testing laboratories at its disposal, and thus rendering invaluable assistance in the many practical investigations undertaken during the survey of Canadian materials required for munition purposes.

Acknowledgments are also due to the following gentlemen constituting the Minerals Advisory Board of the Commission: Dr. W. G. Miller, Mr. Wm. Fleet Robertson, Mr. Arthur A. Cole, Mr. J. S. DeLury, Mr. W. E. McMullen, Dr. A. W. G. Wilson, Mr. Wm. McInnes, Mr. D. B. Dowling, Mr. Hiram Donkin, Mr. Theo. C. Denis, and Mr. J. T. Sterling.

SPECIAL DUTIES AND INVESTIGATIONS

STEEL

Tool Steel.—The supplies in Canada during the war of special steels (known as high-speed steels) for tools used in manufacturing the iron and steel parts of shells and other munitions of war had been inadequate, owing to the restriction placed by the British Government on the export of such steels from the United Kingdom.

In order to relieve this situation it was arranged in January, 1916, through the office of the Prime Minister and at the request of the Colonial Secretary, that all orders placed in the United Kingdom for tools and high-speed steel required for *bona-fide* munition work should pass through the office of the Commission at Ottawa for certification, and that on arrival of these certified orders in the United Kingdom they would receive the sympathetic attention of the Ministry of Munitions.

The Commission circularized the munition workers in Canada and secured from them an estimate of the tonnage of high-speed steel required for 1916 consumption. This estimate was forwarded to the Imperial Ministry of Munitions for its guidance regarding the probable consumption in this country for that year.

The certifications were originally intended to cover only tool steel and tools made from high-speed and carbon steels, required solely for the purpose of manufacturing munitions. However, additional restrictions placed by the British Government on exports from the United Kingdom made it difficult for other Canadian buyers to secure various supplies of which they were in urgent need, and the Commission was called upon to certify to the requirements of the Canadian Government railways, mining companies, and public corporations.

This procedure was followed from January, 1916, and a large number of orders from various munition manufacturers and others were passed through the office of the Commission for certification before being forwarded to England.

On February 24, 1917, the Ottawa agent of the Eagle & Globe Steel Co., Limited, of Montreal, complained that one of their orders, which had received certification from the Commission, had been returned to Canada with the statement that the order could not be filled until it had been duly authorized by the Department of Trade and Commerce of Canada.

On consultation with the Department of Trade and Commerce the Secretary was informed that the Imperial Government had, in December, 1916, instituted what had been called 'Local Priority Authorities' for the Overseas Dominions, and that the Department of Trade and Commerce of Canada had been asked to act as the Local Priority Authority for this Dominion. This regulation and the means whereby it became operative are explained in the following copy of a letter from the Deputy Minister of Trade and Commerce, addressed to Edgar R. Jones, Esq., Priority Branch, 1 Caxton St., Westminster, London, Eng.:

DEPARTMENT OF TRADE AND COMMERCE,

OTTAWA, February 26, 1917.

DEAR SIR,

I am directed by the Right Honourable Sir George E. Foster, Minister of Trade and Commerce, to acknowledge receipt of your letter of the 23rd ultimo, No. 94645.

In reply, I am instructed by the Minister to say:

1. The functions of a Local Priority Committee for Canada will be discharged by the Department of Trade and Commerce at Ottawa, and applications for priority assistance will be signed by the undersigned Deputy Minister or such officer as may act for him.

2. A supply of forms of application for priority assistance will be printed at once, and sample copies sent to you as soon as they are available. One or two slight departures have been made from the draft form enclosed with your letter of the 23rd ultimo, in order to suit conditions in Canada. Question No. 12, asking for name and address of the United Kingdom manufacturer of the order referred to in the application, has been added, as we have previously found this information useful.

3. We shall require Canadian firms to fill out these forms in quadruplicate; one copy to be certified to by myself and returned to the firm to be attached to their order; two copies to be certified and sent direct by this Department to the Ministry of Munitions in London; and one copy to be retained on the files of this Department.

4. Each application will receive a Canadian Priority Serial Number, and a record of all applications will be kept in this Department in a book which will be procured for that purpose.

5. As soon as the necessary forms are ready, the undersigned will cause a general announcement to be made in the Canadian press. and also in this Department's Weekly Bulletin, that no applications for Priority Permits from Canada will henceforth be considered by the British Ministry of Munitions except upon the receipt of the proper forms duly countersigned by an authorized officer of this Department.

6. I note that in urgent and important cases orders may be placed by cable; and in such cases the cable will contain the reference number of the application, which will follow by mail.

7. We note that the cable address of the Priority Branch is 'Municax' London. Please note that my cable address is 'Comagent' Ottawa. Should it be found necessary to communicate in cipher at any time, the Imperial Government Code may be used.

8. I note that confidential memoranda will be issued by the Ministry of Munitions from time to time, giving information in regard to any new restrictions or orders, and will have these carefully kept on file here.

9. In case of articles directly required for war work, I will arrange to have the correctness of the applicants' statements certified to on the application forms by the Imperial Munitions Board at Ottawa, whenever possible.

10. The plan outlined above can be put into operation as soon as this Department receives a supply of the necessary forms, which are now being printed and should be ready in a few days. A number of cases which have been referred to us by the Canadian High Commissioner in London still remain to be disposed of; and in these cases we are procuring the usual affidavits from the Canadian firms interested, and returning them to the High Commissioner. We shall continue to follow this plan with any future enquiries we receive from the High Commissioner, as we understand that you will inform him as soon as you are ready to advise British firms to direct their Canadian customers to send their applications for priority certificates through this Department, and that, after that, no further orders will be referred to us by the High Commissioner.

11. I shall be glad to receive any further suggestions or instructions that the Ministry of Munitions may wish to put forward at any time.

Yours truly,

(*Sgd.*) F. C. T. O'HARA,
Deputy Minister.

The Secretary wrote to the Prime Minister's office on March 6, 1917, stating that the Commission had received no official communication from the Prime Minister cancelling the arrangement previously entered into at the request of the Colonial Secretary. No reply having been received to this letter, and the Secretary finding that the Commission's certification on Canadian orders was no longer required, it was assumed that the Government desired no further action in this matter by the Commission.

Scrap Steel.—On December 7, 1915, the Commission wrote the Honourable Dr. Reid, Minister of Customs, advising him that there would in all probability be a shortage of scrap steel in Canada for purposes of manufacturing munitions and that the export of all scrap should be prohibited during the period of the war. This recommendation was accepted and an embargo was placed by the Minister of Customs on the export of all scrap steel. On January 13, 1916, the Department of Customs was advised that the following classes of scrap iron and steel should be allowed to be exported under special license:

Plate scrap less than 3-16 in., not bundled.
Wrought iron and pipe scrap.
Tin plate scrap.
Scrap rails 26 ft. and over.
Old bridges intact.
Old railway turn-tables.

The embargo on the export of scrap iron and steel, with the exception of the above classes, was in operation during 1916 until the month of September, when, owing to the fact that turnings and borings resulting from the manufacture of shells had accumulated throughout the country in tonnages exceeding the requirements of the steel plants, special licenses were issued for the export of 10,000 tons of this light scrap. The export of 10,000 tons did not, however, relieve congestion, and in October it was found necessary to advise the Department of Customs that turnings and borings might be exported under license up to December 31, 1916. Approximately 50,000 tons were thus exported.

During the last week in December, 1916, a very careful survey of the whole situation was undertaken, and after consultation with the Imperial Munitions Board the Secretary telegraphed all munition manufacturers throughout the country that on and after January 1, 1917, exports under license would be discontinued.

Upon receipt of these telegrams, sent after advice and with the consent of the Imperial Munitions Board, the munition manufacturers brought sufficient pressure to bear upon the Government to effect the export under license of turnings and borings from January 13, forward.

Between January 13 and 31, 1917, the Department of Customs issued licenses for the export of 343 tons of scrap iron and 5,590 tons of scrap steel; and it was arranged that the Department of Customs should furnish the Commission with monthly returns showing the tonnage of scrap iron and scrap steel exported.

The Commission having instructed Mr. J. Dix Fraser, of Port Arthur, to investigate and report upon the general scrap situation, was furnished on January 10, 1917, with Mr. Fraser's report, which will be found in Appendix A.

In view of the fact that shell steel was not produced in Canada west of Sault Ste. Marie, the Department of Customs, on the advice of the Commission, granted licenses during the latter half of 1916 for the export of all turnings and borings and such other scrap materials as could not be absorbed in the country west of the Great Lakes; and in December, 1916, the Commission made a further recommendation that all classes of scrap from points west of and including Port Arthur should be allowed export under license. In January, 1917, certain rolling-mill interests in Manitoba and Alberta were successful in securing an embargo on the export of all classes of steel scrap, with the exception of borings and turnings, from the Provinces of Manitoba, Saskatchewan, and Alberta. It should be noted in this connection that this embargo was placed purely from commercial motives and had no bearing whatsoever on the production of shell steel.

Companies in Canada making shell steel made considerable progress during 1917 in their methods of using turnings, borings, and other light scrap, so that at the end of that year the steel companies were in a position to absorb a much larger quantity of this material than was thought possible at the time Mr. Fraser's report was made.

Increased capacity for the re-melting of light scrap was offset by the advance of from 30 to 50 per cent in prices for this material during the time it was exported under license, and the Commission, being apprehensive that the continued export of this class of scrap would curtail the production of shell steel, made the following recommendation to the Imperial Munitions Board:

(*Excerpts from memorandum addressed to Imperial Munitions Board, dated January 8, 1917.*)

PROPOSAL REGARDING SCRAP STEEL

The embargo against the export of Canadian scrap steel to the United States has operated to the dissatisfaction of Canadian scrap producers in that they claim that they are being discriminated against in the matter of prices for this scrap, declaring that the American prices are on the average above Canadian and that with the embargo in force the Canadian steel companies are enabled to buy this scrap much below its full value.

Messrs. E. Carnegie and G. C. Mackenzie of this Commission have discussed the problem under three different headings as follows:

1st. The embargo should remain in force and applications for license to export should be refused for the reason that such scrap steel is required for munition purposes and that should a large amount of scrap steel accumulate the embargo be lifted temporarily to relieve congestion.

This proposition was dismissed without much discussion, as being too crude and apparently unworkable.

2nd. The Canadian steel makers be asked to pay the going price in the United States as stated from time to time in the *Iron Age* and the *Iron Trade Review*, with freights equalized.

This proposition was decided to be too complicated, as there was quite a wide difference in the prices for scrap quoted at various iron and steel centres in the United States, and it would require a very nice adjustment to fix the price at which steel scrap should be sold at Sault Ste. Marie, Hamilton, Montreal, and Sydney, N.S., so that both the steel maker and the scrap producer would feel that they were being dealt with fairly.

3rd. That the Imperial Munitions Board should undertake to purchase the scrap outright from the scrap producer and sell and move it to the steel maker.

This proposition would seem to be the most workable of the three as it would take the question of price out of the hands of the producer and steel maker altogether, and in all probability would satisfy both the scrap producer and the steel maker, as any profits accruing would then be to the credit of the Imperial Government. The proposition is outlined roughly as follows:

(a) That the Imperial Munitions Board would buy, f.o.b. scrap producing works,—

Turnings and borings..........	at $ 7 per ton.
18-pounder shell ends..........	at $10 " "
Heavy melting scrap..........	at $15 " "

(b) The Imperial Munitions Board would sell to the steel manufacturers, f.o.b., their works,—

Turnings and borings	at $10 per ton.
18-pounder shell ends	at $13 " "
Heavy melting scrap	at $18 " "

(c) The above prices allow the Imperial Munitions Board $3 per ton on each class of material to pay deliveries to steel works. This item we think should prove amply sufficient in the majority of transactions.

(d) Should excess tonnage of scrap accumulate at any point from whatever cause, the Imperial Munitions Board may export such excess tonnage under license.

(e) It is suggested that the above prices would apply only to points in Ontario, Quebec, New Brunswick, and Nova Scotia; the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia would of necessity have to be dealt with under a different schedule adjusted to meet the western demand and supply.

(f) The proposal would mean that the Imperial Munitions Board would organize a scrap steel department which would buy the scrap as fast as it is made and move it to the steel plants as it is required, excess production being exported at the discretion of the Board.

In replying to the above memorandum the Chairman of the Imperial Munitions Board stated that the purchase of scrap steel was not a natural function for the Board to discharge, but advised that a meeting of the steel manufacturers and scrap producers would be helpful in arriving at some decision. This meeting was held at the Imperial Munitions Board in Ottawa on February 27, the Secretary of the Commission being invited to attend. The meeting was addressed by the Chairman and the Ordnance Advisor of the Board, who explained that while the Board did not care to actively participate in the handling or disposal of scrap steel it desired that the machining companies and the steel producers should, if possible, come to some terms of agreement so that a larger tonnage of this scrap might be retained in Canada. It was proposed by the representative of the John Inglis Co., Limited, of Toronto, that the machining companies should sell to Canadian steel makers their turnings and borings, f.o.b. the works of the machining companies, for $1 per ton less than the ruling market price in the United States. This proposal was, however, not favourably received by some of the representatives at the meeting.

It was pointed out by the Chairman of the Board that if a lower price could be agreed upon it was possible that the production of steel would be increased; but one or two of the steel representatives maintained that a reduction in price would not affect the production, as the tonnage that could be produced in Canada was now practically at a maximum. The meeting adjourned after some argument on both sides and without any definite action being taken.

In April, 1917, a number of the steel makers organized what was known as the 'Shell Scrap Bureau', having for its object the purchase of a sufficient quantity of scrap from machining plants and scrap dealers to meet the steel makers' requirements. The Bureau was capitalized at $100,000, of which each of the steel companies interested subscribed an amount proportionate to the percentage of its requirements estimated for a period of six months. The Bureau endeavoured to buy sufficient scrap to fill the steel companies' requirements, in no instance paying more than $12 and $24 per gross ton, respectively, for turnings or heavy scrap, f.o.b. the machining plant or the dealer's yard.

This arrangement continued in force until February 1, 1918, at which date the Shell Scrap Bureau was absorbed by the Shell Scrap Department of the Imperial Munitions Board, which had been organized for this purpose.

This action was taken at the instigation of the steel makers, who felt that not all the scrap was being made available for the shell steel which they were supplying on contracts placed with them by the Imperial Munitions Board.

All machining and assembling orders placed in the provinces of Ontario and Quebec on which contractors were working, contained a clause by which the contractors sold to the Imperial Munitions Board, at $24 and $12 per gross ton, respectively, f.o.b. cars their works, the heavy scrap and steel turnings produced on the orders.

The Shell Scrap Department of the Board, taking into account the number of shells under contract from the machiners and assemblers in Ontario and Quebec to February 1, 1918, and assuming that 45 per cent of the weight of the forgings would be available in the form of scrap, estimated the amount of scrap which would accumulate at the machining and assembling plants during the month of February. They also estimated the ingot production of the steel makers in Ontario and Quebec (omitting the Algoma Steel Corporation) and the percentage of turnings and heavy scrap which would be used in the production of shell steel ingots. With these figures they endeavoured to distribute the February scrap production so as to meet the immediate needs of the shell steel makers with due consideration for the stock of scrap which the makers had on hand at February 1.

The Shell Scrap Department of the Board forwarded orders to the machiners and assemblers for their approximate output of scrap for the month, against which they invoiced their shipments. The material thus invoiced was in turn charged to the steel companies, who received it at the prices paid to the machiner and assembler plus freight charges. Each week a report was received from the machiners and assemblers covering the amount of scrap shipped during the previous week, and in this way the Department was enabled to keep in close touch with the scrap production.

It was the policy of the Shell Scrap Department to ignore the dealers, realizing that allowing them to handle scrap from machining and assembling plants would endanger the principles which prompted the Board to take over the scrap business, namely—preventing inflation of prices incorporated in contracts, and guarding against the possibility of scrap which should be available for shell steel makers finding its way into other hands.

On April 20, 1917, the Department of Customs instructed Collectors of Customs in Ontario and Quebec to suspend the issuance of licenses for scrap steel turnings and borings, and on July 12 authority to issue licenses for these materials was withdrawn from all ports.

'Nicu' Steel.—The trade name 'Nicu' was formed by combining the chemical symbol for nickel (Ni) with that for copper (Cu). This steel is the invention of Mr. G. M. Colvocoresses, who claims originality in the production of steels containing both nickel and copper from ores containing both of these elements, such as exist in the Sudbury district, Ontario.

At the present time the production of this steel is in the experimental stage, and only a few hundred tons have been manufactured for the purpose of experimental tests. The subject has been dealt with in a brief report by Messrs T. W. Hardy and J. Blizzard which will be found in Appendix C.

COPPER AND NICKEL

Copper and Nickel.—The Commission, being aware of the conditions under which ores of copper and nickel are mined and partially refined in Canada and then exported to the United States for refining and marketing, collected all information obtainable, including a report from Mr. J. E. McAllister on the cost of refining copper in Ontario which will be found in Appendix B.

This information was presented to the Government, together with resolutions recommending that definite action should be taken in order to insure the establishment of copper and nickel refineries in Canada.

Mr. McAllister stated that in preparing this report he had consulted with the foremost copper and nickel metallurgists in America at their plants in New Jersey; that these metallurgists had gone carefully over his figures and had assured him that he had arrived at conclusions as near the truth as could possibly be expected without actually building and operating a plant. Therefore he was satisfied that his report could be relied upon as an expression of the opinions of the best authorities on this continent.

In discussing general features Mr. McAllister pointed out that whereas the cost of refining copper at this hypothetical plant had worked out to a figure of $13 a ton, the New Jersey plants were doing the same for $8 a ton. This discrepancy was due almost entirely to the fact that the cost figures of the Canadian plant were based on a capacity of only 50,000 tons of copper annually, whereas the cost figures for the American plants were the result of operations on a scale of 100,000 to 150,000 tons annually. He was of the opinion, however, that a Canadian plant of the same capacity as the American plants would not be able to refine for the same cost, i.e. $8 a ton, because there were other factors which assisted the American plants and which could not be expected in connection with a Canadian refinery for some length of time, such as a highly organized and trained staff, cheap and rapid transportation of all raw materials and supplies, and a better labour market. It was true that the American plants were not securing their electric power for as low a figure as the Canadian refinery could expect from the Niagara power companies. Nevertheless, this advantage of the Canadian plant would be more than offset by the other items mentioned above, and he did not consider that a Canadian plant under the most favourable circumstances and with a capacity of 150,000 tons a year could refine copper for much below $10 a ton.

RESOLUTIONS PRESENTED TO THE GOVERNMENT ON FEBRUARY 24, 1916.

With respect to the Refining of Copper in Canada.

WHEREAS this Commission being in possession of the facts relating to the copper production of Canada showing that almost the entire production of our mines in the shape of copper ore and of our smelters in the shape of blister copper and matte is being exported to the United States for purposes of refining the same, and that this copper exported for refining purposes is available only to the Canadian and British consumer at prices fixed by these smelting companies in the United States; and

WHEREAS the Canadian production in the form of ore, matte, and blister copper for the year 1915 was believed to be 105,000,000 pounds, and the requirements of the Dominion for munition purposes during the same period was practically 91,000,000 pounds; and

WHEREAS it is estimated that the production of the Dominion for the calendar year 1916 may possibly be 150,000,000 pounds, and the country's requirements for munition purposes during this calendar year will probably be not less than 140,000,000 pounds, in addition to which the ordinary commercial demands of the country are considerable, and

WHEREAS there is always a possibility of the United States being drawn into the war, which would mean that the Government of that country might prohibit the export of copper in any form to Canada; and

WHEREAS the export in bond of Canadian blister copper, matte, and ore to the United States for refining purposes, to be returned to Canada, would in all probability be most unsatisfactory under war conditions;

IT IS RESOLVED that this Commission place itself on record as being strongly impressed with the urgent necessity of remedying the situation at the earliest possible moment, and we respectfully suggest that the Government of Canada, by legislative enactment or otherwise, offer inducement which will insure the erection of the necessary works for purposes of refining the total production of Canadian copper.

With respect to the Refining of Nickel in Canada.

WHEREAS this Commission being informed that The International Nickel Company of New York has stated that it is their intention to establish a refinery in Canada for the production of refined nickel from the ores of the Sudbury district in amount sufficient to meet the requirements of the British Empire; and

WHEREAS approximately 85 per cent of the nickel produced from the mines in Sudbury has been refined by the above mentioned Company in the United States; and

WHEREAS it is well known that the countries now at war with the British Empire have obtained a large portion of their supply of nickel from ores mined in Canada and refined in the United States; and

WHEREAS the world's production of nickel for the year 1913 was in the following proportion:

Canada	71 per cent.(1)
New Caledonia	26 "
Norway, Prussia, and Greece	3 "

and assuming that New Caledonia did not increase its production for that year, the Canadian output in 1915 would approximate 80 per cent of the world's supply;

IT IS RESOLVED that this Commission urge the Canadian Government to insist upon the International Nickel Company proceeding with the instant establishment in Canada of sufficient refinery capacity to provide an adequate supply of nickel for the Empire's requirements, and further desire to point out that climatic conditions present no adequate cause for failure to proceed with the installation of such a refinery immediately.

(1) Canadian production was considerably increased during the War.

In acknowledging receipt of the Commission's resolutions the Premier stated that the International Nickel Company of New York, U.S.A., had on January 7, 1916, signified their intention of granting the request of the Canadian Government to the end that a nickel refinery be erected in the Dominion of such initial capacity as to secure a product of finished nickel sufficient for the requirements of the British Empire.

In subsequent discussion of this matter the Commission was made aware that the British America Nickel Corporation, Limited, a company composed mainly of Canadian and British capitalists, had submitted a proposal to the Canadian Government in the spring of 1914 which would insure the British Empire's requirements of refined nickel being produced in Canada and incidentally the production at the same time of a considerable tonnage of refined copper. The Canadian Government had not accepted this proposal, and the Corporation, having failed to finance its undertaking in the United States, had postponed indefinitely the erection of smelters and refineries.

Resolution Presented to the Government on April 17, 1916, with respect to the Refining of Copper and Nickel in Canada.

Whereas this Commission has presented certain resolutions to the Government on the subject of the refining of nickel and copper in Canada; and

Whereas such resolutions were acknowledged and the Commission asked to secure further information on the subject that would enable the Government to take steps to insure the refining in Canada of the above metals; and

Whereas the Commission has learned upon investigation that the total Canadian copper production disassociated from nickel is at present insufficient to insure the economic operation of a refinery for copper alone; and

Whereas the Commission is of the opinion that the establishment of a nickel refinery, independent of the International Nickel Company, would provide the establishment of a copper refinery in connection therewith; and would undoubtedly greatly stimulate the development and operation of a number of the smaller Canadian copper mines which in consequence of lack of Canadian smelting and refining facilities have now no market for their ores; and

Whereas the Commission being informed through a letter dated March 17, 1915, addressed to Colonel Carnegie of the Shell Committee, at Montreal, that the British America Nickel Corporation stated that they had developed a nickel and copper deposit containing eleven millions of tons and did submit a plan to the Government whereby on the guaranteeing of certain securities the Corporation would be prepared to construct and operate in Canada a refinery for the production of nickel and copper from these ores;

It is Resolved that the Commission recommend that the Government communicate with the British America Nickel Corporation to ascertain if this proposal is still feasible, and if so, such aid be given by the Dominion Government by way of temporary advance of capital, guarantee of securities, or otherwise, as will insure the establishment of such refining plants.

The Premier acknowledged receipt of the above resolution and stated that it would be laid before Council at an early date; but in so far as the Commission is aware the Government took no action.

In the early fall of 1916 the British America Nickel Corporation announced that it had secured sufficient funds to enable it to erect smelters and refineries for the production of both nickel and copper in Canada. It is understood that the British Government is the principal shareholder of this Corporation. The British America Nickel Corporation is now actively engaged in developing the Murray mine in the Sudbury district, at which point it is constructing its blast furnaces and convertor plant. The electrolytic refinery of the Corporation is under construction at Deschênes, Que., 5 miles from Ottawa, and is expected to reach the production stage before the end of 1919.

About the same time (fall of 1916) the International Nickel Company made definite announcement that Port Colborne, Ont., had been selected as the site for its Canadian refinery, and began construction forthwith. In July, 1918, the Port Colborne refinery was completed and put into operation for the treatment of copper-nickel matte from its smelters at Sudbury.

MINERAL INVESTIGATIONS

WORK OF FIELD OFFICERS AND OTHERS

The Commission has investigated a large number of mines, prospects, and occurrences of certain minerals essential to the production of munitions. This work has been done by Mr. J. C. Gwillim, Professor of Mining Engineering, Queens University, Kingston, Ont.; Dr. W. F. Ferrier, Consulting Mining Engineer and Geologist, Toronto, Ont.; Dr. W. L. Uglow, Mining Engineer and Geologist, Kingston, Ont.; Mr. J. W. Bell, Assistant Professor of Mining Engineering, McGill University, Montreal, Que.; and Mr. Wm. Thomlinson, New Denver, B. C.; who were engaged directly by the Commission. The Secretary also conducted several investigations and mine examinations.

In addition to the work of the regular field officers of the Commission, certain special investigations were undertaken from time to time by members of the staff of the Department of Mines, Ottawa, whose services were placed at the disposal of the Commission by the Department. The late Dr. D. D. Cairnes reported on tungsten in the Yukon and the Maritime Provinces; Mr. C. Camsell on molybdenite in Quebec, and tungsten in New Brunswick and Nova Scotia; Dr. A. O. Hayes and Mr. E. R. Faribault investigated certain occurrences of manganese, tungsten, molybdenum, and zinc, in Nova Scotia; Mr. S. E. Slipper reported on an occurrence of manganese in southern Alberta; Mr. M. F. Bancroft examined certain manganese deposits in central British Columbia; and Mr. C. S. Parsons, assisted by Dr. Uglow, made detailed examinations of certain bog manganese ores in New Brunswick.

Important laboratory work was undertaken by Mr. J. Keele, Mr. F. G. Wait, Mr. H. C. Mabee, and Mr. W. B. Timm.

All of the plan and map work required for field reports and for the Index of Canadian Mineral Resources was undertaken by Mr. H. E. Baine and his staff.

Mr. J. C. Gwillim was instructed to proceed to British Columbia in the fall of 1916 for the purpose of reporting on the possibility of increased production of the ores of molybdenum, tungsten, and zinc. In the summer and fall of 1917 he undertook the examination of numerous molybdenite occurrences in the Provinces of Ontario, Quebec, and Nova Scotia. He also investigated certain chromite deposits in Quebec, and tungsten and manganese mines in New Brunswick and Nova Scotia.

In August, 1917, the services of Dr. W. F. Ferrier, of Toronto, were secured by the Commission to investigate and report on the possibility of discovering deposits of bauxite, an ore of aluminum, in the Interior Plateau region of British Columbia. Dr. Ferrier continued his field-work during the summer of 1918, and although he was unsuccessful in actually locating a deposit of this mineral, he is of the opinion that the geological conditions in this and other sections of the country indicate that bauxite may yet be found. Dr. Ferrier's work for the Commission has stimulated to no little extent the search for bauxite by individual prospectors, particularly in British Columbia, and it is within the range of possibility that some discovery may be made as a result of the Commission's initiative.

In addition to Dr. Ferrier's field-work on bauxite he, at the request of the Secretary, examined and reported upon a considerable number of mineral occurrences that were of importance in connection with the supply of war minerals, such as manganese ore, chromite, fluorite, mica, platinum, and some others.

During the course of his work in 1917, Dr. Ferrier discovered a new mineral in an olivine basalt on the north shore of Kamloops lake, British Columbia, which was fully described by Prof. R. P. D. Graham, of McGill University, in a paper read before the Royal Society of Canada in May, 1918, and named 'Ferrierite' in honour of its discoverer. The mineral is a zeolite containing magnesium, of no commercial value, but of considerable scientific interest.

During the winter months Dr. Ferrier, assisted by Mr. A. M. Campbell, took charge of the Mineral Resources Index under process of construction by the Commission. Difficulties encountered in connection with the preparation of the necessary maps for the Index were the cause of much unforeseen delay, and greatly hindered the work. Mr. Campbell made good progress in the preparation of the cards covering some of the more important war minerals.

Dr. Ferrier also prepared several special reports; made numerous laboratory examinations of minerals and answered enquiries from the Imperial Munitions Board and others regarding them; and edited and saw through the press the First Report and the present Final Report of the Commission.

Dr. W. L. Uglow with Mr. C. S. Parsons made examinations of New Brunswick manganese bog ores and completed the reports thereon. He also examined manganese deposits in Nova Scotia. In the spring of 1918 Dr. Uglow was placed in charge of field-parties investigating certain platinum resources in Alberta and British Columbia. He resigned from the staff in November, 1918, and was replaced by Mr. Wm. Thomlinson, who was already in the employ of the Commission in the capacity of ore sampler.

ALUMINUM

General

Bauxite, the principal ore of the metal aluminum, has not been found in Canada up to the present time, but, as already stated, since the engagement of Dr. Ferrier in the fall of 1917 he has devoted his time chiefly to a reconnaissance for that mineral in British Columbia.

The extensive works of the Northern Aluminum Company at Shawinigan Falls, Que., are producing aluminum from ores imported from the United States and France (formerly also from Germany). A mill for the manufacture of wire and cables is also operated by the same company.

The metal aluminum has become of late years familiar to every one through its introduction in the form of kitchen utensils. Its use in other forms is, however, not so well known. Several thousand tons of aluminum wire have been used in the points of the modern long-tapered rifle bullets. The copper-nickel sheath has a small pellet of aluminum inserted in its point, the remaining space being filled with lead in the usual manner. The bullet is not a 'dum-dum' bullet, because the aluminum is harder than the lead which it displaces and thus tends to prevent 'mushrooming' or spreading of the nose of the bullet on impact. The device is said to give a flatter trajectory and increased accuracy of fire.

Time-fuses for shrapnel are made of aluminum in place of brass, several million having been put into shells made in the United States for the Russian Government. Machine guns of the air-cooled type use aluminum radiators. Aerial construction has absorbed large quantities of aluminum.

The explosive 'ammonal', consisting of powdered aluminum and ammonium nitrate, has been used in large quantities by all combatants in the late war.

Large quantities of aluminum wire are now used instead of copper in the manufacture of electric power-line cables, and aluminum dust is being extensively used in place of zinc dust for the precipitation of gold and silver from cyanide solutions.

Bauxite and the Possibility of its Occurrence in British Columbia

By W. F. FERRIER

General Statement of Field-Work, and Acknowledgements.—The prospecting for bauxite which the writer was instructed to undertake was done in the Interior Plateau region of British Columbia. A reported discovery of that mineral in Saskatchewan was investigated and proved to be without foundation. Investigations were conducted from the economic standpoint and no detailed geological work was attempted.

Many large and fine specimens of ores, minerals, and rocks, were collected during the progress of the work and presented by the Commission to the Museum of the Geological Survey. Numerous photographs were taken, some of which accompany this report.

Much of the territory covered by the field-work lies within the area covered by the Kamloops and Shuswap map-sheets issued by the Geological Survey.

Work in 1917 within that area was commenced on September 6, and brought to a close on November 5. On telegraphic instructions, certain mineral investigations in the Grand Forks mining division, British Columbia, and in southeastern Alberta and southwestern Saskatchewan were then undertaken under considerable difficulties owing to weather conditions, and continued until December 3, when the heavy snowfall stopped the work.

In 1918, work in the field commenced on July 5, and was closed on October 21. Some delay was caused by the abnormal rainfall and the scarcity of suitable men and horses. The territory covered lies wholly in British Columbia, chiefly within the same boundaries as in 1917.

During a portion of the season of 1917, Mr. Fred Nelmes, of Kamloops, rendered efficient aid in the physical work of carrying on the investigations. Experience in former years with the geological parties of the 49th Parallel survey specially fitted him for the work, and he also proved himself to be a keen observer. Dr. J. A. Allan, of the University of Alberta, Edmonton, assisted for a few days on a particularly trying trip, and it was largely due to his hearty co-operation that we were enabled to attain our object.

In 1918, Prof. R. P. D. Graham, of McGill University, acted as field-assistant and also conducted several independent investigations. His able and untiring assistance in gratefully acknowledged.

Kamloops was made the headquarters for the British Columbia work, and the thanks of the Commission are due to Mr. D. Roy Cameron, District Inspector of Forest Reserves, who, during both field-seasons, furnished office and storage accomodation. His help in planning routes and obtaining suitable men for the field-parties greatly facilitated the work.

Among the many others who freely gave information and assistance in connection with this and other field-work, special thanks are due to Mr. F. W. Peters, General Superintendent, Canadian Pacific Railway, Vancouver; Mr. R. W.

Thomson, Resident Engineer, Mineral Survey District No. 3, Kamloops; Mr. P. B. Freeland, Resident Engineer, Mineral Survey District No. 4, Grand Forks; Mr. J. D. Galloway, Resident Engineer, Mineral Survey District No. 2, Hazelton; Mr. W. S. Clark, Canadian Pacific Railway, Ashcroft; Mr. J. A. Dawson, Inland Revenue Department, Vancouver; Mr. W. W. Wood, Government Offices, Kamloops; Mr. H. W. McKenna, Fire Ranger, Hat Creek Forest Reserve; and Mr. M. McIntyre, Merritt.

Introduction.—When the question of possible new mineral resources was considered by the Commission, bauxite, the ore of aluminum, was suggested and instructions were received to investigate the possibility of its occurrence in Canada.

Bauxite is found under a great variety of conditions. It occurs in place, as a residue from rock decomposition; also, seemingly, as a true chemical precipitate. Deposits are also found as beds composed of transported material, contaminated with sand and clay.

It was thought best to confine attention at first to some comparatively small area, where geological conditions appeared favourable to the formation of bauxite.

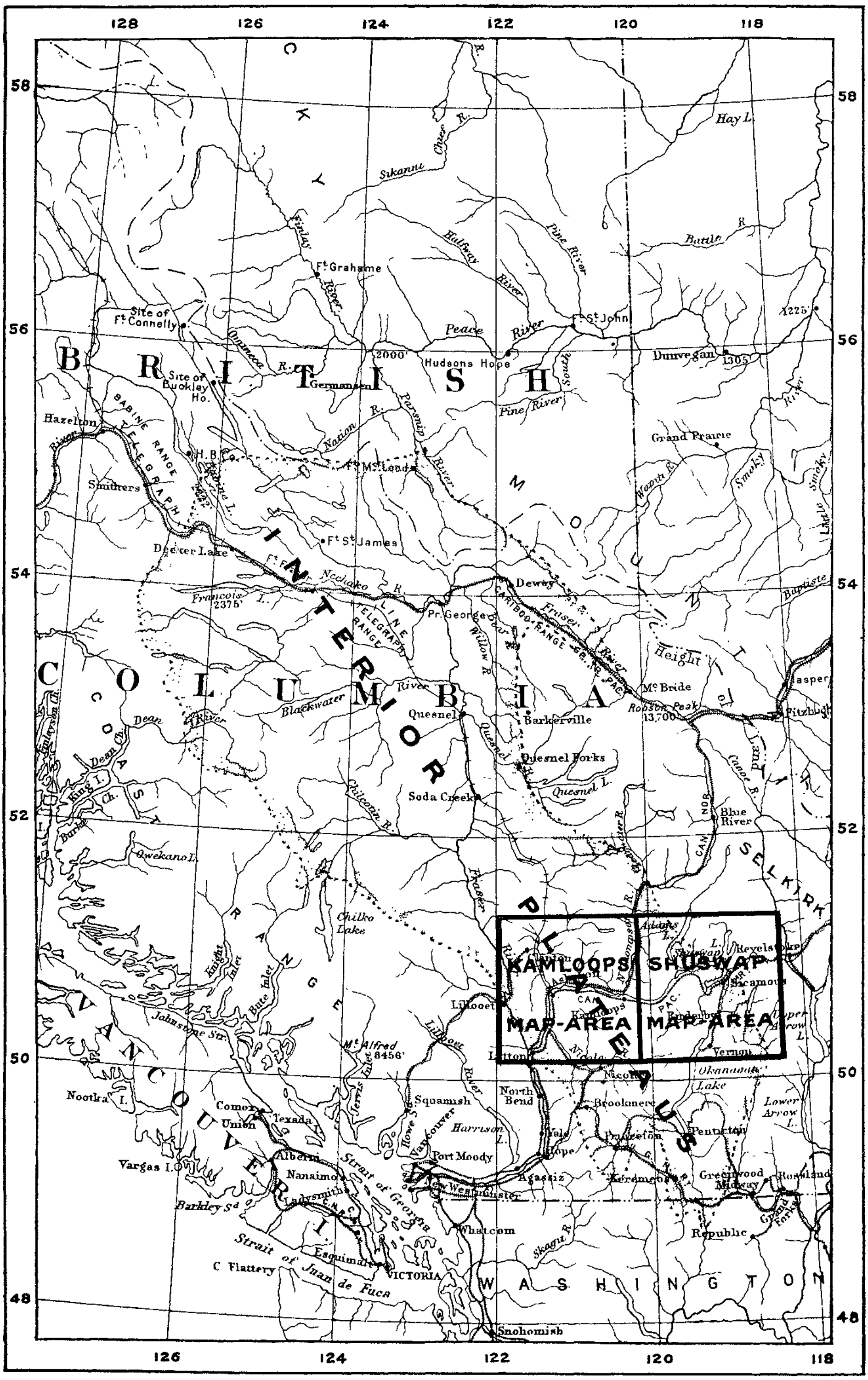
Bauxite is known to result at various localities from the decomposition of basaltic rocks. From a hasty perusal of the literature in the short time available, the writer was at once impressed with the apparent similarity of geological conditions accompanying the bauxite deposits of northeastern Ireland and those prevailing in portions of the Interior Plateau region of British Columbia, more particularly in the Kamloops district. Rocks from the Kamloops district were studied and described by him in Dr. G. M. Dawson's report on the district, published in 1896. This district, with a part of the country to the east of it where similar rocks occur, was the one selected in which to conduct the first search. The reasons for the selection will be given in detail further on.

Unfortunately, owing to the sudden termination of the war and the consequent cessation of work by the Commission, the necessary chemical and mineralogical analyses, and microscopic examinations, required for a proper understanding of the processes involved in the decomposition of the eruptive rocks and the nature of the resulting products, could not be undertaken. This report, therefore, can only be regarded as suggestive to future workers in the field, who may be able to arrive at some definite conclusions.

The results, so far as actually finding bauxite is concerned, were negative; but interesting facts observed regarding rock decomposition in the area await further study. The information to be gained by such study would be of the greatest assistance when considering the advisability of further search.

Area Examined.—The area in which the explorations were conducted lies between latitudes 50° 15′ and 51° 15′, longitudes 118° 30′ and 122°, and is shown on the Kamloops and Shuswap map-sheets of British Columbia,[1] issued by

(1) Maps Nos. 556, 557 (Kamloops) accompany Ann. Rep., Geol. Surv. Can., new series, vol. 7, 1894. Maps Nos. 604, 669 (Shuswap) were published separately in 1898.



Index map of British Columbia showing Interior Plateaus region, also Kamloops and Shuswap map-areas.

Scale: 100 miles to 1 inch.

the Geological Survey. Reference may be made to these maps, of which both geological and topographical sheets have been published. This area constitutes only a small portion of the Interior Plateau region in which the same rocks occur, as may be seen from the accompanying index map (Plate I).

Geology.—The geology of the Kamloops portion of the area is described by G. M. Dawson in the Annual Report of the Geological Survey for 1894, Part B.(1) Notes on that of the Shuswap portion, by G. M. Dawson, will be found in the Reports of Progress for 1876-77 and 1877-78; and by J. McEvoy in the Summary Reports of the Survey for the years 1891, 1892, and 1894 to 1896 inclusive.

Dawson, in the above mentioned report, gives the following table of formations met with:(2)

	Period	Special Names of Groups or Formations	Character of the Rocks	Approximate observed or estimated thickness in feet	
Kainozoic (Tertiary)	Early Pliocene?	....	Conglomerates..........		
	Later Miocene	....	Volcanic rocks, largely basalt..............	3,100	
	....	Tranquille beds	Bedded tuffs............	1,000	
	Earlier Miocene	....	Volcanic rocks, largely porphyrites*...........	5,300	9,400
	Oligocene	Coldwater group	Conglomerates and sandstones............	5,000	5.000
Mesozoic	Earlier Cretaceous	Queen Charlotte Islands formation (chiefly)	Sandstones, conglomerates, and argillites..........	7,000	7,000
	Triassic (and Lower Jurassic)	Nicola formation	Chiefly volcanic, some limestones and argillites, 7,500 to..............	13,500	13,500
Palaeozoic	Upper Palæozoic (Chiefly Carboniferous)	Câche Creek formation	IN WESTERN DISTRICT Upper part.—Marble Cañon limestone, with some volcanic rocks, argillites and quartzites..	3,000	
			Lower part.—Argillites, quartzites and volcanic rocks with some limestone.................	6,500	9,500
			IN EASTERN DISTRICT Campbell Creek beds (?) argillites and amphibolites, about...........	5,000	
			Argillites and grauwackes, limestones and volcanic rocks.................	7,500	12,500

* Later work has shown that these are chiefly basalts and porphyrites. See Sum. Rep. Geol. Surv. Can., 1912. p. 153.

(1) Report on the area of the Kamloops map-sheet, British Columbia, 1896.

(2) Those below the Carboniferous are here omitted.

Later work, by C. W. Drysdale[1] and B. Rose[2] in the Kamloops area, and R. A. Daly [3] in the Shuswap area, has led to certain modifications in the classification of the rocks adopted by Dawson.

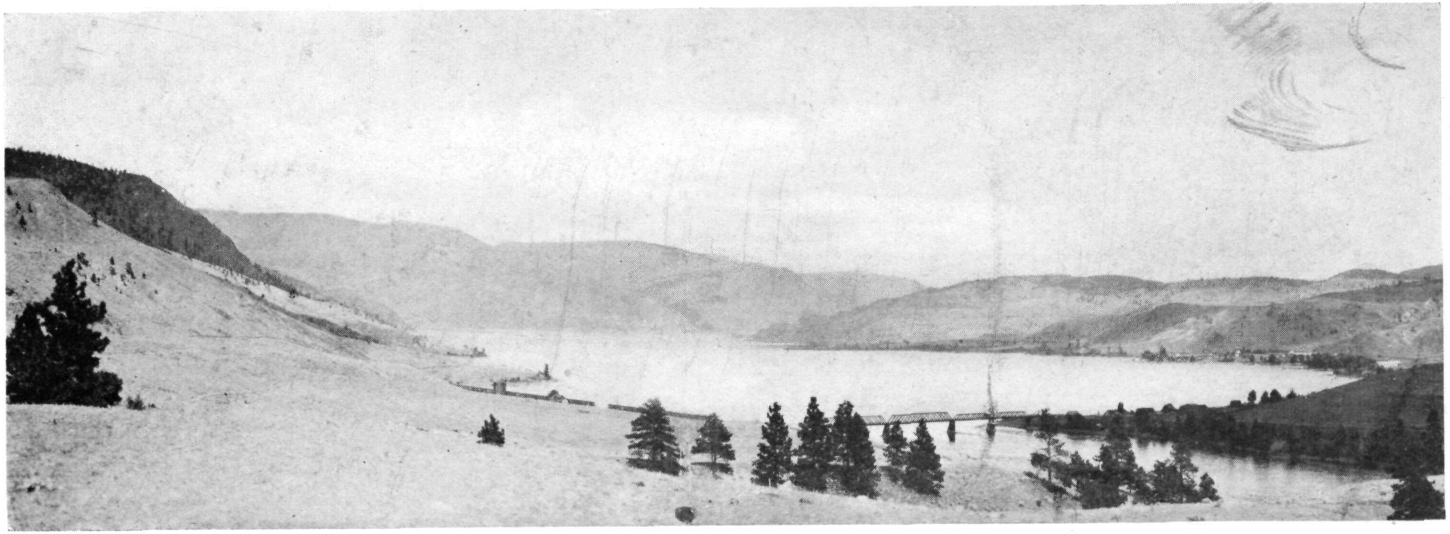
The following table gives Drysdale's classification of the formations, later than Cambrian, represented in the Kamloops area:

Table of Formations

			Approx. thickness in feet
Quaternary	Recent	Soil and Subsoil	
	Pleistocene	Fluvio-glacial deposits	
Tertiary	Lower Miocene	Kamloops Volcanic group basalt, andesite, agglomerate, breccia, and tuff (Tranquille beds).	3,000 ∓
	Oligocene (?)	Ashcroft rhyolite porphyry	1,000 ∓
		Coldwater group conglomerate, sandstone, and shale.	5,000 ∓
Mesozoic	Lower Cretaceous	Queen Charlotte Islands formation (?). chiefly shale, conglomerate, and sandstone.	5,000 ±
	Jura-Cretaceous	Spence Bridge Volcanic group liparitic and andesitic lava, tuff, arkose, and conglomerate.	5,000 ±
	Upper Jurassic (?)	Granitic intrusives	
	Jura-Triassic	Nicola group greenstone (porphyrites), impure quartzite, argillite, limestone, agglomerate, and tuff.	10,000 ∓
Palæozoic	Carboniferous	Câche Creek group cherty quartzite, argillite, greenstone, and limestone (Marble Cañon limestone)	9,500 ±

The main differences between the two classifications are that Drysdale includes the Lower Volcanic group, the Tranquille beds, and the Upper Volcanic group, of Dawson, under the new term *Kamloops Volcanic group*, and also introduces another new term, *Spence Bridge Volcanic group*, to replace the name Lower Volcanic group (hitherto mapped as Tertiary) applied by Dawson to the extensive development of rocks in the western portion of the area, which are now regarded as of Jura-Cretaceous age. By some mistake, Drysdale gives as a section representing the whole of the Kamloops Volcanic group,[4] one representing only the upper members of the group measured by B. Rose at Savona mountain.[5] Daly [6] is inclined to believe that the *Kamloops Volcanic group* should be assigned to the Oligocene.

(1) Sum. Rep., Geol. Surv. Can., 1912, pp. 115-150.
(2) Ibid., pp. 151-155.
(3) Memoir 68, Geol. Surv. Can., 1915.
(4) Sum. Rep., Geol. Surv. Can., 1912, p. 142.
(5) Ibid. p. 155.
(6) Guide Book No. 8, Part 2, Int. Geol. Congress, Ottawa, 1915, p. 149.



West end of Kamloops Lake, showing Savona on the extreme right.

Characters of Bauxite.—Bauxite derives its name from the village of Baux (or Beaux), near Arles, in southern France, where it was first found and described by Berthier in 1821. It is the ore from which the metal aluminum is obtained.

Dana assigns to it the formula $Al_2O_3.2H_2O$ = Alumina 73·9, water 26·1, but notes that some analyses give $Al_2O_3.H_2O$ which corresponds to diaspore. It is now, however, generally regarded as an ore or rock, rather than as a definite mineral species. Analyses show a very wide range in composition. Maximum and minimum percentages of the principal constituents in a series of bauxites from 14 different localities,(1) are:

Alumina (Al_2O_3)	33·2—76·9
Water (H_2O)	8·6—31·4
Iron sesquioxide (Fe_2O_3)	0·1—48·8
Silica (SiO_2)	0·3—37·8
Titanium dioxide (TiO_2)	1·6— 4·0

Besides the impurities shown in the above table, phosphoric acid, carbonic acid, lime, and magnesia are often present. Pure material is probably a mixture of the two hydrates, diaspore ($Al_2O_3.H_2O$) and gibbsite ($Al_2O_3.3H_2O$), but in an amorphous condition. Both diaspore and gibbsite, in crystalline form, occasionally occur associated with bauxite. Bauxite is usually very impure and frequently mixed with clay, quartz sand, and hydroxides of iron.

Its colour ranges from white or grey, through shades of yellow and brown, to red, generally dependent on the quantity and state of hydration of the contained iron. Specific gravity of the purer varieties is about 2·5, but varies with the iron content. The hardness of good ore varies from 1 to 3. It is found in compact, or earthy and clay-like, masses, usually with a coarse ('pisolitic') or fine ('oolitic') concretionary structure. Some varieties which have been extensively mined, as in France, present the appearance of a fine, homogeneous paste, with a splintery conchoidal fracture, and are dark red in colour.

Unfortunately there is no conclusive field-test for bauxite. Chemical analysis is necessary. Dry bauxite of good grade when rubbed on glass will stick to it, whilst clay or kaolin will not; and bauxite will not scratch the glass.

Uses.—Bauxite is the ore of the metal aluminum, but other important uses have been found for it, which are increasing rapidly. It forms the basis of a chemical industry, furnishing the material from which alum, aluminum sulphate, and other aluminum salts are made. Bauxite is also used in the manufacture of bauxite bricks for furnace linings. A considerable quantity of the bauxite mined in the United States is used in the manufacture of artificial abrasives, such as alundum, aloxite, exolon, etc., and many of these are made in Canada. They are essentially artificial corundum (aluminum oxide), produced by fusing alumina obtained from crude bauxite. Calcium aluminate, which gives a quick set to plaster compositions, is prepared by grinding and

(1) G. P. Merrill, Non-Metallic Minerals, New York, 1895, p. 88.

sintering a mixture of bauxite with lime and clays or slags. For the production of metallic aluminum, bauxite low in silica and titanium is required, but the iron content may run fairly high. For aluminum salts, bauxite low in iron and titanium is preferred. Lower grade bauxite, with larger proportions of silica and iron, can be used in the manufacture of abrasives, but most of them, at the present time, are made from bauxite low in silica and iron. A fairly low percentage of iron is required in a bauxite for the manufacture of refractories.

Origin.—The origin of bauxite has been the subject of much discussion, and the literature is voluminous and conflicting. F. W. Clarke in his 'Data of Geochemistry' (1) gives what is probably the best and most concise summary of the various proposed theories. C. K. Leith and W. J. Mead (2) give clear and exhaustive descriptions of the various processes of rock weathering. These and other sources have been freely drawn from in the following notes. Clark comments that:

> Bauxite, like laterite, occurs under a variety of conditions, which suggest a dissimilarity of origin. Its formation has been explained in various ways, but no one theory seems to fit all cases.

Again—

> Taking all of the evidence into account, it seems clear that bauxite may be formed by more than one process. It occurs in place, like laterite, as a residue from the decomposition of rocks; it is found also, apparently, as a precipitate, and sometimes, like any other product of disintegration, it is in beds which represent transported material.

Bauxite is closely related to laterite. The term 'laterite' was first applied in 1807 to certain red, porous, ferruginous, earthy residual deposits found in India, used to make bricks (L. *later*, a brick). It has been very loosely employed by different writers to mean very different things.

Feldspars, which are silicates of aluminum, with varying quantities of lime, potassium, sodium, and rarely barium, constitute from 50 to 60 per cent of the material of average igneous rocks and are all highly alterable.

When an igneous rock is subjected to the ordinary processes of weathering, the chief final residual product is clay, composed of more or less impure kaolin. This kaolin may contain a high percentage of the mineral kaolinite ($H_4Al_2Si_2O_9$), and also other aluminous silicates. It is mainly derived from the decomposition of the feldspars through their hydration and more or less complete removal of their lime, alkalies, and part of the silica. The word 'kaolin' is generally used by geologists to indicate merely the products of kaolinization in a broad sense. The process of rock weathering which produces kaolin is termed 'kaolinization'.

Leith and Mead (3) consider that under exceptionally favourable conditions, a continuation of the ordinary processes of weathering may break down the hydrous aluminum silicates by leaching out the silica more or less completely, and form aluminum hydrates, the chief constituents of bauxite. This process by which bauxites and laterites are formed is termed 'lateriza-

(1) Bull. 616, U. S. Geol. Surv., 1916.
(2) 'Metamorphic Geology,' New York, 1915.
(3) Ibid., p. 25.

tion'. In both kaolinization and laterization the process may be complete or partial, the typical product appearing only when the rock alteration is complete.

The above mentioned authors note that there seems to be some question as to whether laterization is preceded by kaolinization, but conclude that it is reasonable to regard laterization as simply one step further from kaolinization, and that it is possible that alteration may go on so rapidly as to obscure the intermediate hydrous silicate stage.[1]

The same authors note[2] that alumina and ferric iron are the two most stable rock constituents under surface weathering conditions, and that under extreme conditions of weathering, the residual products of decay consist essentially of limonite (ferric hydroxide) and bauxite (aluminum hydroxide). The relative quantities of these in the residual products depend, in general, on the relative quantities in the parent rock. They cite the Arkansas bauxite deposits as representing one extreme in which a rock rich in alumina and containing very little iron yields a comparatively pure bauxite; and the lateritic iron ores of Cuba as representing the other extreme in which a rock fairly rich in iron, and containing very little alumina, yields a limonitic iron ore, containing a small quantity of bauxite. Laterites are defined by them as the products of weathering lying between these two extremes, that is, containing various proportions of ferric hydroxide and alumina hydroxide, with varying quantities of free silica and clay.

Clark[3] takes the same view, stating that there is no dividing line between bauxite and laterite, which is merely an iron-rich variety of bauxite.

L. L. Fermor[4] differs from Leith and Mead in regarding kaolinization and laterization as two totally distinct modes of decomposition. His definition of laterite is essentially the same.

A recent article by J. M. Campbell,[5] on laterite and bauxite, is a most interesting and important contribution to the subject. As several of his conclusions, based on close field-study of laterites in many countries, are novel and suggestive, his summary of them is given here:

> The 'alteration'[6] of crystalline rocks is more rapid and intense in warm than in cold climates, but the results in every climate are fundamentally the same, differing only in degree. The final result of alteration is mostly hydrous silicate of alumina. The 'weathering'[7] of rocks proceeds much more slowly in warm than in cold climates, mainly on account of frost, but the ultimate results are similar. Crystalline rock, either altered or unaltered, is not transformed into laterite in any country while it is either out of contact with atmospheric air or out of contact with vadose water.[8] Unaltered or impermeable rock is incapable of being laterized.
>
> Laterization is the process by which certain hydroxides, principally those of ferric iron, aluminum, and titanium, are deposited within the mass of a porous rock near the surface.

(1) Op. cit., p. 44.
(2) Op. cit., p. 43.
(3) Op. cit., pp. 494-496.
(4) Geol. Mag., vol. 8., 1911, pp. 459, 460.
(5) Mining Magazine, London, vol. 17., Aug.-Nov., 1917.
(6) Defined as 'rock changes taking place *below* water-level'.
(7) The term 'weathering' is used to signify rock changes taking place *above* water-level.
(8) A term applied by Posepny to waters circulating within the earth's crust above the ground-water level, which he assumes to correspond to the lower limit of oxidation.

Unless a rock formed near the surface contains uncombined alumina in the form of hydroxide it cannot be regarded as lateritic. Lateritic constituents are deposited in porous rocks between maximum and minimum vadose water-level only in places where that level is near the surface and oxygen can gain free access. Lateritic constituents are believed to be deposited in limited quantity in suitable situations in temperate climates. Rock, at the time laterization commences in it, usually contains no iron. The rate of formation and deposit of lateritic constituents appears to increase directly with the temperature.

Iron is primarily deposited in laterite as amorphous, highly-hydrated ferric hydroxide, formed by the atmospheric oxidation of ferrous salts, principally carbonate, in solution in vadose water. This hydroxide is often converted into almost or quite anhydrous ferric oxide by means of the simultaneous action of heat and water acting continuously.

Alumina is primarily deposited in laterite as the amorphous tri-hydrate, which may be mixed (or possibly combined) with ferric hydrate, in which case segregation partial or complete into gibbsite ($Al_2O_3.3H_2O$) and ferric oxide usually takes place. Alumina in laterite is derived from hydrous silicate of alumina, which is believed to be broken up by alkaline water producing alkaline aluminate and silicate; this action may be reversed. Alkaline aluminate decomposed by carbonic acid yields amorphous tri-hydrate of alumina; so also does the spontaneous decomposition, but under favourable conditions the latter yields gibbsite. Water from the laterizing zone when exposed to the air deposits ferric and aluminum hydrates with hydrous silicate of alumina, all amorphous. An aqueous medium from which lateritic constituents can be deposited is capable of re-dissolving them.

Secondary change in laterite usually tends towards complete hydration of alumina and complete dehydration of ferric hydrate, usually also toward removal of iron, with a consequent increase in the percentage of alumina and the production of aluminum ores commercially known as bauxite. When amorphous tri-hydrate of alumina is approximately pure it suffers dehydration under favourable conditions, yielding an amorphous di-hydrate. An amorphous aluminum mono-hydrate has been found in old pisolitic laterite. Ancient laterites which, owing to geological movements, have passed below water-level have their iron leached; most bauxites of commerce originate in this way.

The composition of laterite is rarely, if ever, static. It may overlie almost any form of rock, and the ratio of its lateritic constituents is not dependent in any way upon the composition of the rock, which originally occupied the same place and from which it is commonly said to be derived.

As before stated, some authorities account for the formation of certain bauxite deposits in Germany, France, the United States, and elsewhere, by theories of chemical action. As an example, the deposits in Tennessee near Chattanooga, are stated to differ from all other American, and from most of those of foreign countries, in that they are not bedded and are not the product of weathering of any associated rock. They form pockets in a dolomite of Ordovician age. C. W. Hayes (1) advanced a theory of their origin which Lindgren (2) summarises and comments on as follows:

Water of atmospheric origin, which still retained some oxygen, percolated through the shale, decomposing the abundant pyrite. The resulting sulphuric acid decomposed the clay, carrying the alumina upward as sulphate. When the water finally ascended on major fissures through the dolomite the calcium carbonate was dissolved and precipitated flocculent aluminum hydroxide, and this was brought to the surface in suspension. The pisolites were formed by aggregation in moving and ascending water. . . . . . . A weak point in this explanation is evidently the postulated condition of oxidising waters active in the shale at great depth. Ordinarily when depths of 2,000 or 3,000 feet are reached the descending waters would be robbed of their oxygen and would be incompetent to decompose pyrite. However, it is known that the shales of Virginia yield strongly acidic waters carrying alumina.

(1) Trans. Am. Inst. Min. Eng., vol. 24, 1895, pp. 243-254.
(2) Mineral Deposits, New York, 1913.

T. L. Watson [1] and H. K. Shearer [2] both find Hayes' explanation the best yet advanced to account for these deposits. A. Liebrich[3] and others have suggested similar theories for other occurrences.

The foregoing somewhat lengthy notes on the formation of bauxite from rock weathering and by chemical action have been inserted in an endeavour to explain the conditions of which evidence was sought in the field. It will be shown that there is good reason to believe that the geological and climatic conditions during a portion of the Tertiary in British Columbia were very similar to those prevailing in other localities, for example in Ireland, at the time that bauxite deposits resulting from laterization were formed. The possibility of deposits formed by chemical action was also borne in mind. Limestones are abundant and much pyrite occurs in the rocks. Most of the extreme chemical alteration noted, however, ascribed by Dawson to hydrothermal or solfataric action, has resulted, in the case of the alumina, in the formation of hydrous sulphates. Among these, the mineral aluminite ($Al_2O_3.SO_3.9H_2O$), which is new to Canada, was identified by Mr. Graham.[4]

Occurrences.—In its mode of occurrence, bauxite shows the same wide differences as in its composition. Deposits are scattered throughout the world. Well-known ones are found in France, Germany, Austria, Italy, Ireland, India, Seychelles, Australia, the Guianas, and the United States. All are, however, comparatively small, and when this is considered in connection with the rapidly increasing demand for aluminum, it is apparent that the discovery of new deposits, even small ones, is important.

Bauxite is found associated with the rocks from which it has been derived; or sometimes in deposits, probably formed by chemical action, at some distance from its source; also as transported material interstratified with sedimentary beds. The deposits are not confined to rocks of any particular geological period. In Tennessee they are found in Cambrian shale and Ordovician limestone, but were probably formed during Eocene time. Most of the known occurrences appear to be of Mesozoic (chiefly Cretaceous) and Tertiary age.

W. Lindgren,[5] after reviewing the various occurrences, concludes that

> all these occurrences bear a certain family resemblance, and that after all, it looks as if most of the deposits were simply the result of weathering in place under tropical or semi-tropical conditions but without the aid of specially acidic or alkaline solutions. It seems probable that most of the deposits in the United States were formed long ago, under climatic conditions different from those now prevailing.

It was thought that the type of deposit which results from 'weathering' or subaerial decomposition, of acid and basic igneous rocks and tuffs would be the most likely to be found in the Interior Plateau region of British Columbia where prospecting was commenced for the Commission. Abundant proof

(1) Bull. 11, Geol. Surv. Georgia, 1904.
(2) Bull. 31, Geol. Surv. Georgia, 1917.
(3) Zeit. Prakt. Geol., 1897, p. 212.
(4) On the Susan mineral claim, 1 mile south of Spatzum, on the east side of the Thompson river.
(5) Mineral Deposits, New York, 1913, p. 330.

exists of the derivation of bauxite from basic igneous rocks, as in Ireland, Germany, India, British Guiana, and elsewhere.

Such deposits may be formed from practically all types of aluminum-bearing rocks and have been observed in connection with granite, rhyolite, gneiss, syenite, nepheline-syenite, diorite, diabase, trachyte, basalt, tuff, etc.

The bauxite deposits of Arkansas is a typical case of the result of extreme weathering of an acid igneous rock (nepheline-syenite), and those of Germany (Westerwald, Vogelsberg, etc.) illustrate the same result from a basic one (basalt).

Possibility of occurrence in Interior Plateau region.—As previously stated, the Interior Plateau region of British Columbia was selected as the field in which to commence prospecting for bauxite, chiefly because of the apparent similarity of the Kamloops Volcanic group, which forms large areas in it, to the Tertiary rocks of County Antrim in northeast Ireland, in which bauxite is found. It also appeared to be an area favourable to the formation of deposits by chemical action. In this connection it may be pointed out that a supposedly correct description of a deposit near Silver City, New Mexico, given by W. P. Blake,(1) tallied so closely with conditions which might be expected in the volcanic rocks of the Interior Plateau region that it greatly strengthened the belief that bauxite might be found in connection with those rocks. Throughout the most recent literature on bauxite, this deposit is quoted as an example of bauxite resulting from the alteration of basalt.

H. K. Shearer in his 'Report on the Bauxite and Fullers' Earth of the Coastal Plain of Georgia,' 1917, in his descriptions of American localities of bauxite, under the heading '*New Mexico*', states (p. 25):

> The deposits occur in the vicinity of Silver City. On account of the difficulty of transportation they are considered commercially unavailable at present. They are most closely related to the Vogelsberg type of deposits, as they are derived from the alteration of a basic volcanic rock in place. The area is about half a mile square, of nearly horizontal beds of volcanic porphyry and basalt breccia. Aluminous solutions of solfataric origin, produced by the decomposition of pyrite, are drawn to the surface by capillary action. As the climate is arid, the sulphate of aluminum (alunogen) is deposited at the surface, while the internal residual mass is bauxite. The structure of the bauxite is amorphous, perhaps because the limited amount of water present was insufficient to permit the re-arrangement of the alumina in nodules.

The occurrence is cited by F. W. Clarke, who, in the latest edition (1916) of his 'Data of Geochemistry', in discussing Hayes' theory, to which reference has been made, says (p. 497):

> The occurrence of bauxite in immediate association with alunogen on the upper Gila river, in New Mexico, as reported by W. P. Blake, gives added emphasis to this suggestion.

W. Lindgren, in his 'Mineral Deposits' (1913), states (p. 328):

> Clay is decomposed by sulphuric acid and by sodium hydroxide or sodium carbonate and at some places aluminum hydroxide may have originated in this way. W. Maxwell,

(1) Trans. Am. Inst. Min. Eng., vol. 24, 1894, pp. 571-573.

W. P. Blake, and C. W. Hayes have demonstrated this origin for the soils of Hawaiian volcanoes and for a deposit of aluminum sulphates and bauxite on the upper Gila river in New Mexico.

It is to be noted that the reference given for Hayes is to his paper in Bulletin No. 315 of the United States Geological Survey, which contains an account of the *re-examination* of the deposit reported by Blake, and shows that no bauxite occurs there. Hayes' words are:

In his paper on these deposits Blake states that the residual rock from which the soluble sulphates have been leached consists essentially of hydrated aluminum oxide or bauxite. The analyses given on page 219 do not indicate the presence of free aluminum oxide, but, on the contrary, show that the residual rock is essentially the silicate of aluminum, having approximately the composition of kaolin.

Others might be quoted to the same effect. All have overlooked the fact that Hayes' paper, published in 1906, describes the true nature of the deposit.

The present writer's attention was first called to the real facts during a recent visit to Washington, where, through the courtesy of J. M. Hill of the United States Geological Survey and G. P. Merrill of the National Museum, he was enabled to examine Hayes' original specimens. There was no indication of bauxite in any of them.

It is important to call attention to the matter, so that these misleading statements may in future be eliminated from the literature, and this occurrence cease to be cited as an example in America of an interesting type of bauxite deposit.

Between the Kamloops Volcanic group and the basaltic rocks of the County of Antrim, Ireland, there is, apparently, in many respects a remarkable similarity. All geologists who have studied the subject agree that the Irish rocks are of Tertiary age. A. Geikie [1] refers them, somewhat doubtfully, to the Oligocene. He states that for many years certain plant-bearing strata which are mainly distributed in the great volcanic plateaux of Antrim and the west of Scotland, with a small detached basin at Bovey Tracy, Devonshire, were considered as Miocene, but that they have since been regarded as the equivalents of the Oligocene formations on the Continent. At the Bovey Tracy locality, which is about 80 miles from the Eocene leaf-beds of Bournemouth and the Isle of Wight, a small group of sand, clay, and lignite beds, 200 to 300 feet thick, contain fossil plants, which Heer of Zurich described and assigned the beds to the horizon of some part of the Molasse or Oligocene (Lower Miocene) of Switzerland. Later, S. Gardner referred them to the same horizon as that of the Bournemouth beds, namely, Middle Eocene. C. Reid commented on the striking resemblance of the beds and flora to the Bagshot beds (Eocene) of Dorset, but did not regard the botanical evidence as conclusive. Geikie states that if the views of Gardner and Reid be ultimately established, the basaltic rocks, with their leaf-beds, may be relegated to the Eocene period; but in the meantime they are retained in the Oligocene series.

(1) Text Book of Geology, vol. 2, 1903, pp. 1251-1252.

He describes the plateaux of Antrim, Mull, Skye, and adjacent islands, as composed of successive outpourings of basalt, which are prolonged through the Faroe Islands into Iceland, and even far up into Arctic Greenland. In Antrim, where the great basalt sheets attain a thickness of 1,200 feet, there occurs in them an intercalated band about 30 feet thick,* consisting of tuffs, clays, thin conglomerate, pisolitic iron-ore, and thin lignites. Some of these layers are full of leaves and fruits of terrestrial plants, with occasional insect-remains. In the west of Scotland the same volcanic sheets are 3,000 feet thick and include tuffs, leaf-beds, and lignite. In a foot-note it is stated that at one place there is a band of tuff 100 feet thick, but that the tuffs take a subordinate place among the basalts.

One of the memoirs [1] of the Geological Survey of Ireland, treating exclusively of the interbasaltic rocks of northeast Ireland, gives the results of a revision of the interbasaltic series of beds, which in places contain plant remains and deposits of bauxite and iron ore (Plate III). The following extracts from the letter of instructions issued to the geologists, are quoted as bearing on some points of resemblance between these beds and those of the Kamloops Volcanic group:

(1) The interbasaltic beds occur at various horizons, but mainly in a zone representing a presumably prolonged epoch of repose between two epochs of considerable volcanic activity.

(2) The attention of the geologists will mainly be given to this zone, marked by beds of iron ore, bauxite, and deep decomposition of the underlying basalt.

(3) The source of these beds may in some cases be found in the underlying basalts, in other cases in material brought from some distance and accumulated in lakes. The formation of laterite in tropical climates as a surface-crust, and possibly in connection with alternating dry and rainy seasons, should not be lost sight of, even in cases where the lacustrine view has been put forward.

(4) In Co. Antrim, local eruptions of rhyolite occurred in the comparatively quiet interval. Pebbles from these centres of activity may be found in interbasaltic beds, and are already known from the Glenarm area.

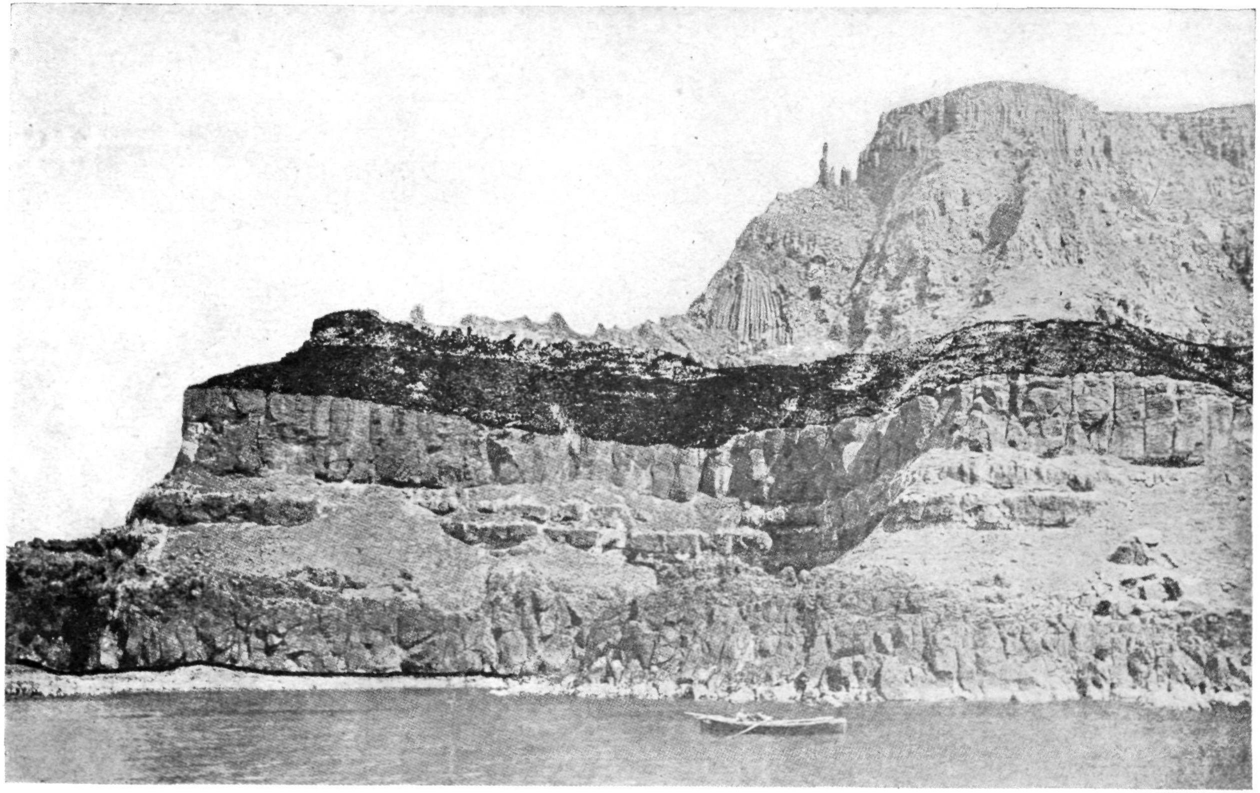
(5) The mode of decomposition of these rhyolites makes it probable that the light-coloured bauxites were derived from similar lavas poor in iron.

(6) Plant-beds are well known in certain places. Remains of land molluscs or other animals would be of great assistance, if discoverable. The interbasaltic beds are the only guides we possess in determining the geological age and duration of the eruptive period.

(7) Local records of rumors of 'coal' having been raised in this or that spot are common in the north of Ireland. These should be investigated, as they may lead to the discovery of new beds of lignite; hence also of new laterite or bauxite layers.

Referring to this memoir, it is there stated that the bauxite has been formed not only from the basalts but also from rhyolites of mid-basaltic age; that the iron ores, laterites, and bauxites may have arisen from any rock exposed to conditions such as now prevail in tropical India or Africa, and that these conditions prevailed in Eocene or Oligocene times. The typical downward succession of the red lateritic deposits in the County of Antrim is given as follows:

* Other bands occur at various horizons, both in the Upper and Lower Basalt.
(1) Geol. Surv. Ireland. The Interbasaltic Rocks of Northeast Ireland, G. A. J. Cole, and others, 1912.



Cliff east of the Giant's Causeway, County Antrim, Ireland.
Main Interbasaltic Zone is coloured black, also a smaller zone along the beach level. These zones contain the bauxite deposits.

(Reproduced from 'The Interbasaltic Rocks of Northeast Ireland.' Memoir, Geological Survey of Ireland, 1912.)

(3) **Pisolitic iron ore**; (2) **'pavement'** (a material varying from a siliceous iron ore to a lithomarge, with a false appearance of stratification, due to coloured streaks connected with the decomposition of residual blocks of basalt); (1) **lithomarge** (decomposed basalt retaining the original joint-structure and often showing pseudomorphs after the feldspars of the groundmass). Lithomarge may consist largely of kaolin; but in Ireland it passes into ferruginous bauxite, and its silica percentage represents silicates not completely decomposed. This passes down into a basic lava of the Lower Basaltic series.

There is another type of interbasaltic beds, consisting of grey bauxite clays and rhyolitic gravelly and sandy beds, described thus:

The **pale bauxites** derived from rhyolite, as at Glenarm and Straid, overlie the pisolitic iron ore when they occur. At Straid, rhyolitic flows may have decomposed, under laterizing conditions, *in situ*. In other places the rhyolitic matter is clearly detrital, and has been washed down as mud over a lowland, or has been transported, as a fine dust mingled with quartz grains, by wind. The occurrence of rhyolitic tuffs at Sandy Braes shows that some of this material may have been fragmental at the outset. The laterites and lithomarges of northeastern Ireland, that is, the main mass of the interbasaltic zone, cannot, however, be connected either with volcanic explosions or with accumulation in lakes, but must be regarded as typical examples of soils and subsoils formed under conditions now prevalent, in regions of seasonal rains, nearer the equator.

Attention may be drawn to the statements made, that at the time of the original geological survey of the Northern district, the interbasaltic zone was mapped as a deposit of volcanic ash; also that the types of interbasaltic formations vary both in character and in mode of occurrence, and that it does not appear that all the members that go to make up the interbasaltic zone are ever to be found together.

Lignite seams, from 1 inch to over 14 feet thick, occur in the interbasaltic beds. The pisolitic iron ore is not always present, ochreous beds of 'tuff', or red ash beds, taking its place in some of the sections. The bauxite is usually pisolitic, but frequently compact and finely oolitic.

The protection from erosion afforded to the softer beds by the Upper Basalt cap during the Glacial epoch, is noted.

A chapter on the plant remains of the interbasaltic rocks, by C. E. Moss, is contained in the memoir.

The Kamloops Volcanic group consists, like the Irish rocks above described, of a great group of basaltic lavas; with intercalated bedded sediments at various horizons, containing plant and fish remains. Dawson applied the name 'Tranquille beds' to these sediments. They consist of stratified tuffs, and tuffaceous agglomerates, with, apparently, some sandstones and shales. The basalts, whilst fresh at some localities, are much altered at others. They are cut by andesitic dykes, as the Irish basalts are by rhyolites, and these form agglomerates with an andesitic matrix. Lignite seams occur in the same way as at the Irish localities.

A comparison of the list of plants from the Tranquille beds of the Kamloops Volcanic group, given by Penhallow,[1] with that from the Interbasaltic beds of Ireland, quoted by Moss,[2] shows a marked similarity between the two

(1) Report on Tertiary Plants of British Columbia, Geol. Surv. Can., No. 1018, pp.115-116.
(2) Op. cit., pp. 103-111.

floras. In both cases the geologists and palæobotanists leave in doubt the precise horizon of the beds, within the Tertiary. Drysdale (1) assigns a Lower Miocene age to the Tranquille beds, based on Penhallow's work. Daly (2) refers them to the Oligocene. Penhallow gives a list of the plant remains determined and concludes that:

> An inspection of the distribution shown in the above table conveys the information that there are
>
> | | |
> |---|---|
> | Eocene, chiefly Lignite Tertiary | 14 |
> | Oligocene— | |
> | Upper Eocene | 14 |
> | Lower Miocene | 4 |
> | Miocene | 15 |
>
> thus giving a preponderance of the Eocene over the Miocene, in the proportion of 28 to 19; but inasmuch as the Eocene and the Miocene are practically equal, while there are 18 Oligocene, the conclusion appears justified, to the effect that these beds (Tranquille beds near the base of the series) are of Oligocene age, and possibly not higher than Upper Eocene, though the presence of such strong Miocene types as *Ficus asiminaefolia, Pinus trunculus* and *Sequoia brevifolia* would seem to give them a stronger Miocene tendency. I therefore assign them to the Lower Miocene provisionally.

Moss, in the case of the Irish beds, accepts Gardner's conclusion that they are of Eocene age, as in the main correct, but adds that 'it is quite possible that he placed the Antrim deposits too low down in the Tertiary series'. He regards the plant remains as indicating a climate comparable to that of south Europe or north Africa at the present time.

Geikie places the basalt plateaux of Antrim in the Oligocene.

From the foregoing, it will be seen that a justifiable conclusion would be that the Irish beds and those of British Columbia belong approximately to the same geological period, and there is no evidence against their approximate correlation. In fact, the lists of fossil plants from the two localities strongly support this view.

If Campbell (3) be correct in his view that crystalline rocks must be altered, and therefore porous, before they can be laterized, it is to be expected that only localities where such alteration has taken place, as regards the Tertiary igneous rocks of the Interior Plateau region, would be favourable ones in which to look for the type of bauxite deposits accompanying laterization.

Laterite and associated bauxite deposits are surface formations, independent of any overlying rocks. They are formed where denudation takes place undisturbed by volcanic action or serious crustal movements. In the case of the sedimentary beds of the Kamloops Volcanic group, the fineness of the sediments, their well and thinly bedded character, the presence of coal, plant remains, and fossil fish, all point to a quiet period of deposition, during which there must have been a normal cycle of erosion. The source of the tuffs may have been, and probably was, distant from the point of deposition. The fineness of the material leads to this conclusion, for such fine material

(1) Sum. Rep., Geol. Surv. Can., 1912, p. 143.
(2) Memoir 68, Geol. Surv. Can., 1915, p. 126.
(3) J. M. Campbell, Op. cit., p. 123.

Cliffs of decomposed volcanic rocks between the Buce Lakes, southwest of Ducks. Thin beds of clay occur in the surrounding flat.

would be readily transported by wind or water. The presence of the plant remains and coal seams shows that the region must have been free from any violent volcanic action.

It has been held by many writers that laterites and, therefore, the type of bauxite deposits which accompany them, are formed only under tropical or sub-tropical climatic conditions. This is disputed by others, who hold that such climatic conditions are not necessarily essential to their formation, although they would form more rapidly and extensively in a warm than in a cool climate. But, granting that the first mentioned opinion be correct, we have in the plant remains of the British Columbia beds strong evidence that climatic conditions during the deposition of these sediments were approximately the same as those prevailing when the Irish beds were formed. Therefore, taking all the facts into account, it appears not unreasonable to expect that laterite and bauxite may have been formed in connection with some of the Tertiary rocks of the Interior Plateau region of British Columbia.

It was not expected when the prospecting for bauxite was undertaken, nor is it now, that very extensive high-grade deposits might be found, but the war has shown that many mineral deposits which cannot be operated at a profit under normal conditions become valuable in an emergency, and it is well to ascertain if a country possesses even small or low-grade sources of supply which could be utilized when urgently needed. The production from the Irish deposits has always been small, but was increased from 8,282 tons in 1913 to 14,724 tons in 1917. It may be mentioned that in Germany, during the war, low-grade deposits, in which the bauxite occurs as nodules in basaltic rocks, were utilized. The rock was crushed and washed, yielding a product rich enough to serve as an ore of aluminum.

Field-Work.—A careful revision in detail of the geology of the Kamloops and Shuswap areas is much to be desired. Close geological study was, of course, impossible in connection with the prospecting for bauxite, which was conducted according to usual prospecting methods. Exposures of rocks, particularly igneous ones, showing evidence of extreme alteration were sought for and examined when found, regardless of the precise geological position assigned them on the maps, which in many cases was found to need revision.

As a recent writer has said:(1)

> Prospecting for bauxite is guided by a knowledge of the characteristics of the mineral, and to some extent by the known occurrences now being mined. Conditions under which bauxite occurs, however, are so variable and its methods of formation so indefinite that it may be expected to occur under other conditions which differ materially from those that are now known.

The steep mountain-sides were carefully studied by means of powerful field-glasses during the preliminary reconnaissance, and where conditions of rock-weathering were observed which seemed to warrant it, the outcrops

(1) Mineral Industry, 1912, pp. 87, 88. See also W. C. Phalen, Min. & Sci. Press, vol. 105, 1912, pp. 305, 306.

were visited. Particular attention was given to the rocks of the Kamloops Volcanic group, but sections showing the sedimentary beds in relation to underlying basalts, in the reconnaissance area, were usually obscured by talus. Few were seen, and could not be satisfactorily examined.

In the absence of the necessary data definite statements cannot be made regarding the rocks or the phenomena of rock decomposition which were observed.

The following notes indicate, briefly, where and how the prospecting was done.

The work was commenced, during the short time available for field-work in 1917, by a rapid reconnaissance of as wide an area as possible. It was too late in the season to undertake work at the higher altitudes. Over 600 miles of roads and trails were traversed by automobile and on foot, in order to get a general idea of the formations in the area covered by the Kamloops and Shuswap maps. Rock exposures showing extreme weathering were carefully examined.

Shuswap Area.

The rocks mapped by Dawson as Upper Volcanic group and Tranquille beds (now included in the Kamloops Volcanic group, of Drysdale) are extensively developed in the southwest portion of the area covered by the Shuswap map. Practically all the mapped areas of these rocks would lie below and to the left of a diagonal line drawn from the northwestern to the southeastern corner of the map. In 1918 other mineral investigations afforded opportunities to examine sections not seen during the previous year.

The largest area mapped as Upper Volcanic rocks was traversed along, approximately, the following routes: Along the south side of the South Thompson river, between Campbell creek and Martin creek; from Martin creek, along the northwest flank of Martin mountain to a point about 3 miles west of its summit, thence west and northwest to Monte creek; between Campbell creek and Monte creek, by the Buce lakes and Robins creek; from Ducks to the contact with the lower Câche Creek rocks on the Salmon river, near Twig creek, by way of Monte creek and lake, Grande Prairie, and the Salmon river; from Grande Prairie easterly to Warren creek on the Salmon river. The smaller area of the same rocks north of Pillar lake, on the east side of Chase creek; that south of Salmon Arm, of which Mount Ida is the centre; and a portion of the small area on the east side of the Shuswap river between Mara and Enderby, were also investigated.

In the Shuswap area it was found, as Daly has shown for the portion which he re-examined, that the boundaries of the Kamloops Volcanic group, as mapped by Dawson, must be considerably modified. Rocks, since found to be of Mesozoic age, have in certain localities, as on Monte creek, been included in the group. Southwest of Ducks, a station on the Canadian Pacific railway, the plateau is bounded by an escarpment in which sections of the Kamloops Volcanic group, consisting chiefly of basalts, breccias, and tuffs, were examined. The decomposition of the igneous rocks is extreme,

Flat surrounding cliffs of decomposed volcanic rocks, showing openings made in clay bed. Between the Buce Lakes, southwest of Ducks.

and, between the Buce lakes, has resulted in the formation of thin beds of clay, from 1 to 3 feet thick, close to the surface, at the base of the outcrops (Plates IV and V). Samples of this clay were submitted to Mr. J. Keele, of the Mines Branch, Ottawa, who reports:

> These clays vary from a dark grey, highly plastic and pasty material, which burns to a deep red colour like brick clay, to a white clay which was granular in texture, of low plasticity, and burned white or nearly so. An intermediate grade is a light-grey plastic clay which burns to a buff colour and somewhat resembles a stoneware clay. The white clay is refractory enough to be classed as a fire clay, but its shrinkage in burning was excessive. The white clays from this locality have the properties of kaolins but they have certain defects which are detrimental to their use as commercial kaolins or china clays.

Just south of the Buce lakes, near the summit of the escarpment, is an intercalated lens of sedimentary material which Daly (1) has described as a brown-weathering sandstone, with grit and shale phases. In places it is about 100 feet thick, and is probably, together with the peculiar light-grey sedimentary rock some distance beneath it, near the horizon of the Tranquille beds. Unfortunately the section is so covered by talus that the contacts between these rocks and the basalt are obscured.

No other sedimentary beds were found in connection with the volcanic rocks during the reconnaissance, but they may, and probably do, occur.

On the road up Monte creek, about one mile from Ducks, the volcanic rocks (Nicola series?) on the east side of the road have a southerly dip of about 50°, and are extremely decomposed. Some are completely altered to a plastic, clay-like mass, in which amygdaloidal structure is still distinctly visible. The amygdules are represented by a white kaolin-like material, whilst the main mass of the rock is converted into a soft red clay. Occasionally, through leaching, the whole rock is a soft, white, clay-like mass. The decomposition is apparently due to hydrothermal action.

The rocks of Mount Ida and vicinity consist chiefly of basalts, often amygdaloidal, and andesite. They overlie granite, unconformably. Nothing of special interest was seen here, although the rocks are sometimes much decomposed.

The reconnaissance in the Shuswap area showed that it was less favourable for prospecting than the Kamloops area to the west of it, and most of the work was therefore confined to the latter area.

Kamloops Area.

A rapid reconnaissance was made in 1917 in the territory covered by the Kamloops map, in which the rocks of the Kamloops Volcanic group are extensively developed. As mapped by Dawson, their chief development lies north and northwest of Kamloops lake, extending as far as the northern boundary of the map. They also occur along the south shore of Kamloops lake as far as Cherry creek; south of Kamloops as far as Stump lake; immediately south of that portion of the Canadian Pacific railway between

(1) Memoir 68, Geol. Surv. Can., 1915, pp. 128-130.

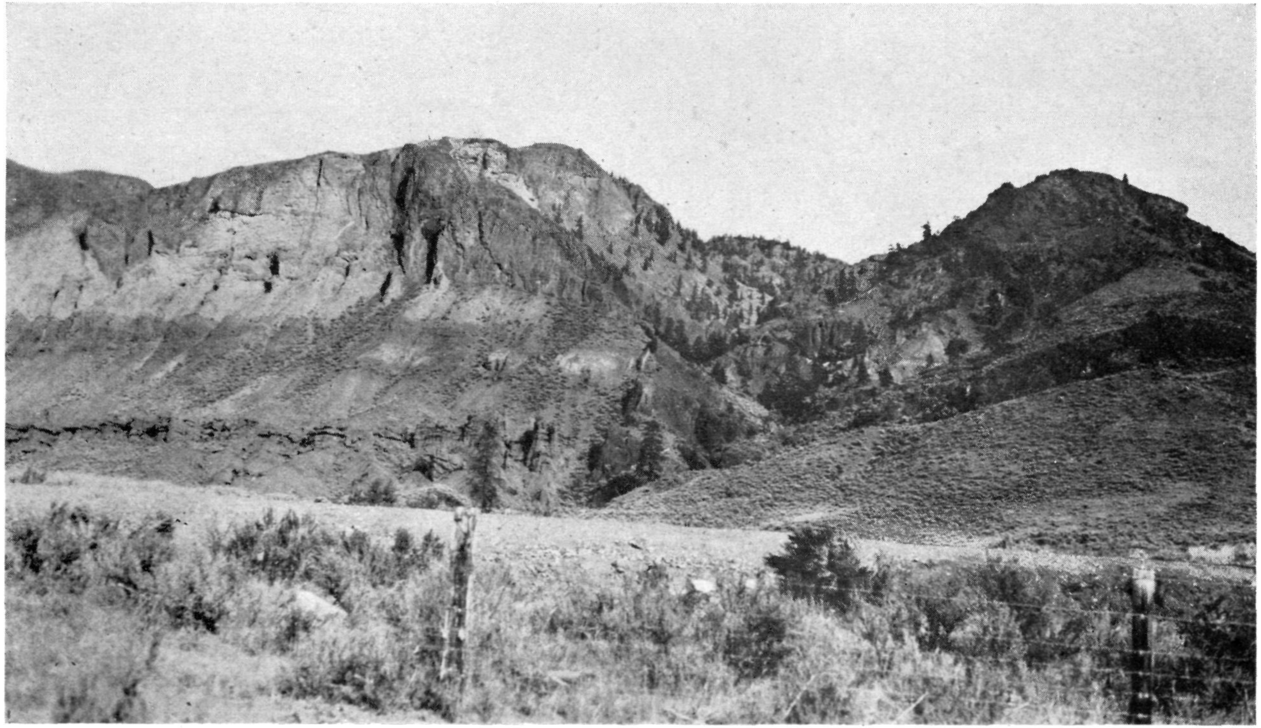
Savona and Ashcroft; and in a broad zone striking northwesterly from the southern boundary of the map, on both sides of the Nicola river, to the bend of the Fraser river at Eleven Mile creek, where the zone narrows but continues until it passes beyond the western boundary of the map in the vicinity of Leon creek. In this zone, as already noted, some of the rocks near Spence Bridge were believed by Drysdale to be of Mesozoic age. Besides the above, numerous small outliers are indicated on the map.

Opportunities for observing these rocks on routes travelled were afforded on the north shore of Kamloops lake, in the vicinity of Mara hill and the mouth of the Tranquille river (Plate VI), and also between Copper creek and Red point; south of Kamloops as far as Stump lake; in the vicinity of Meadow creek and Witches brook, on the road leading southerly and westerly to Highland valley; along the road from Witches brook north to Savona by Guichon creek, Toon-kwa lake, and Three Mile creek; between Kamloops and Cherry creek, south of Kamloops lake, on the road leading west to Savona; south of the Canadian Pacific railway, between Ashcroft and Walhachin (near Pennys); along the road from Savona westerly to Câche creek, and thence north on the Cariboo road as far as Scottie creek; north, on the same road, in the vicinity of Clinton and beyond to the northern boundary of the map; north of Martley on Pavilion creek; along Hat creek from the mouth of Marble cañon south to a point due east of Cairn mountain; on the Cariboo road along the west bank of the Thompson river, north of Spence Bridge; south of Spence Bridge along the Canadian Pacific railway on the east side of the Thompson river, as far as the mouth of the Nicoamen river; from Spence Bridge along the road on the northeast side of the Nicola river, as far as the southern boundary of the map.

The intrusive mass of syenite on Edwards (Heffley) creek, which empties into the North Thompson river from the east, about 13 miles north of Kamloops, was also examined, but no evidence of reported extreme alteration was found.

The Tranquille beds, which here lie horizontally, are well exposed along the southern face of Mara hill, close to the wagon road between Kamloops and Tranquille, and the associated basalts show fine columnar structure (Plates VII and VIII). In the vicinity of Copper creek the volcanic rocks are extremely decomposed, forming masses of clay-like material which by erosion have given rise to a 'bad lands' topography. The remarkably brilliant colouration of these extremely altered rocks was observed at many localities and is well seen at the 'Painted Bluffs,' about one mile east of Copper creek (Plate IX). The bright red, purple, green, and yellow colours give a most remarkable appearance to the exposures. Dawson ascribes the decomposition to solfataric or hydrothermal action operating from below. At Red point, farther to the east, thin layers of clay occur interstratified with the sedimentary tuffaceous beds. South of Kamloops the volcanic rocks where examined did not show much alteration. On Dropping Water creek, west of Napier lake, fragments of sedimentary tuffaceous beds occur, but were not seen in place. The fine section of

View looking easterly toward Mara Hill and Kamloops from an elevation of about 2,700 feet on the southeast flank of the Red Plateau, west of Tranquille river.
Characteristic topography resulting from denudation and erosion chiefly of volcanic rocks.



Southern face of Mara Hill, from road between Kamloops and Tranquille, showing flat-lying Tranquille beds near the base.

Columnar structure in basalt of the Kamloops Volcanic group, Mara Hill, near Kamloops.

The 'Painted Bluffs,' north shore of Kamloops lake, showing decomposition of volcanic rocks to clay-like material.

volcanic rocks exposed in 'The Chasm' on the Cariboo road, northeast of Clinton, is remarkable for the brilliant red and yellow colours of some of the beds of tuff or volcanic mud in the high cliffs. (Plate X).

Prospecting was carried on in 1918 in that portion of the Kamloops map-area between the Fraser and Thompson rivers north of their confluence, and bounded to the north by Pavilion creek, Marble cañon, Hat creek, and (Oregon) Jack's creek. The country is mountainous, a practically continuous range, the Clear mountains, running in a northwesterly direction from Spence Bridge on the Thompson river for over 26 miles. In the extreme southern part of the area the Botanie mountains lie on the west and the Scarped mountains on the east of Botanie Creek valley. The elevations of the principal peaks of the Clear Mountains range, commencing at Spence Bridge, as given by Dawson, are: Arthur's Seat, 5,500 feet; Mount Murray, 6,880 feet; Blustry mountain, 7,640 feet; Cairn mountain, 7,650 feet. The elevation of the highest summit in the Botanie mountains is 6,460 feet; and in the Scarped mountains, 5,860 feet. The mountain slopes are usually densely wooded to an elevation of between 5,000 and 6,000 feet, above which the forest becomes more open, with occasional park-like stretches of country. Some of the summits are rounded and grassy, others bare and rocky. The prevalence of fallen timber on the lower slopes and in the valleys, forming at times almost impenetrable barriers for horses, added to the difficulties of travel when off the main trails which have been built by the Dominion Forestry Branch. The abnormal rainfall and cold weather interfered considerably with the work. A heavy snowstorm occurred on Cairn mountain and vicinity on the 18th of August. The region was traversed on horseback, and supplies and camp equipment were transported by pack-train.

Dawson, on the Kamloops sheet, has mapped the greater part of the rocks of the Clear mountains and Scarped mountains as Upper and Lower Volcanic groups, with a few small areas of the Tranquille beds. Other Tertiary rocks (Coldwater group), of Oligocene age, are shown along upper Hat creek and between the headwaters of La-loo-wissin creek and Botanie lake. A small area on Botanie creek and a continuous narrow belt running northwesterly along the Fraser river from Lytton are coloured as Cretaceous. Carboniferous rocks (Câche Creek formation), chiefly the upper limestones, with smaller outcrops of the lower members of the formation, are shown east of upper Hat creek and in the vicinity of Mount Martley and Chi-pooin mountain on the northern end of the Clear Mountains range, with small outcrops of the lower members between the headwaters of La-loo-wissin creek and Botanie lake, and near the mouth of Iz-man creek. Plutonic rocks, chiefly granites, with crystalline schists and foliated granititic rocks, occupy an irregular belt which includes the Botanie mountains and extends northwesterly to near the mouth of Cinque Foil creek, where it narrows out. Smaller areas are indicated on the south end of the Scarped mountains and south of Pavilion creek, including Mount Martley and Chi-pooin mountain.

Drysdale, as already stated, regarded some of the Upper Volcanic rocks of Dawson, in this area, as of Jura-Cretaceous age, applying the name Spence

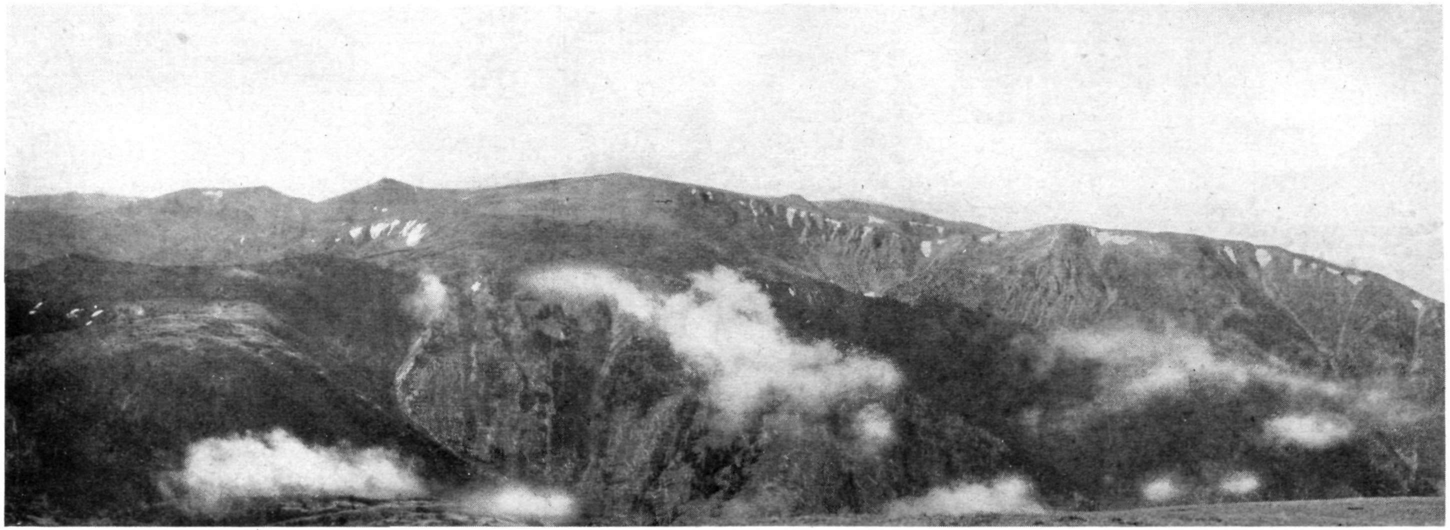
Bridge Volcanic group to them; but much detailed field-work would be required to delimit the group and prove its extent. The Clear Mountains range was the main axis of eruption of the lavas.

The outfit for the trip was assembled at a base camp in the 'Amphitheatre,' which probably owes its present picturesque features to the action of an old glacial stream on the Câche Creek limestones. The mountains were entered, on July 26, from this point, which lies about 9 miles due east of Cairn mountain.

The first camp was on the south slope of Cairn mountain, at an elevation of 7,200 feet. A good view over the country was obtained from the summit (Plate XI). The rocks in the immediate vicinity appear to be mainly porphyrites and agglomerates, but on the western slope are overlain by basalts. They were examined northward toward Limestone creek, but, in general, show very little alteration. On the edge of a steep cliff facing Chi-pooin mountain, yellow, red, and white, crumbling, highly altered rocks were seen, also on the southern slopes of Cairn mountain, and in other places. The fresh rocks are full of pyrite in minute crystals, and the decomposition is ascribed by Dawson to solfataric action occurring during the period of decadence of the volcanic forces, the sulphuric acid resulting from the decomposition of the pyrite acting on the constitutents of the rock. Thinly-bedded trachytes and tuffs were observed on the slopes of a hill to the northwest of the summit of Cairn mountain, overlooking a creek flowing west to Three Lake valley. These beds weather white, and from a distance have a very clay-like appearance. Blustry mountain (7,610 feet) was next ascended. Its north slopes are strewn with rusty-coloured rubble, with crags of the same materials, apparently chiefly porphyrites, standing out from the rubble. In places the rocks show extreme alteration, as on Cairn mountain, becoming quite clay-like and plastic. Thin layers of clay have been deposited by the streams along the bottom of the valley between Cairn and Blustry mountains.

The second camp was on Blue Earth creek, about 8 miles southeasterly from Cairn mountain, and about 1 mile west of the small lake shown on the map. The water-level of the lake is from 15 to 20 feet lower than it was when mapped, owing to the breaking of a dam, and there are now two bodies of water. The country to the south and southeast of the camp was examined, in the vicinity of Lookout point and the headwaters of Twaal creek. On the north side of Blue Earth creek the rocks are the limestones of the Câche Creek formation, whilst on the south side Tertiary rocks, mapped as Upper Volcanic group, occur. The Tertiary rocks rest directly on the limestones just below the lake. Here they consist of soft, yellowish and bluish deposits, some of which are, apparently, tuffaceous. They contain fragments of basalt and hard concretions of the same material as the enclosing mass, which is quite plastic. Reddish, kaolinized volcanic rocks were observed in a small exposure about 1 mile west of the lake. Just beyond the east end of the second lake, some distance up a small creek entering Twaal creek from the south, are fine exposures of highly altered volcanic rocks, forming

The Chasm, looking south from the Cariboo road about 12 miles northeast of Clinton, showing flat-lying basaltic lava flows and tuffaceous beds.



View from summit of Cairn mountain (7,650 feet), Clear Mountains range, looking south toward Blustry mountain.

steep banks of white and rusty-coloured soft material in which sulphates, including selenite, have been formed. Near the mouth of this creek argillites and carbonaceous shales (Câche Creek group?) occur.

Lookout point (6,600 feet) was ascended, and from it an unobstructed view of the country in every direction was obtained. The series of photographs taken here form a complete cyclorama. The rocks seen on the slopes were mainly basaltic, often amygdaloidal. Some fine-grained red beds are apparently tuffaceous. The summit is composed of fine-grained, unaltered, slightly vesicular, black basalt, with resinous lustre. An outcrop of deep-red decomposed amygdaloidal basalt, containing zeolites, was investigated. The rock caps a hill on the southeast fork of Hat creek, about 1 mile from the Spoonimore ranch.

The third camp, from 2 to 3 miles northwest of Mount Murray was on the divide over which the old trail leads to the Cariboo district. Mount Murray (6,880 feet) was ascended and a fine view obtained of the southern portion of the area. The rocks are mainly augite porphyrites and quite fresh. On account of the deep narrow valleys and the dense timber it was necessary to reach the highest elevations in order to see over the country and detect evidence of alteration in the rocks.

The fourth camp was at the forks of La-loo-wissin creek, and from it the basaltic rocks to the west and northwest were examined. They frequently show columnar and amygdaloidal structure, and contain zeolites. These rocks are well exposed near the summit of a mountain (5,800 feet) in which the east fork of the first creek north of La-loo-wissin creek rises. North of the mouth of La-loo-wissin creek, on the east side of the Fraser river, the underlying granitic and dioritic rocks are extremely shattered and altered, and frequently mineralized, mainly with pyrite. Dawson notes their proximity to the main line of the Tertiary volcanic eruptions and ascribes their condition to solfataric action accompanying the eruptions. The exposures form very steep bare slopes of mixed fine and coarse rubble and clay-like materials. One of these, nearly opposite As-kōm mountain, was examined (Plate XII). Native sulphur, alunogen, epsomite, and selenite have been formed, probably by the action of sulphuric acid derived from the decomposition of the pyrite. The rocks are of red and yellow tints in the higher ground, and bluish lower down. In the face of the cliff, near the top, a small open-cut has been made in a dark green, fine-grained, altered rock, containing pyrite, which may be a dyke.

The fifth camp was on the north side of Murray creek, almost due south of Mount Murray, where severe storms interrupted the work.

The sixth camp was on the north side of Murray creek, about 2 miles below the forks. The mountain north of the camp was ascended. Its elevation is 5,800 feet, and the rock on the summit is a coarse agglomerate. Descending Dry creek, which heads on its eastern flank, the narrow rocky cañon through which Murray creek flows was followed back to camp. The rocks in this vicinity are, in general, quite fresh.

The seventh camp was to the east of a small pond about 1 mile northwest of Pasulko lake, which drains into the south fork of La-loo-wissin creek. The country to the south was examined as far as a point about 2 miles south of Botanie lake. Very stormy weather prevailed for two days at this camp. From here a return was made to La-loo-wissin creek, and the Fraser River valley reached by following down the creek over a very difficult steep and rocky trail.

The eighth camp was made at the McGillivray ranch (Halfway House), just south of the first creek north of La-loo-wissin creek. Prospecting tunnels have been driven into the hillside west of this place. In a steep gulch about 3 miles north of here the rocks of the granitic batholith, which underlies the Tertiary volcanics, are well exposed. About 2½ miles up the gulch they form high bare cliffs, sometimes almost perpendicular, of grey granite or granodiorite, cut by dykes of a pinkish muscovite granite.

Leaving this camp the wagon road was followed northward for about 4 miles, where a trail was taken leading up Cinque Foil creek to Three Lake valley. A heavy storm prevented any observations en route.

The ninth camp was at the south end of Fish lake, the most southerly of the three lakes in the valley. This valley lies along the line of junction between the Tertiary volcanic rocks and the Cretaceous series. The hills on both sides are densely wooded, and, in order to see over the country, the highest point of Fountain ridge, on the west side of the valley, was ascended. Here a magnificent view was obtained over the Clear mountains, then covered with snow (Plate XIII), and down the valley to the mouth of Fountain creek.

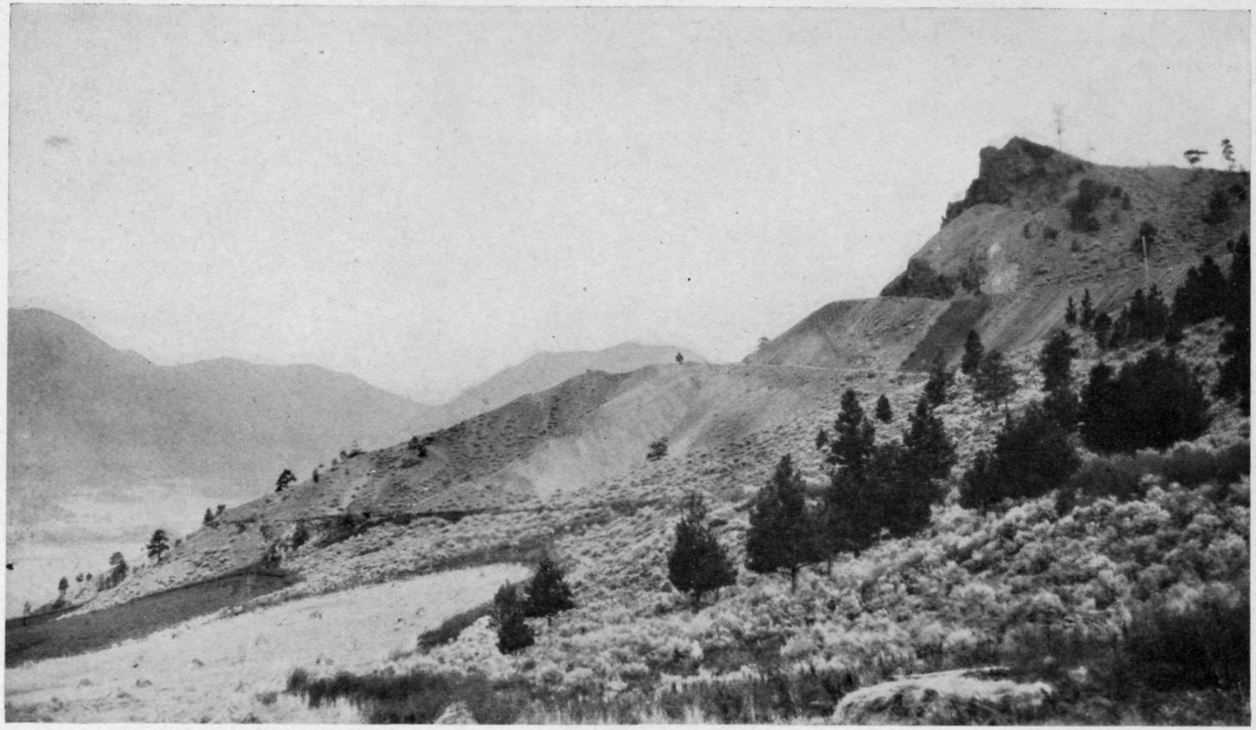
The tenth camp, just east of the mouth of Fountain creek, on the south side of the Fraser river, was reached by following the road down Three Lake valley and Fountain creek. Here we met L. Reinecke of the Geological Survey, and in his company a remarkable exposure of decomposed rocks, mapped by Dawson as Lower Volcanic group, was examined. (Plate XIV). This exposure is on the wagon road, about three-quarters of a mile south of 18 Mile creek and just north of the 17 Mile ranch. The rocks are interbedded basalts, andesites, dacites, and tuffs, as since determined microscopically by Mr. Reinecke. A section measured by him across these lava flows gave a total thickness of about 650 feet. The decomposition of the rocks, probably due to the action of heated waters from below, is extreme, most of the beds having been almost completely altered to soft clays of white, bright red, yellowish, brown, and purplish colors.

The field-work was closed at this point, the party returning to the 'Amphitheatre,' August 23, by way of Pavilion creek, Marble cañon, and Hat creek, camping at the Bryson ranch (Martley) on Pavilion creek, and on Hat creek at a point about 1½ miles north of Medicine creek.

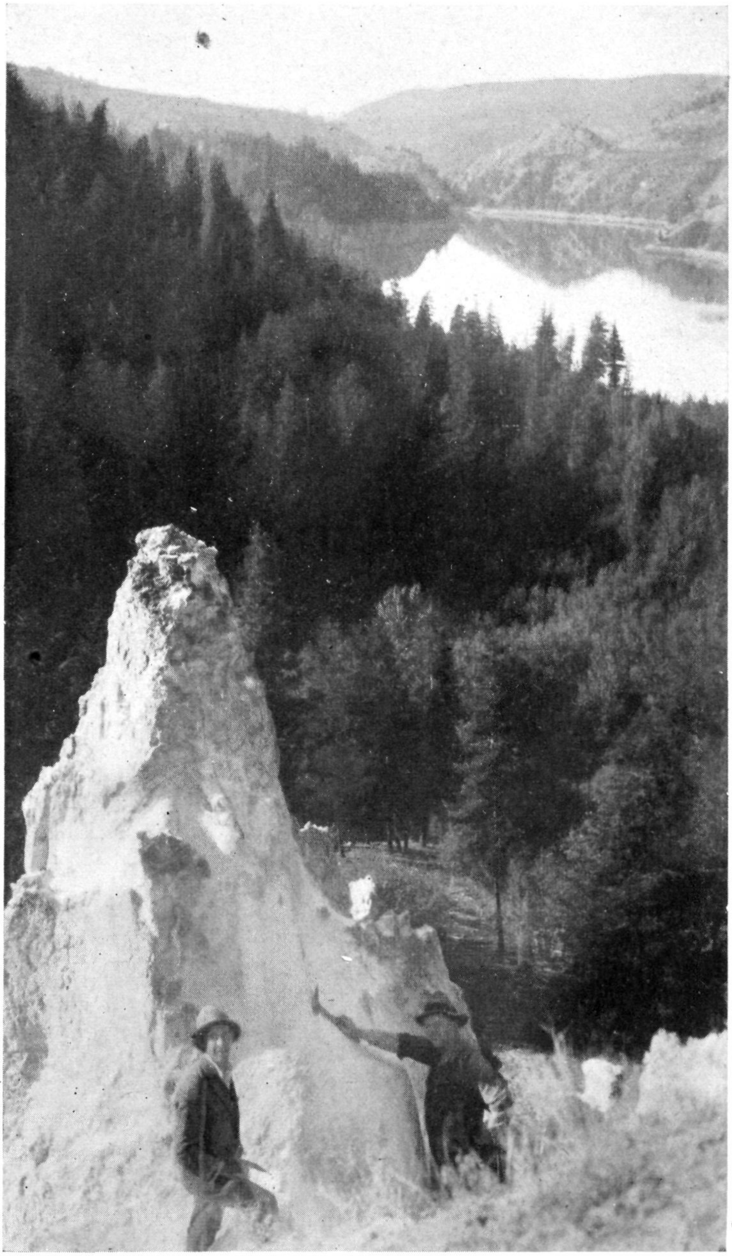
The next area prospected was that lying along the valley of the Deadman river, which flows into the Thompson river from the north at a point about 2½ miles west of Kamloops lake. North of the large lake named Deadman

Highly altered plutonic rocks overlain by basalt.
Head of east fork of first creek north of La-loo-wissin creek,
Fraser river.

Clear Mountains range, looking east from summit of ridge (5,800 feet) on west side of Three Lake valley. Cairn mountain on the left and Blustry mountain on the right.



Interbedded basalts, andesites, and tuffs of the Kamloops Volcanic group, decomposed to clay. Three-quarters of a mile south of Eighteen Mile creek, east side of Fraser river.



Looking southwest from main exposure of volcanic tuff near Last Chance creek, east side of Deadman lake, showing isolated tuff pillar or 'hoodoo.'

(or Snoo-hoosh) lake on the map, are two smaller lakes (Skookum and Deadman lakes of the provincial maps), and about $1\frac{1}{4}$ miles south of it is another small lake, known as Mowich lake. Skookum lake is shown, but un-named, on the map; the other two are not shown. The portion of the valley which was prospected extends from the mouth of Criss creek on the south to a point about 2 miles north of Deadman (Snoo-hoosh) lake, a distance of about 18 miles. The river has cut down in places to the Nicola rocks (Jura-Trias), and outcrops of these are indicated on the map. The first, about 2 miles north of Criss creek, extends north for about 2 miles. After an interval of about $1\frac{1}{2}$ miles, outcrops are again indicated, extending north almost to the south end of Deadman lake. To the north of the lake these rocks reappear in the bottom of the valley. They are shown overlain by the rocks of the Upper Volcanic group and the Tranquille beds, which are both included in Drysdale's Kamloops Volcanic group.

The outfit and supplies were taken by automobile to a camp site on the west side of Deadman river, just south of the mouth of Gorge creek. Here horses were hired and a trip made up the valley as far as Last Chance creek, which enters Deadman (Snoo-hoosh) lake from the east at a point about halfway up the lake, where we camped. On both sides of the valley remarkable deposits of white and yellowish volcanic tuffs or ash rocks are exposed in high cliffs, overlain by basaltic breccias and basalt flows. These well-stratified ash beds must have originally extended across the valley in this vicinity and were evidently laid down in water. The exposure immediately northeast of the camp consists of nearly horizontal, alternating beds of coarse and fine-grained material, with a total thickness of about 450 feet. Isolated pillars, or 'hoodoos,' of most fantastic forms, capped with material from the coarser, harder beds, have resulted from weathering (Plate XV). One bed of very fine-grained, pure white, compact material, resembling chalk, in places 4 feet thick, was traced along the outcrop for over 500 feet. Samples from this bed have been variously named infusorial or diatomaceous earth, volcanic ash, and kaolin, by those to whom they have been sent in the past. Mr. Albert Mann, of the Bureau of Plant Industry, Washington, an authority on diatoms, to whom I sent samples from this and other beds, states that he cannot find diatoms in them. Other microscopical examinations have been made with the same result, and the material must therefore be regarded as a highly siliceous volcanic ash.

The following analysis of a large sample taken from this bed, at the point marked 'x' on Plate XVI, was made at the Ore Testing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa:

SiO_2	71·00
Al_2O_3	14·90
Fe_2O_3	1·70
CaO	1·40
MgO	trace
H_2O (combined), etc.	8·80
Undetermined (Na_2O, etc.)	2·20
	100·00

It is, of course, possible that some thin layers of diatomaceous earth may occur in the deposit, as this association with ash beds deposited in water is not unknown. In the coarser-grained beds, rounded or angular fragments occur, which are chiefly quartz but sometimes a coarse tuffaceous material. There are occasional layers of hard, firmly cemented material of the same nature. A vesicular structure was noted in some of the beds, possibly due to the leaching out of carbonates. A little pyrite is sometimes present. A bed near the base of one of the large pinnacles contains rounded and angular fragments (up to 1 foot in diameter) of firmly cemented tuffaceous rock. Coarse, hard, siliceous, and somewhat porous beds are exposed along both sides of Last Chance creek, dipping apparently to the west at angles of from 10° to 15°. The basalt flow which caps the deposit is vesicular and contains sphærosiderite. On the east side of Deadman (Snoo-hoosh) lake, at its head, a similar deposit occurs, capped as before by horizontal beds of basalt and basalt breccias (Plate XVII). A meerschaum-like mineral fills cavities in the altered amygdaloidal basalt and forms the cementing material in portions of the breccias. Radiated aragonite, zeolites, and sphærosiderite were noted. On the trail, about 1 mile north of the camp on the east side of the lake, a coarse conglomerate or breccia overlies fine-grained brick-red beds. These beds are exposed for some distance below the trail and, covered by soil, extend for about 90 feet up the 30° slope to the east. Soil of a bright red colour forms a patch about 200 by 120 feet on the hillside. The beds are apparently tuffaceous and may be near the horizon of the Tranquille beds.

A base camp was next established on the old site just below Gorge creek, from which the main valley and side creeks, as far south as Criss creek, were prospected. Gorge creek was ascended, first along the trail on its northeastern side to the summit, and then along its bed for about 1½ miles. About one-half mile up the trail pale yellowish ash beds occur. The float rock here is mostly amygdaloidal basalt. Farther up, boulders of coarse agglomerate were seen. Near the summit are high cliffs of horizontally bedded, fairly fresh eruptives with interbedded tuffs. A rough analysis, which needs confirmation, of weathered, fine-grained, bright red, apparently tuffaceous material, appears to indicate the presence of aluminum hydroxides.

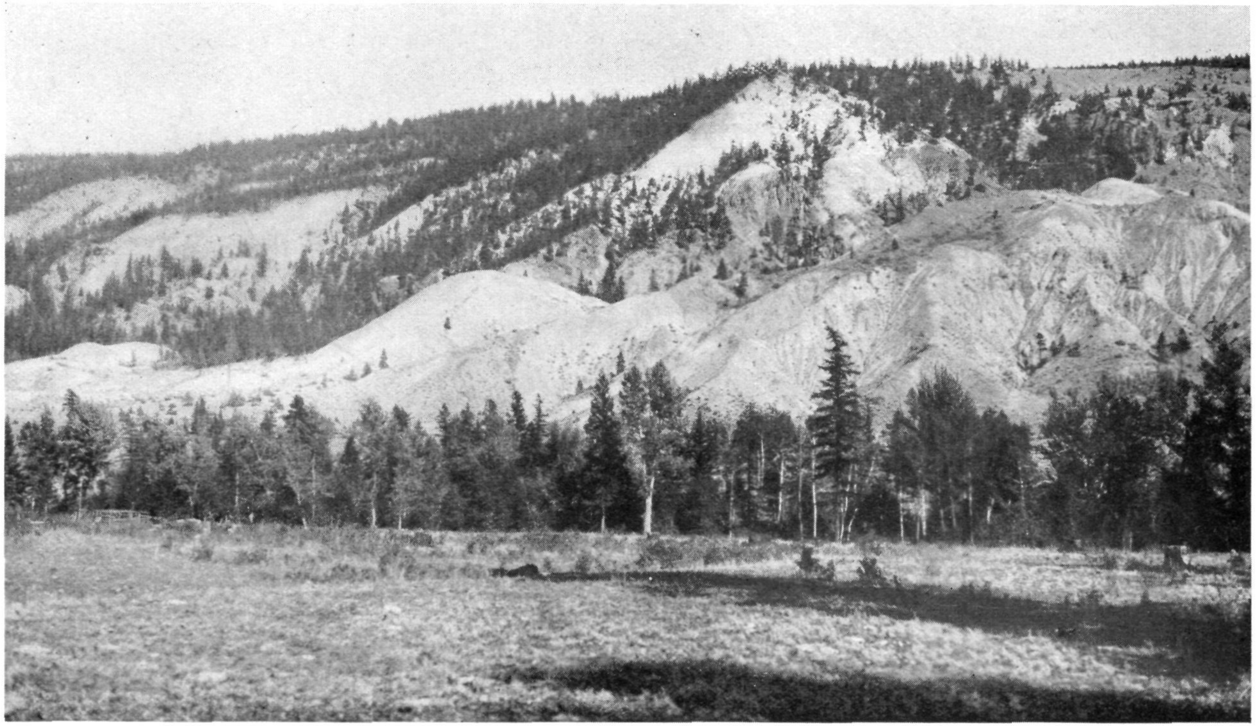
The high cliffs on the west side of Deadman Creek valley for some miles south of the camp are capped by horizontal basalt flows, mapped as Upper Volcanic group. About 1 mile south of the camp, on the west side of the valley near the road, there is an exposure of highly altered rocks, showing brilliant red, yellow, and white tints. They are much fractured and slickensided, with clay-like material in the fracture seams. On the east side of the river, about 4½ miles from camp, the base of the high cliffs is covered by talus, mainly fragments of amygdaloidal basalts. The amygdules are greatly elongated, largely filled with chalcedony and calcite, and have a bright green coating. They weather out from the decomposed rock and lie scattered over the surface. Amorphous decomposition products are plentiful (Plate XVIII). Just north of the mouth of Criss creek the cliffs are composed

PLATE XVI.

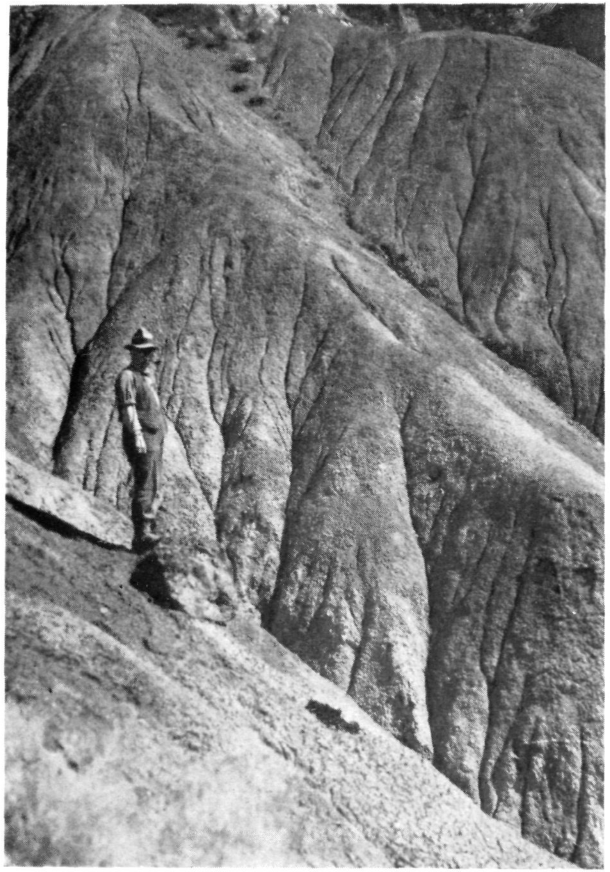
Beds of volcanic tuff near Last Chance creek, east side of Deadman lake.

('X' marks position of bed from which sample mentioned on p. 37 was taken.)

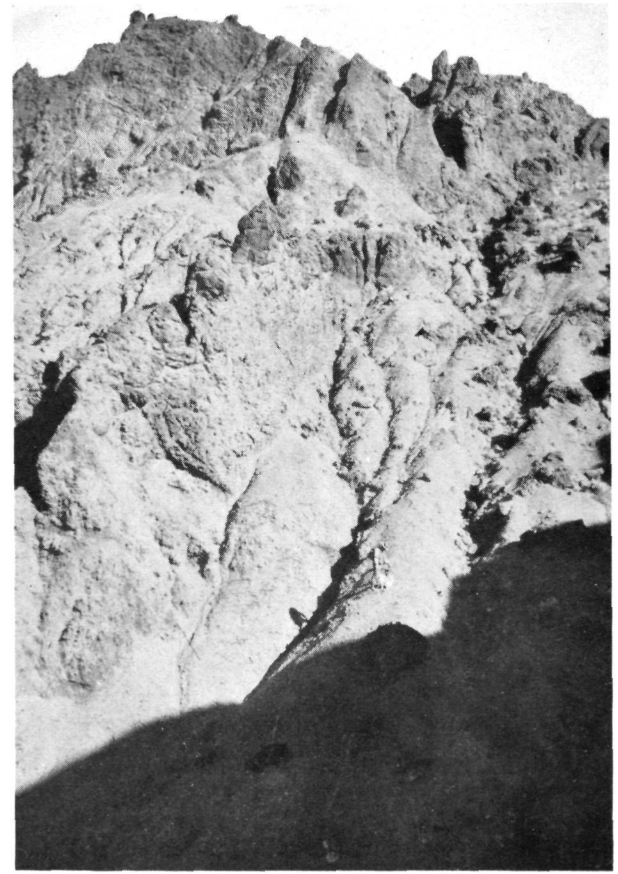
Beds of volcanic tuff on east side of Deadman lake at its head.



Decomposed volcanic rocks on east side of Deadman river, three and one-half miles north of Criss creek.



Decomposed volcanic rocks (basalts, breccias, and tuffs) on east side of Deadman River valley, three and one-half miles north of Criss creek.



High cliffs of volcanic rocks, showing slopes of rubbly decomposed material. East side Deadman River valley, just north of Hoey ranch.

of breccias and tuffs capped by basalt. About 200 yards east of the wagon road, a short distance north of the Hosfeld ranch and 2½ miles from camp, is a small hollow in which a curious dark-coloured, wax-like, plastic clay has been deposited. Between the Church and Hosfeld ranches, on the same side of the valley about 3½ miles north of Criss creek, the tuffs, breccias, and basalts are extremely decomposed, forming rounded slopes of crumbling material of brilliant red, yellow, green, and white colours, in which erosion has produced a topography resembling that of the 'bad lands' of the West (Plate XIX). The lower portion of the section is concealed by talus. Much of the decomposed material is clay-like, plastic, and fairly free from gritty particles. Fragments of amygdaloidal basalt occur in the debris, also gypsum and fibrous calcite which were probably formed in the rocks before they were broken down. Near the top of the slope a fine white quartz sand with clay beneath it was noted in narrow dry watercourses, and a gray, crumbling, weathered dyke of andesite or trachyte found higher up is evidently the source of these materials. The highest point of the slope is capped by what appears to be glacial till, in places apparently about 200 feet thick, resting on the altered volcanics. The boulders in it, some quite large, are mainly granitic. The volcanic rocks which were seen in place here seem to be largely porphyritic. On the south end of the exposure high jagged cliffs rise out of the crumbly weathered slopes. The rocks near the Hoey ranch 1 mile north of Criss creek are chiefly amygdaloidal basalts and coarse breccias, not much altered except by surface weathering (Plate XIX). The amygdules are frequently filled with chalcedony and calcite, and numerous veinlets of chalcedony occur in the face of the cliff. About one-half mile up Criss creek very fine crystals of analcite, heulandite, natrolite, and other zeolites were collected and sent to the museum of the Geological Survey.

CHROMIUM

General

Metallic chromium has no direct use, but raw chromite and chromium salts have a variety of applications. Owing to its great heat-resisting qualities, chromite is used as a basic refractory lining for furnaces, in the form of manufactured bricks or lumps of ore. It withstands wide changes of temperature and resists the attack of molten metals. For refractories, ore with 35 to 45 per cent of chromic oxide can be used.

Ferro-chrome is extensively used in the manufacture of steel for armour plates, armour-piercing projectiles, mining machinery, automobiles, high-speed tool steel, etc. Chrome steels containing one or two per cent of chromium are distinguished by their great hardness.

The largest producers of chromite are Rhodesia, Turkey, United States, New Caledonia, and Canada. The United States produces about 25 per cent of its requirements of high grade ore, importing the balance from abroad. Canada exported over 10,000 tons to the United States in 1916 and more than doubled that tonnage during 1917.

It was expected that the Canadian output for 1918 would exceed the production of the previous year, but owing to an over-production of '40 per cent ore' in the United States in 1918 Canadian mines exported only about 20,000 tons during that year, of higher grade, however, than in 1917.

Previous to the war, chrome ores commanded a price of approximately 30 cents per unit of chromic oxide for ores containing not less than 50 per cent chromic oxide (Cr_2O_3). Penalties and bonuses of 50 cents per unit per ton were applied, respectively, to ores below and above the 50 per cent standard.

Owing to difficulty in securing bottoms, foreign ores were practically off the market in North America in 1917, and as the mineral was an essential in the production of munitions the domestic supplies were more carefully investigated than ever before. So urgent became the demand that in the latter half of 1917 and for the first half of 1918 a price of $1.20 per unit ruled for ores containing only 40 per cent chromic oxide (Cr_2O_3), while 50 per cent ores brought a price of $1.50 per unit of chromic oxide.

Practically the total Canadian chromite output is from the Black Lake district in the Province of Quebec. Several interesting discoveries in British Columbia have been recorded, one of which is described by Dr. Ferrier in this report, but these have not yet reached the stage of commercial development.

At the direction of the Secretary, Mr. J. C. Gwillim visited the Black Lake district in Megantic county, Quebec, during the fall of 1917, and made a report on the possibilities of stimulating the mining of chromite, which is given further on. He found that the war price of approximately $1.20 per unit of chromic oxide had effected an increase in the production, but he considered that experimental testing to ascertain the best method of concentrating these ores would be of great value. Acting on his advice the Quebec Asbestos & Chrome Company, St. Cyr, Que., forwarded a carload of ore to the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, at Ottawa, from which a high grade chromite concentrate containing approximately 48 per cent chromic oxide was made.

The result of this test awakened the interest of some other producers in the district, and the Department of Mines was asked to undertake additional experiments. Incidentally, the test encouraged the Quebec Asbestos & Chrome Company to at once proceed with the erection of a concentrating mill, which has since operated successfully.

The Secretary called the attention of the Imperial Munitions Board to the production of chromite ores in Quebec, and also to the fact that the British Ministry of Munitions was conserving supplies of chrome ores and ferro-chrome in England. It was pointed out to the Board that, should the Ministry so desire, it would not be difficult to reserve the Canadian chromite for the use of the Ministry instead of allowing it to be exported to the United States. Incidentally, should the Ministry become interested in the proposal, this might lead to the establishment of electric furnaces in Quebec for the production of ferro-chrome. The British Ministry of Munitions did not reply to this proposal.

At a meeting of the Commission on March 7, 1918, the chromite mining industry of Quebec was discussed, and the decision made that in view of the importance of this war mineral means should be taken to increase Canadian production. Dr. Robert Harvie, of the Canadian Geological Survey, gave a brief description of chromite mining in the Province of Quebec and made suggestions for an increased production of this mineral. The Secretary was instructed to co-operate with Dr. Harvie in the preparation of a memorandum dealing with the subject, and to submit the same at the next meeting of the Commission. Subsequently it developed that the Canadian War Trade Board was taking an active interest in chromite production and had secured the services of Dr. Harvie to prepare a report on the possibilities of increased production from Quebec. The Commission, therefore, to avoid overlapping, took no further direct action other than assisting Dr. Harvie and the War Trade Board upon request.

The Secretary of the Commission attended a meeting of chromite producers held at the Ottawa office of the War Trade Board on March 14, 1918, at which Dr. Harvie was present. Mr. Newcombe, representing the Mutual Chemical Company of Canada, Limited, and Mr. Douglas B. Sterrett, representing the Quebec Asbestos & Chrome Company, as well as other gentlemen present, were of the opinion that production could be increased if field officers of the Geological Survey would spend the summer in the Black Lake district to encourage and direct small operators in prospecting and developing their properties. The chromite operators were directed by the War Trade Board to prepare a memorandum setting forth particulars of the industry, and to make certain recommendations for securing the required increase in production.

In due course the report of the chromite producers was presented to the War Trade Board and transmitted to Dr. Harvie and the Secretary of this Commission for consideration. Dr. Harvie then commenced his field investigation and about the middle of June submitted his report. Subsequently he requested that Prof. John W. Bell, of McGill University, Montreal, be secured to report upon certain engineering problems involved in the recommendations made in his report. Prof. Bell was engaged directly by the Commission, and in a report addressed to the Secretary, which is given farther on, fully endorsed the recommendations made by Dr. Harvie.

On October 12, 1918, a Canadian Government Order in Council, P.C. 2438, was passed, authorizing the War Trade Board, on the recommendation of its consulting engineers, to take over and operate any chromite mines. The authority was not, however, exercised by the War Trade Board, because the chromite market became exceedingly dull in October, more 40 per cent ore being offered than could be absorbed by the market in the Eastern United States. This condition very seriously affected production from the mines in the Western United States and Eastern Canada, and at the present time many of the Western United States producers have considerable stocks of 40 per cent chromite ore on their dumps, which they are unable to market. It should be noted, however, that high-grade ores containing over 50 per cent chromic oxide are still in some demand.

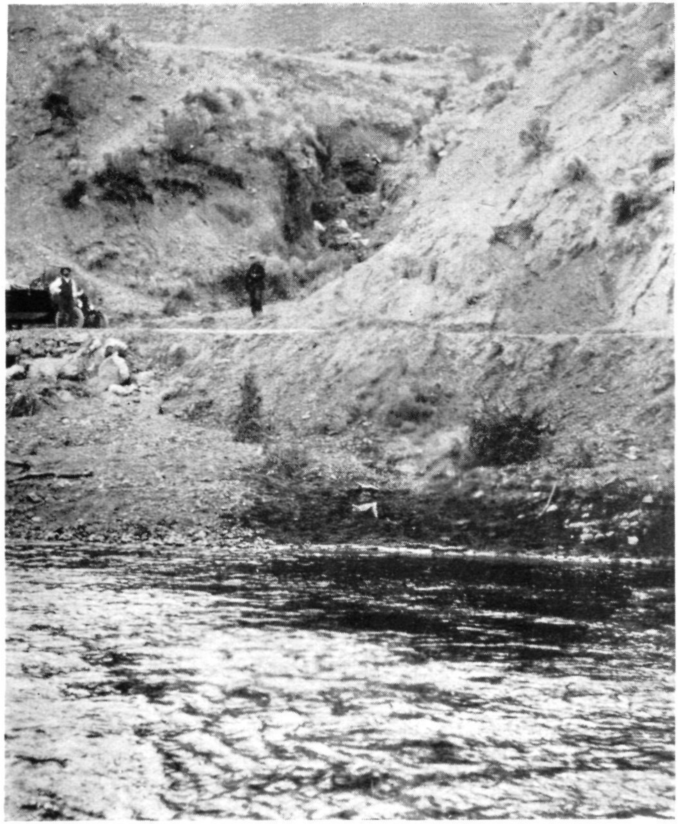
Chromite near Ashcroft, British Columbia.

By W. F. FERRIER

Late in September, 1918, information was received from Mr. Phillip Oppenheim, of Ashcroft, B.C., who accompanied me as packer during the work in the Clear mountains between the Fraser and Thompson rivers, that he had found and located a deposit of chromite close to Ashcroft.

On October 3, the locality was visited in company with Mr. R. W. Thomson, Resident Engineer of the Central Mineral Survey District. The outcrop is in a small gulley opening directly on the main wagon road leading north from Ashcroft to Câche creek and is reached by following that road as far as the bridge over the Bonaparte river, just south of Câche creek. From that point a new road leads off north along the west bank of the river, and the chromite deposit is situated about 300 yards up this road, on its west side. It is distant about 6 miles from Ashcroft. The accompanying photographs give a good idea of the situation (Plate XX).

As no work, other than the digging and blasting of small test pits, had been done, it was impossible to form any idea of the extent of the deposit, but chromite was found in place all along the gulley, low down on its south side, and blocks of ore weighing over 100 lb. were broken out of the outcrop.



Chromite near Ashcroft, B.C.
Looking west across Bonaparte river to small gully in which outcrop occurs.

Chromite near Ashcroft, B.C.
Looking west up the gully, showing test pits low down on its south side.

The ore is finely crystalline and contains some pyrite which is mostly confined to definite seams readily eliminated by hand-sorting. No analysis has been made of the ore, but it is probably a chrompicotite.

The country rock is serpentine, apparently resulting from the alteration of a peridotite, and somewhat resembles that accompanying the chromite on Scottie creek, about 12 miles further up the Bonaparte river. The rocks in the vicinity were mapped by Dawson as Câche Creek formation (chiefly Carboniferous).

The overburden at the gulley is not very thick, and the deposit could be opened up and tested without much difficulty. It is ideally situated for operation, on a good wagon road with a general downhill haul to Ashcroft, and there are good sites for a concentrating plant close at hand on the Bonaparte river which is separated from the outcrop by the width of the road and flows only a few feet below the road level.

Two boxes of ore were shipped to the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa, for a concentration test, and the following results were obtained, according to a report furnished by Mr. W. B. Timm and given below:

A shipment of 420 lb. of chrome ore was received on December 24, 1918, from Dr. Ferrier.

On examination the chromite was found to be finely crystalline, much more so than the Black Lake, Que., chromite, necessitating finer grinding to free it from the gangue, which consisted of serpentine. Iron pyrite was also present.

The ore was crushed to 50 mesh and sampled for analysis, which gave 10·7 per cent of chromic oxide (Cr_2O_3).

A small preliminary test was run on 24 lb., on a small Wilfley table. The weights analyses, and contents of the products were as follows:

Weight of ore taken	24·00 lb.
Analysis, Cr_2O_3	10·70 per cent
Content "	2·57 lb.
Concentrates obtained	3·00 lb.
Analysis, Cr_2O_3	47·34 per cent
S	2·40 "
Content, Cr_2O_3	1·42 lb.
Recovery of chromic oxide in ore	55·30 per cent
Middlings obtained	1·50 lb.
Analysis, Cr_2O_3	12·75 per cent
Content "	0·19 lb.
Recovery of chromic oxide in ore	7·50 per cent
Tailings obtained	12·50 lb.
Analysis, Cr_2O_3	4·56 per cent
Content "	0·57 lb.
Recovery of chromic oxide in ore	22·20 per cent
Slime loss	7·00 lb.
Analysis, Cr_2O_3	5·56 per cent
Content "	0·39 lb.
Loss of chromic oxide in ore	15·00 per cent

A larger test was then conducted on the remainder of the ore on a large Wilfley table. Two grades of concentrates were cut out, a middling held, and a tailing run to waste after being sampled. The results were as follows:

Weight of ore taken	390·00 lb.
Analysis, Cr_2O_3	10·70 per cent
Content "	41·73 "
First concentrates obtained	37·00 lb.
Analysis, Cr_2O_3	48·88 per cent
S	2·20 "
Content, Cr_2O_3	18·09 lb.
Recovery of chromic oxide in ore	43·40 per cent
Second concentrates obtained	29·00 lb.
Analysis, Cr_2O_3	42·10 per cent
S	1·13 "
Content, Cr_2O_3	12·21 lb.
Recovery of chromic oxide in ore	29·30 per cent
Middlings obtained	11·00 lb.
Analysis, Cr_2O_3	17·00 per cent
Content "	1·87 lb.
Recovery of chromic oxide in ore	4·50 per cent
Tailings and slime loss	313·00 lb.
Analysis. Cr_2O_3	3·05 per cent
Content "	9·56 lb.
Loss of chromic oxide in ore	22·80 per cent

Note.—Tailings as samples, which does not include slime loss, gave on analysis 2·51 per cent of Cr_2O_3.

The above results show that practically all the chromite is freed from the gangue at 50 mesh; that a satisfactory separation can be made by water concentration on tables, resulting in a recovery of 72·7 per cent of chromic oxide contained in the first and second concentrates which averaged 45·8 per cent of chromic oxide.

Both grades of concentrates are metallurgical products and can be used for reduction to ferro-chrome, but on account of the iron sulphide present in the ore, which reports in the concentrates by water separation on tables, they cannot be classed as chemical products.

It is rather remarkable that this deposit should so long have remained unnoticed. Since my visit, I understand that more claims have been located, and should the deposit prove to be of satisfactory size and grade it would possess a great advantage as regards cost of operation over other less favourably situated ones in the Province.

Report on the Chromite Situation in the Black Lake District, Quebec.

By J. W. BELL

(St. Remi d'Amherst, July 16, 1918.)

In compliance with instructions in your telegram and letter of June 29, I left Huberdeau July 7, and arrived at Black lake on the following morning. In company with Dr. Harvie, the representative of the War Trade Board, I examined the conditions prevailing at the Montreal pit of the Dominion Mines and Quarries, Limited, lot 25, range II, Coleraine township (Plate XXI).

Briefly, Dr. Harvie contended and made representation to the Dominion Mines and Quarries, Limited, that by making certain changes in its methods and equipment, a considerable increase over its former annual production could be made, and that in view of the large profits made by this company, even with the limited production obtained under the O. Paré contract, it was fair and reasonable to request the Dominion Mines and Quarries, Limited, to endeavour to considerably increase its output of chromite.

Upon Dr. Harvie's request that the services of an engineer be obtained to report on the situation above outlined, I was appointed by the Munition Resources Commission, and beg to report as follows:

I was pleased to find that not only were Dr. Harvie's representations to the Dominion Mines and Quarries, Limited, sound and fair, but that they were evidently accepted as such by the company's consulting engineer, Mr. M. Schwerin, and by Mr. F. Mathez, the resident engineer, and that these gentlemen were planning and preparing to carry out certain operations designed to stimulate development and a larger output of chromite, while I was there.

The required thirty days notice of the termination of his contract was given the contractor so that the company would have a free hand in the execution of its larger operations.

I have to acknowledge the utmost frankness and interest on the part of the company's engineers in acquainting me with the general scheme they had planned, which briefly is as follows:

(1) Installation of an inclined skipway (single track) at the southeast end of the Montreal pit, with the bins and skip-loading and dumping equipment required to greatly increase the daily quantity of material hoisted.

(2) Driving lateral drifts or cross-cuts at four or five places in the walls of the pit, now in ore. This operation is designed to extract ore and to prospect unknown ground to the right and left of the main axis of the pit.

(3) Continue mining ore from benches in the northwest end of the pit as in the past.

(4) At some later date, sink an independent prospecting shaft near the proposed skipway.

In general these proposals seem to me to be excellent, while at the same time the following comments on them may be worth considering.

There is evidence for believing that much good ore is now available in the bottom of the present pit. In order to develop this and prepare for its cheap extraction, I believe it desirable to commence sinking operations just as soon as the skipway and bins are installed, and, by putting in the skipway at as steep an angle as possible, it would seem simple and practicable to commence sinking by extending the skipway. I would also make the skipway wide enough to install two tracks, even if only one was put in for the present. The reason for this, and an additional reason for sinking as soon as possible, is that large portions of the more or less barren rock forming the walls of the present pit may cave at any time, and it would seem wise to have facilities available for its rapid removal from the pit. In this connection great care will be necessary to protect the entrances of the lateral cross-cuts and drifts so that a safe and sure exit for the men will be available in case a large mass of the wall-rock slides into the pit. This work could be carried out quite safely by sinking and then drifting and cross-cutting, but it would of course take longer than the plan contemplated. As long as these lateral drifts are in ore, production will be obtained, but, as I mentioned to Mr. Schwerin, if they encounter barren ground it will be necessary to attack the known ore in the bottom of the pit to maintain production. I have Mr. Schwerin's assurance that development will not be allowed to interfere with production.

These considerations all point to the desirability of starting sinking operations at the earliest moment possible.

The necessity for providing more sanitary and comfortable bunk and boarding-house accommodation is to be met by the immediate erection of a large bunk-house, 20 by 72 feet, and by renovating and changing the present bunk-house into dining room and kitchen, etc. Altogether, provision is now made for putting on and holding (by more attractive and comfortable quarters) a sufficiently large force of workmen.

In closing my reference to the property of the Dominion Mines and Quarrries, Limited, I feel sure that Dr. Harvie's representations to this company cannot fail to result in greater output and profit to it, especially since it has led to the appointment of experienced and capable engineers who are attacking with enthusiasm the problems connected with a considerable expansion of the company's operations.

I also made a brief visit to the Greenshields and Big Caribou pits. At present these are being worked under leases. It is probable that a more vigorous exploitation of these properties by people willing to invest some capital for development and equipment would lead to new discoveries of ore and increase production. The Big Caribou pit and adjacent territory impresses me as being especially favourable.

Montreal chrome pit, Dominion Mines and Quarries, Limited, Black Lake, Que.

Chromite in Quebec.

By J. C. GWILLIM

(Ottawa, September 1, 1917.)

The Canadian output of chromite has, up to the present time, been entirely derived from the Province of Quebec, which between 1886 and 1917 produced 90,223 tons.

Prior to the war the largest recorded output was 9,035 tons for the year 1906; but the average production has been from 2,000 to 3,000 tons. From 1910 to 1914 inclusive, the production was very small, only 692 tons being recorded. In 1915 the output went up to 12,341 tons; and in 1916, according to Mr. T. C. Denis, Superintendent of Mines for Quebec, it was 15,412 tons.

Prices before the war ranged from $8.47 per ton for low grade ores to $20 for high grade ores; the average being about $12 per ton. The output in 1915 is stated to have been marketed at $14.55 per ton; hence this greatly increased production was not brought about by high prices such as obtained in 1916 and 1917. Dr. Harvie, in the Summary Report of the Geological Survey for 1915, has stated that the very considerable revival of the chrome-mining industry in Quebec was due to demands from the United States, owing to the non-arrival of other foreign ores.

The rapid increase in production was largely secured by the working over of old dumps and in the extraction of lenses of ore from old pits ('gophering'). A steady output cannot be expected from these rather uncertain ore bodies.

In 1916 the market prices advanced and much lower grades were accepted. This further stimulated the industry and the output for that year was 15,412 tons. For 1917, it is expected that the output will decline to some extent, at least from the Black Lake-Coleraine pits, which are producing at the rate of about 200 tons per week. This should make the 1917 output anywhere from 10,000 to 12,000 tons for this district.

However, another promising property is being developed at St. Cyr, near Richmond, Que. This mine, if its promise is fulfilled, will ship in 1917 nearly as much ore as all the other mines combined.

Conditions of Black Lake Chromite.—As a general statement it may be said that the ore bodies are usually very uncertain. They occur in lenses or sporadic masses, scattered here and there throughout the country rock, and in order to mine them great quantities of waste must be removed. Boring has been used with some success in locating lenses of ore, but systematic development is the exception rather than the rule, and the visible sources of supply will be gradually mined without much reserve ore being developed.

The ore now being produced is largely in the hands of jobbers who lease the ground and deliver the low-grade product to custom mills, and the shipping grade (30 per cent Cr_2O_3 or over) on the cars at certain prices fixed by the owners of the ground.

Such conditions naturally prevail owing to the uncertainty of future prices. There is little encouragement to develop blind ground against a resumption of the former price of say $12 per ton; but whatever is in sight will be mined while the present prices of from $22.50 to $50 per ton may be had, f. o. b. Black Lake, for ores which run from 30 to 50 per cent chromic oxide.

Conditions at Coleraine and Orford.—These townships, which contributed some tonnage in 1916, are now about to cease operations for various reasons, but might still produce a few hundred or a thousand tons if demanded.

The St. Cyr Property.—This is a new property discovered by Douglas B. Sterrett in October, 1917. The owners are now hauling about 200 tons of ore per week over three miles of country road into St. Cyr, Que., whence it is shipped to the United States. (Plate XXII.)

The ore body is somewhat unique, and, unlike the Black Lake deposits, shows a remarkable continuity along a narrow zone or belt for about 1,000 to 1,500 feet. While this ore is in lenses, they are elongated and almost continuous along the zone. Some of them are 8 to 10 feet wide and have been mined by a narrow open-cut to a maximum depth of 75 feet, with ore still in the bottom.

The St. Cyr property produces both high and low grade ore; at present these are graded to carry 30 per cent or over of Cr_2O_3 to meet the market demands.

It is probable that a considerable tonnage of milling ore will be developed, and it is the intention of the management to have concentration tests undertaken by the Mines Branch, Department of Mines, at Ottawa.

Summary.—The chromite production at Black Lake during the present year may equal that of 1916, but seems likely to decline thereafter. The most promising ground now being operated appears to be the Montreal pit of the Dominion Mines and Quarries, Limited, and some new workings opened up by J. V. Belanger on the Reed lots near Caribou lake. The advent of Sterrett's St. Cyr mine, 6 miles west of Richmond, Que., as a large shipper, makes it possible that the production for 1917 may total over 20,000 tons.(1)

Concerning the concentration of these ores, the mills will take ore as low as 10 per cent Cr_2O_3, and after crushing to 20 mesh pass it over Wilfley tables only. These tables make a concentrate containing probably about 45 per cent Cr_2O_3, with a saving of probably not over 75 per cent. The principal loss appears to be due to a lack of classification and also to the presence of fine chromite in the slimes, which are apparently not properly treated.

(1) The total chromite output for Quebec in 1917 was 23,300 tons.

Chromite mine of the Quebec Asbestos & Chrome Company near St. Cyr, Que.

I have asked Mr. H. B. Fletcher of the Montreal Chemical Company, and Mr. W. P. Melville of the Dominion Mines and Quarries, Limited, at Black Lake, to send some of their ore to the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa, for testing purposes.

FLUORITE

Investigation of a reported occurrence of Fluorite near Birch Island, North Thompson River, B.C.

By R. P. D. GRAHAM

The discovery of a large deposit of fluorite near Birch Island was reported to Dr. Ferrier at Kamloops, during his field-work of 1918, and instructions were received to examine and report on it. Concentration tests were made at the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa, by Mr. W. B. Timm.

Location.—On the summit of Red Ridge, a prominent hill southeast of Birch Island station on the Canadian Northern railway which is 80·9 miles north of Kamloops and on the south side of the North Thompson river. The deposit is rather more than 2 miles in an air-line from the river. Red Ridge lies just east of Cañon creek, which enters the river from the south about one-quarter mile west of Birch Island.

Claims.—Two adjacent claims, the Atlantic and Pacific, were staked on July 25, 1918, by A. G. McDonald, as agent for J. F. Gardner and E. H. Mansfield. From the No. 1 post the Atlantic extends 1,500 feet to the north, and the Pacific 1,500 feet to the south; both claims extending 150 feet to the east and 1,350 feet to the west from the same post. No development work had been done on the claims up to the time they were visited (Aug. 29-30), and samples were taken from the surface.

Accessibility.—There is at present no road or trail up Red Ridge to the claims. They are most conveniently reached from Birch Island (elevation, 1,392 feet) by following the road leading up Cañon creek to the Lydia group of claims, for about four miles, and then climbing the steep western slope of Red Ridge to its summit (elevation, 4,462 feet). A branch road could easily be constructed from the Lydia wagon road to the claims.

Geology.—The area has not been examined or mapped by the Geological Survey. No rock exposures were seen on the northern slopes of Red Ridge. The float consisted chiefly of dark micaceous schists and phyllites, with pale coloured, hard, fine-grained rocks, which appear in part to be quartzites or siliceous argillites, but probably also include sericite schists derived from the metamorphism of granitic rocks or quartz porphyries. Angular fragments of quartz, evidently from veins of considerable size, were observed. The country rock is well exposed on the claims. It is pale coloured to nearly white and varies from medium-grained to fine-grained and compact. The coarser-grained rock has a somewhat porphyritic granitic texture, and consists almost entirely of quartz and orthoclase. A thin section of the compact variety showed a very finely crystalline mosaic of quartz and orthoclase with orthoclase phenocrysts scattered through it. No glassy matter occurs in the matrix. The rock has all the characters of an intrusive and may be classed as a quartz porphyry or a porphyritic aplitic granite. Pyrite is invariably present, in places very plentiful, and by its decomposition gives a rusty appearance to weathered surfaces. Colourless to white porphyritic crystals of orthoclase may usually be found disseminated through the compact varieties of the rock, as well as in the coarser-grained ones.

Although the rock generally appears quite massive, a well defined strike and dip is exhibited in some of the exposures. The mean observed strike is S. 5° W., and the dip about 18° to the west. The rock outcrops are usually lenticular in form, with their longer axes running north and south.

Mode of occurrence.—From the No. 1 post a band of very fine-grained deep-violet or purple coloured material, quite opaque in hand specimens, was traced in discontinuous but, in general, not widely separated exposures for about 180 feet along the strike to the south on the Pacific claim; and for 240 feet to the north on the Atlantic claim. North and south beyond these distances the ridge slopes off and exposures are less frequent, but Mr. McDonald states that outcrops of similar material occur along the line of strike across both claims. The average width of this band, as exposed on the surface, is from 2 to 3 feet, but if, as is believed, the dip is about 18°, the actual width would not be more than about 12 inches. Pyrite is distributed through it in crystals varying from one-eighth of an inch in diameter to microscopic dimensions.

On either side of this band is a zone, in places 20 to 30 feet wide on the surface, of more coarsely crystalline material of similar colour but containing much pyrite in larger crystals up to one-quarter of an inch in diameter. It was estimated that the pyrite content is often as high as 10 per cent. The proportion of quartz, feldspar, and other minerals also appears to be greater and more variable than in the fine-grained band. Beyond this zone the rock still contains the purple material but, so far as observed, in very small quantity.

Another outcrop, about 6 feet square, of material somewhat different in character, which proved to be a very pure fluorite, occurs about 50 feet east of the No. 1 post. The fluorite is very fine-grained, compact, translucent, and mostly pure white in colour with occasional purple tints. It contains little or no pyrite. A small outcrop of the same material was seen a little farther north along the strike, and three or four others are reported to occur on the property.

Composition.—On analysis the fine-grained purple material was found to have a remarkable composition. It is in fact essentially a mixture of fluorite (calcium fluoride) and celestite (strontium sulphate) with minor quantities of lime, iron sulphide and oxide, alumina, silica, magnesia, manganese, etc. as impurities or present in associated minerals. The results of two partial analyses of this material are given below:

	I.	II.
CaF_2	47·20	51·11
$SrSO_4$	32·30	26·29
$CaCO_3$	2·50	1·84
FeS_2	3·70	0·54
Fe_2O_3	——	1·18
Al_2O_3	3·00	2·19
SiO_2	6·50	not det'd.
MgO	present	present
MnO_2	——	present
Undetermined	4·80	16·85
	100·00	100·00

Analysis I. was made at the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa, on a sample composed of typical average specimens taken at short intervals along the whole length of the band. Analysis II. was made by me on the same material, after the removal of most of the pyrite by concentration. The inverse variation in the percentages of CaF_2 and $SrSO_4$ in the two analyses would indicate that the material contains both fluorite and celestite, together with minor quantities of other minerals such as quartz and aluminous silicates.

Examination of a thin section under the microscope bears out this view. The material exhibits a finely crystalline, even-grained structure, and is composed largely of purple isotropic fluorite showing no crystal outlines. Interspersed through this is a colourless mineral (or minerals) with low to medium birefringence. These colourless crystals are no doubt mainly celestite, but many of them appear to be feldspar and quartz. A little muscovite is also present. The fluorite, whilst essentially contemporaneous with the other minerals, has evidently been the last to crystallize. Both fluorine and strontium were doubtless original constituents of the magma which gave rise to the acid intrusive rock underlying the claims. During the crystallization of the magma, they become more and more concentrated, and now appear together as fluorite-celestite-rich bands within the main body of the intrusive mass.

The white material was found, on analysis, to be exceptionally pure, containing 96·12 per cent of CaF_2. A spectroscopic test showed only an extremely faint strontium line.

Concentration tests.—The sample (10 lb.) of the fine-grained purple material taken by Prof. Graham was subjected to concentration tests at the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines. The sample was crushed to 50 mesh and a small portion taken for analysis (see analysis I.) It was found to contain 3·70 per cent of iron sulphide. Small tests were made by table concentration and flotation to remove these sulphides. Analysis showed 1·94 per cent of iron sulphide in the table product, and 1·07 per cent in the flotation product. Table concentration removed the coarse pyrite but a percentage of the fine pyrite slimed and was carried over into the fluorite product. Flotation concentration removed the fine pyrite but a percentage of the coarse pyrite was too heavy to float satisfactorily and remained in the fluorite product. A combination of table and flotation concentration should give satisfactory results.

Conclusions.—The fine-grained purple material is too impure to use as a flux or for purposes other than, possibly, the production of hydrofluoric acid. It is doubtful if such use could profitably be made of it. The celestite apparently cannot be removed by concentration The coarser-grained material in the zone bordering the fine-grained band probably contains too low a percentage of fluorite and too much pyrite to be utilized. The white fluorite is of excellent quality but was only observed in a few small exposures. It is possible that further prospecting might reveal its presence in larger quantity.

MAGNESITE AND DOLOMITE

General

Magnesite—Magnesite is a basic refractory mineral essential for lining open-hearth and high-temperature electric steel furnaces. Until 1915 the Canadian production of this mineral was very small. Three hundred and fifty-eight tons of crude magnesite were mined in 1914 as against 64,767 tons in 1917 and 57,799 tons in 1918.

The war having shut off all supplies of Austrian and Grecian magnesite from Canada and the United States, attention was turned to the occurrences of magnesite in the vicinity of Grenville, Que., and prospecting soon developed the fact that there was considerable magnesite available. The rock is sufficiently high in magnesia to enable the shippers to meet a requirement of approximately 85 per cent magnesium carbonate with less than 13 per cent of lime.

It has always been supposed that the Canadian mineral, on account of its higher lime content, was inferior in quality to the European varieties. However, it has been demonstrated beyond question that Canadian magnesite when properly treated makes furnace linings comparable with the best Austrian magnesite linings hitherto used.

The Scottish-Canadian Magnesite Company, Limited, has been mining magnesite for the last four years on its property in Grenville township, Argenteuil county, Quebec. The material shipped runs as high as 12 per cent lime, all rock with a higher percentage of lime (magnesite-dolomite) is rejected and piled in waste heaps.

The magnesite was shipped in the raw state to the steel plants near Pittsburg, Penn., and also to plants at Hamilton and Toronto, Ont.

The method of using the raw magnesite for the bottoms of steel furnaces is described farther on.

The Scottish-Canadian Magnesite Company began the making of dead burned magnesite in 1917. The cement plant at Hull, Que., was used for this purpose, and the ordinary cement-mill practice was adopted for the manufacture of the dead burned product, the procedure being as follows.

The magnesite is first hand-picked to eliminate impurities such as serpentine and dolomite. It is then put through a crusher and ball mill and ground to pass a 100 mesh screen. Five per cent of magnetite is added, this also being ground to 100 mesh. The magnetite is obtained from the dump at the old Forsyth iron mine at Ironsides, Que., and hauled in wagons to the cement plant at Hull, a distance of about 5 miles by road.

The ground mixture of raw magnesite and iron ore is fed into one of the rotary kilns ordinarily used for burning cement, and fired at a temperature of probably 2700° F.

The product which comes from the kiln is a dark brown, dense, hard, granular material, and appears to be completely dead burned. About 35 tons of dead burned product was produced daily in this manner from one kiln and shipped mostly to Pittsburg, Pa., but some quantity was sent to Hamilton and Sault Ste. Marie, Ont.

This material was considered so satisfactory by the users that the output of the Hull plant was increased to 100 tons per day during the summer of 1918.

Some experiments were made by Mr. J. Keele at the laboratories of the Mines Branch, Department of Mines, on the sintered or dead burned magnesite produced at Hull.

Mr. Keele reports that a portion of this material, placed in a Hoskins electric resistance furnace, did not show any indication of fusion when submitted to a temperature which softened cone 34 (3290° F. or 1810° C.) and it appeared to stand this heat treatment as successfully as the base on which it rested. This base was a portion of a magnesite brick made by the Harbison-Walker Refractories Company in 1914, probably from Austrian magnesite.

The sintered magnesite from the furnace at Hull was then ground to pass a 12 mesh screen, and made into test bricklets in a hand press. Six per cent of calcined magnesite, made into a milk, was used as bonding material and appeared to give satisfactory results, as the brick could be easily handled from the press. These bricks were burned to cone 20 (1530° C.) in the electric kiln, and resulted in a compact, structurally-sound bricklet, without any shrinkage whatever.

When burned to cone 26 (1650° C.) the shrinkage of the bricklets was between one and two per cent.

The data obtained so far seem to show that the Grenville magnesite can be made into a marketable product ready for steel-furnace bottoms by grinding to 100 mesh, adding 5 per cent magnetite ore as a sintering material, and burning to about 2700° F. in the ordinary rotary furnace of cement mills. It also appears that the sintered magnesite when ground and made into brick, using calcined magnesite (magnesite burned at a low temperature) as a bond, is satisfactory as far as temperatures up to cone 26 are concerned, which is about the commercial limit of burning these wares.

The Steel Company of Canada, Limited, at Hamilton, Ont., allowed the Secretary in 1916 to inspect its methods of using Grenville magnesite, and the following notes detail the various operations.

The magnesite arrived at the steel furnaces in crude unburnt condition, in pieces up to 12 to 14 inches square, and in this condition, without any preliminary breaking or crushing, was partially calcined in a small coal-fired furnace. The furnace held approximately 9 tons of raw material and this charge was burnt sufficiently in 8 hours with a consumption of 3 tons of coal. No attempt was made to dead burn, but rather to calcine only, as one would burn limestone for the production of lime.

When discharging the calcined stone from the furnace it was spalled down to one-half inch size and smaller by means of flat pounding-hammers. These hammers were made up of a plate-shaped casting 6 or 8 inches in diameter, fixed to a piece of ordinary pipe for a handle. The hammer was used much in the same manner as a ramming-hammer. This method of breaking down the calcined stone was preferred to crushing, which would make too much dust.

After being calcined and broken as described, the magnesite was mixed with broken up basic open-hearth slag which had been crushed to approximately one-half inch size, in proportions that varied between 15 to 40 per cent of slag and 85 to 60 per cent of burnt magnesite.

The calcined magnesite and broken slag were mixed on the floor facing the open-hearth furnaces by shovelling a layer of slag over a layer of magnesite and then turning the whole over several times by means of shovels. The furnace to be lined was brought to a temperature of about 2700° to 2800° F. The mixture was then thrown in on the bottom of the hot furnace in small amounts, care being taken to distribute the material evenly, and the bottom built up in successive layers until completed.

The essential requirements in putting in a bottom are that small quantities of the material should be put in every 15 minutes, that the furnace should start with a temperature sufficiently high to flux the material, and that this temperature should be maintained throughout the operation. A 75-ton open-hearth furnace can be lined in this manner at the Hamilton works in 4 days, and if care is taken the bottom will be equal in every respect to that obtained by the use of Austrian magnesite. The operation of putting in a bottom consisting of 40 per cent slag and 60 per cent magnesite, in a 75-ton furnace, was viewed during a visit to these works. Assurance was given that absolutely no trouble was experienced as long as ordinary care was exercised that the raw material was properly burned (not to a dead burn), and that an intimate mixture of the slag and magnesite was made preparatory to forming the bottom.

If the work is done carefully the bottom should last for a considerable time without any patching being required, but when patching is necessary it is usually put on with a mixture of 90 per cent calcined magnesite and 10 per cent slag.

As previously stated, the mineral magnesite is essential as a lining for steel furnaces whether the steel be produced for munitions or for ordinary commercial purposes. The most important deposits in North America, as regards transportation to the great steel-producing centres, are in Grenville township, Argenteuil county, Quebec. Certain deposits of hydromagnesite are found at Atlin, in northern British Columbia, but their inaccessability has so far prevented their utilization except for experimental purposes. They would, however, become active producers if steel works should be established on the Pacific coast. A deposit of magnesite recently discovered near Orangedale, Inverness county, Nova Scotia, has been acquired by the Nova Scotia Steel and Coal Company, who mined a small quantity for experimental purposes. The only serious competitors to the Grenville quarries are deposits situated in the states of Washington and California, and the cost of transportation of the Western mineral to steel centres in the East favors the producers in Quebec.

Until 1914 Austria and Greece enjoyed practically a monopoly of the magnesite trade, and unless we are able to develop this relatively new Canadian mining industry to the point where it can meet competition, Austria and Greece will again dominate the production of this particular mineral.

Dolomite—Thoroughly shrunk or dead burned dolomite was in use for a long time as a basic lining for steel furnaces in England, but was afterward largely replaced by magnesite. Owing to the comparative scarcity of magnesite and the abundance of dolomite, the latter has come into a limited use in the United States and Canada during the last three years.

Dead burned dolomite is manufactured by the National Portland Cement Company, Limited, of Durham, Ont., and sold under the trade name of 'durmite'.

The method of preparing the 'durmite' is almost exactly the same as that used in the manufacture of sintered magnesite and the product is similar in appearance.

This product has given good results in steel furnaces, but the life of the linings made from it is said to be shorter than that of those made from magnesite, although the cost of the latter is greater.

MANGANESE

General

Of all the metals employed in the production of steel, manganese is the most vital, since without its use it is impracticable to make good steel commercially; and since a small excess in the steel is not harmful, it has come to be the custom to add considerable quantities of it to practically all industrial steel. This has created a demand for manganese, preferably in the form of ferro-manganese. About 425,000 tons of ferro-manganese, which is about three-quarters of one per cent of the weight of steel produced, was consumed during 1918 in the steel production of North America. The principal sources of supply for manganese ores before the war were Russia, India, and Brazil. The chief outlet for the Russian ore was through the Dardanelles, which fact has made Russian ore practically unobtainable since 1914. The ores of India and Brazil were available only in proportion to the shipping that could be released for their transportation. Therefore, the supplies necessary for steel production in North America had to be obtained locally or transported with difficulty and at considerable cost from India and Brazil.

For the five years prior to January 1st, 1915, the price of 49 per cent manganese ore ranged from 24 to 26 cents per unit (1 per cent per ton) or approximately $12.50 per ton laid down at Pittsburg. For the same period the market price of ferro-manganese ranged from $40 to $65 per ton. After war was declared the price for 49 per cent ore delivered at Pittsburg rose steadily to $1 per unit, and the price for ferro-manganese finally attained $250 per ton.

Probably the most important use of manganese ore aside from the steel industry is in the making of dry batteries. Some quantity is also consumed in the glass industry. These industries require a very high grade ore containing more than 80 per cent manganese dioxide and less than 1 per cent of iron, which during the war commanded a price of over $100 per ton.

Manganese in New Brunswick and Nova Scotia.

The investigations with respect to supplies of manganese were carried out chiefly at the request of the Imperial Munitions Board, and are summarized briefly as follows:

At present there is no manganese mine in the Maritime Provinces developed to the point of steady production. Practically all the recent tonnage has been derived from small mines at New Ross, Lunenburg county, Nova Scotia, producing only from one to two tons daily of very high grade ore, all of which was exported under license to the United States and sold to the glass and dry-battery manufacturers at prices ranging from $120 to $175 per ton.

There is no production in Nova Scotia or New Brunswick of ore suitable for the manufacture of ferro-manganese, but field-work of the Commission has disclosed the possibility of securing some tonnage of low-grade ores capable of concentration. The bog manganese ores found in New Brunswick have been carefully examined by the Commission, and while there is some tonnage of ore available for the production of spiegeleisen (an iron alloy containing less than 30 per cent manganese), they do not contain sufficient manganese for the production of ferro-manganese.

A deposit of banded manganese ore in sandstone has been prospected to some extent at Walton, Hants county, Nova Scotia. This ore contains about 15 per cent manganese, and experiments conducted at the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa, have demonstrated that it is possible to concentrate it to a product containing over 45 per cent manganese. Experiments conducted by the Commission have shown that this concentrated product will produce high-grade ferro-manganese in electric furnaces.

The waste dumps at the Rossville Manganese mine in Lunenburg county were examined with a view to recovering manganese waste that had been thrown away after selecting the high-grade manganese ore already referred to. A carload sample shipment from these waste dumps was forwarded to Ottawa and concentrated at the Ore Dressing and Metallurgical Laboratories of the Mines Branch. It yielded a concentrate containing approximately 30 per cent manganese and 30 per cent iron, which would be suitable for the manufacture of spiegeleisen only.

Manganese in Alberta and British Columbia.

In the early summer of 1917 certain manganese deposits in southern Alberta were examined by the Geological Survey at the request of the Commission. The geologist who made the investigation reported the existence of some deposits, from calcareous springs, which contained less than 10 per cent of manganese. The deposits are not regarded as a valuable source of manganese ore.

Some activity has been displayed in developing an occurence of manganese ore near Kaslo on Kootenay lake, British Columbia. This locality was also examined for the Commission by the Geological Survey. Indications at first gave the impression of a small tonnage of 40 per cent ore, but subsequent development work has uncovered more ore, and the operators exported several hundred tons to the United States.

In the fall of 1918, the Secretary, at the request of the Canadian War Trade Board, examined a new discovery of manganese ore situated near Cowichan lake on Vancouver Island. He reported finding a promising prospect of merchantable metallurgical ore which the owners were prepared to develop under certain guarantees providing for the marketing of the ore produced. The War Trade Board, after due consideration of the proposal, eventually declined to furnish the guarantees required.

Manganese in New Brunswick and Nova Scotia

By J. C. GWILLIM

(*August 23, 1917*)

There are two varieties of manganese ore found in the Maritime Provinces. First, the hard ores, pyrolusite, manganite, and psilomelane, which occur usually as kidneys or streaks, and sometimes as large pockets containing several hundred tons, in the reddish shales, the conglomerates, and in the gray limestone strata of the Lower Carboniferous. Examples are found at Shepody mountain, Markhamville, Jordan mountain, and Quaco Head in New Brunswick; and at Loch Lomond, Cheticamp, Walton, and other places in Cape Breton and Nova Scotia. There is also a local variation in such occurrences in the New Ross district of Nova Scotia, where this hard ore occurs in vein formation in a biotite granite. New Ross is the only producing locality at the present time. These ores are closely associated with geological conditions and might well receive careful geological study for the purpose of assisting in more systematic development. In the past such deposits have been mined until some particular local enrichment was worked out, very little systematic search being made for other pockets which probably occur on the same geological horizon.

Second, the soft bog manganese ores or wad found at many places, especially in New Brunswick. These are deposited by springs and occur in patches on the surface of the ground, varying in superficial extent for an acre or less to many acres, and in depth from a few inches to 20 feet. Usually they are very wet and contain much organic matter, being covered with moss, grass, or even large trees, where the springs have ceased to saturate the ground.

Such ores on drying at 212° F., or on ignition, lose over 50 per cent of their weight and may contain from 10 to 55 per cent metallic manganese. Heretofore, they have not been considered attractive as they are unable to compete with the more desirable Russian and Brazilian ores which are used in making ferro-manganese.

The hard ores are valuable for the chemical, dry-battery, and glass trades and have commanded a price in normal times of $60 per ton. At present they are worth considerably more than $100 per ton and are therefore unavailable for the manufacture of ferro-manganese. Any ores which are worth over $100 per ton offer encouragement to operators even if the geological horizon they follow is narrow and uncertain.

The soft or bog ores, amounting in the aggregate to possibly several thousand tons, cannot enter the market for the chemical high-priced grades, hence their production depends upon competition with the more plentiful and richer foreign ores temporarily unavailable on account of the war.

At present, with metallurgical manganese ores quoted at over $1 per unit for 50 per cent metallic content, these bog ores may possibly be worked up into a saleable product, but at normal prices of say $12 per ton they offer little encouragement and have so far remained inactive.

The question is, therefore, will the high price for ferro-manganese and spiegeleisen continue long enough to justify their development, and will these lower grade ores be attractive to the manufacturers of manganese ferro-alloys? If so, they might contribute a small tonnage toward the making of these alloys in Canada.

My conclusions are that we have not yet in evidence any deposits of manganese in Eastern Canada which offer a reasonable supply for the ferro-manganese industry, in competition with foreign ores. We have, however, some quantity of desirable ore for use in the arts at high prices, and this hard ore is worthy of close investigation and systematic development.

A manganese ore of 55 per cent metallic content, unless it has over 2 per cent in iron, will be classed as a high-grade variety, valuable for its manganese dioxide. We do not appear to possess such high-grade ores, carrying over 2 per cent iron, in New Brunswick or Nova Scotia, but there is a plentiful supply of such ores in other parts of the world which are available in normal times.

New Brunswick.

Hopewell Manganese Mines, Albert County, N.B.—This property lies 4½ miles northeast of Hopewell, over a good road ('Chemical road'). It is on the western side of Shepody mountain, 250 feet above sea-level. The mine is now covered with grass and second-growth timber; nothing can be seen underground, hence I can only give the statements of others. Early reports state that the ore occurred at the base of a reddish conglomerate along its contact with Lower Carboniferous limestone.

In 1898 Dr. Bailey writes that the workings are on a 500 foot adit level from which came 500 tons of 'compact black oxide' said to have been sold in England and the United States at $50 per ton.

T. C. Denis, in the Mines Branch Summary Report of 1909, gives a total of 1,800 linear feet of driving with a reported production of 1,600 tons.

A sketch elevation given me by B. F. Fails, of Hopewell, who worked in this mine, indicates about 1,200 feet of drifting on the adit level, 250 feet on a 45° slope to reach the adit level, and various intermediate levels, totalling 1,800 feet of narrow work.

This property apparently possessed workable patches of ore over an area of triangular shape between the adit level and the slope further up the hill. There seems to be a probability of similar patches of ore in the continuation of this ground beyond the intersection of the slope and adit, and following the base of the inclined conglomerate. To open up this ground a new slope would have to be driven, as the old adit and slope are choked but would probably be useful drainage channels.

Memel Manganese, Albert County, N.B.—On the south side and close to Sawmill creek, 3 miles northeast of Hopewell, N.B., at a slight elevation above sea-level, there is a small hill of reddish conglomerate dipping 45° to the northwest. Some drifting has been done along a small ravine, following the strike of the beds. From this drift a little ore has been shipped in the past, but the work has now fallen in and forms to-day the bottom of the ravine.

The adjacent beds of conglomerate on both sides carry small nodules of manganese ore. One pebble or nodule of two inches diameter was found, the rest about the size of a walnut or smaller. These do not appear to constitute one-half of one per cent of the rock, but certain strata on the bottom of the ravine may be richer. B. F. Fails, an old miner, believes he can pick out or hand jig this nodular manganese from its loose matrix and put it on cars for $25 per ton.

This ground is worth cross-cutting and prospecting to find which bed carries best values. It may contribute a few tons of ore quickly by open-cutting the easily accessible decomposed banks. As an underground mine it looks unpromising.

Waterside, Salisbury Bay, Albert County, N.B.—At this locality there are some workings of forty years ago scattered over a low hill close to the east side of the bay.

The rocks are grits or coarse sandstones dipping eastward at 60°. Pits have been sunk wide apart on strata showing a general distribution of manganese, but I do not think any of these workings were profitable, nor can I find any record of shipments. The only ore seen was in small fragments adherent to the seams in the rock, and a few loose pieces on the old dump.

Dr. Ells mentions this occurrence in his 'Geology and Mineral Resources of New Brunswick.' (1) He states that the workings are near the contact of Triassic and Lower Carboniferous rocks.

Markhamville, Kings County, N.B.—This place is eight miles due south of Sussex and may be reached from that town by a 14-mile good up-hill wagon road. It is on the farm of James Wilkins at an elevation of 650 feet above sea-level. This mine was the largest producer of manganese ore in New Brunswick, having shipped since 1860 an amount variously estimated at from 20,000 to 33,000 tons, and at times employing from 75 to 100 men. At the present time the workings, scattered over a hillside of 10 acres, have fallen in and the place is a sheep pasture. G. F. Parlington, of Halifax, is said to have a 'license to search' for this ground.

The ore occurs in a rather thick bed of gray rugged limestone; or as residual outliers in the adjacent lowlands, probably derived from the decay of this limestone. The lower strata at the base of the hill appear to have been the most productive, being reached by adits and pits, with one shaft 75 feet deep, and a large open pit on the hill, the sides of which look very barren. This pit must have carried ore, or it would hardly have been made so large. On the dumps there is very little, but a few tons might be cobbed out or picked up along the base of the hill, and there are two piles containing

(1) Geol. Surv. Can., Publication No. 983, 1907, p. 97.

about 150 tons of irony ore which will run low in manganese. One of these piles containing 30 tons was sampled, and a sample was taken of broken ore of better grade from an old sorting-floor.

This property is probably worked out. Denis states [1] that work was abandoned after a rather careful prospecting which included diamond-drilling to a depth of 100 feet.

All the same there are in the vicinity untouched portions of the ore-bearing formation which potentially carry manganese. The ground worked was very productive and its extensions may carry good ore. The following samples were sent for assay to the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa:

Sample A.—Represents broken ore such as may have been shipped. It assayed 44·65 per cent metallic manganese.

Sample B.—Represents probably as good ore as the mine produced. It comes from some of the old dumps at the base of the hill. It assayed 42·77 per cent metallic manganese.

Sample C.—Is a grab sample from a pile of irony ore 10 feet square by 4 feet deep. It assayed 8·63 per cent metallic manganese.

Jordan Mountain Manganese, Kings County, N.B.—The property is about 6 miles due north of the town of Sussex, and may be reached by a good wagon road 7 miles to the base of the hill, thence by a 10 per cent hill-road one-third of a mile to the mine. The elevation is 550 feet above sea-level. The mine is situated in a clearing in the woods of about one-half an acre in area, and is now part of a block of land under a 'license to search' in the name of A. S. Charters of Sussex.

There are remnants of a trench 75 feet long and 10 feet deep, two shafts adjacent now fallen in, and another shaft 40 feet south of these which has filled with water to within 15 feet of the surface. Scattered over this little clearing are small piles of rough uncobbed ore, of which sample D, representing 75 tons, was taken, and there is also one pile of 100 tons of broken and apparently selected ore from which sample E was taken.

Very little waste rock was noticed, and the conclusion—from what could be seen and from information supplied—is that a pocket of ore some 80 feet long by 6 feet wide was taken out from a depth of less than 80 feet. This appears to have been an enriched bed or stratum which contributed, according to E. A. Charters, between two and three thousand tons of ore, but, according to Denis,[2] between four and five hundred tons. After this pocket had been mined there seems to have been no development in search of other ore bodies.

This ground has been very productive from the very small area developed and there are still several carloads of shipping ore if it is selected from the piles.

(1) Summary Report of the Mines Branch, 1909, p. 60.
(2) Ibid.

The ore body apparently consisted of a bed dipping southeast at 70°, and the adjacent country should be further prospected. The ore now on the ground is a sort of shale manganese breccia difficult to sort unless broken small. It could be jigged readily if there was water enough for this purpose at the mine. The two following samples were assayed by the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa.

Sample E.—Represents the more or less selected broken ore. It assayed 24·23 per cent metallic manganese.

Sample D.—Represents the rough broken ore piles. It assayed 9·32 per cent metallic manganese.

The Glebe Mine, Kings County, N.B.—This property is on Larry Boyle's farm, 7 miles by road southeast of the town of Sussex, at an elevation of 900 feet above sea-level. The road is good for 4 miles, and then climbs rapidly to the grassy hill-top.

Apparently this ground is abandoned and open to any one for 'license to search'. About 500 feet of drifting has been done consisting of an adit level, and also 100 feet of shaft work in three different openings. All of this work is in a bed or mass of rough gray limestone similar to that at the Markhamville mine.

A search through these workings and over the dumps showed very little ore. In places the underground workings widened out as if ore had been followed, but little remains to indicate a possible paying ore body. Specimen E was taken from inside the mine, and is a selected sample from an isolated segregation. It assayed 59·0 per cent of metallic manganese.

Nova Scotia.

Loch Lomond Manganese, Richmond County, Cape Breton, N.S.—This property is controlled by C. V. Wetmore, of Sydney, and lies 2½ miles east of Enon P.O., Cape Breton. It has been examined by Dr. A. O. Hayes[1] of the Geological Survey, and is also mentioned in another report by Mr. Jas. Fletcher.[2] My own inspection, made in company with Dr. A. O. Hayes on August 10, 1917, will add little to the information already available.

Many years ago the Hon. E. J. Moseley, of Sydney, did some extensive shallow work on the Morrison and McCuish farms, at points one-half mile apart. He is said to have taken out 75 tons of high-grade ore from the western or McCuish workings beside McCuish creek, and an unknown quantity from the eastern or Morrison workings. The Dominion Steel Corporation sank a 20-foot shaft on the Morrison area and apparently abandoned work in 1915.

In 1916 C. V. Wetmore made a trench at a point part way between the McCuish and Morrison workings. This trench was about 300 feet long and

(1) Geol. Surv. Can., Summary Report for 1917, part F, p. 27.
(2) Geol. Surv, Can., Report of Progress for 1882-84, part H, p. 92.

10 to 15 feet deep, but is all fallen in at present. From this trench which followed a stratum of ore-bearing ground at 10 to 20 feet below the surface, 12 tons of ore are said to have been shipped. A sample was taken, and sent for assay to the Ore Dressing and Metallurgical Laboratories, Mines Branch, Department of Mines, Ottawa.

Sample G.—Is representative of such ore as was found at the western workings on the McCuish farm. It assayed 55·14 per cent metallic manganese.

There is a small area of manganese-bearing Lower Carboniferous rocks from one-quarter to one mile wide extending for four miles east of Loch Lomond. These strata may be worth prospecting by shallow pits or bore-holes, and if such prospecting develops commercial quantities of manganese ore some systematic work could be undertaken. As it is at present, local pits, trenches, etc., are made to depths of 20 feet, more or less, at points far apart; a few tons of ore are taken out, then water and overburden fill in the workings and nothing but hearsay can be obtained as information. If, as is reported, the manganese horizon carries from 1½ to 5 inches of ore, more or less in kidneys, this horizon might by systematic work be made to pay the costs of opening up the rather heavy loose ground, such as overlies the productive stratum. The ore is apparently of the high-priced type not used for making ferro-manganese, and there does not appear to be much chance of an early or large production, without much expensive development.

The manganese deposits examined in Lunenburg county, Nova Scotia, are situated in the north corner of the county, from 9 to 11 miles north of New Ross and 27 miles by wagon road from Chester Basin, which is a small port on the south coast and a station on the Halifax Southwestern railway.

The mines have been operating for some years and have reached depths of from 100 to 200 feet, following high-grade manganese ore-shoots in a biotite granite. The sorted ore has been barrelled and carted to Chester Basin for shipment to the United States at prices of from $80 to $180 per ton. It has been sold for uses in the arts requiring a high-grade manganese dioxide for its oxidising qualities. There are three principal mines, as follows:

The Rossville Manganese Mine.—This property belongs to the Nova Scotia Manganese Company, Limited, who leased it to the Metals Development Company and, later, to the Rossville Manganese Company, Limited. The property is known as the Dean and Chapter concession, of 3 square miles in the extreme northern corner of Lunenburg county.

Unlike the more or less stratified Lower Carboniferous manganese ores of New Brunswick and Nova Scotia, this deposit occurs in a region of biotite granite and follows, nearly vertically, fractures or lines of weakness in this granite. There is little to be seen in the way of vein matter other than lenses and streaks of manganese or iron ores in direct contact with a much decomposed granite which caves badly and calls for heavy close timbering.

The mine workings consist of a nearly vertical shaft of small dimensions, with drifts at the 155 and 220-foot levels. The upper levels extend for about 180 feet east and west of the shaft. The lower levels are run 180 feet to the east and 75 feet to the west. Good ore, mostly pyrolusite, was stoped from the 155-foot level upwards, but this ground is now caving and unsafe. The work in the 220-foot level has shown some good ore in the east drift and raises, but little or nothing in the west drift.

In the lower level the granite is badly decomposed and caves easily, with the result that the workings have to be forepoled and close lagged. A cross-cut has been driven 25 feet east in the soft granite without reaching ore, but the zone of possible ore-bearing rock extends farther north than the end of this cross-cut. There is a large mill at the mine (Plate XXIII), containing a small crusher, one pair of rolls, and some Newago screens. This machinery is only used when the market calls for broken or pulverized material. At present they sort the ore on flat $\frac{3}{8}$-inch screens, and the undersize going through is piled on a dump which contains seven to nine hundred tons.

Sample H.—A grab sample taken from this dump and quartered. It assayed 14·91 per cent metallic manganese.

There are 23 barrels of about 600 pounds each of better screenings from the sorting of picked ore.

Sample I.—Taken from one of these barrels and found to contain 36·25 per cent of metallic manganese.

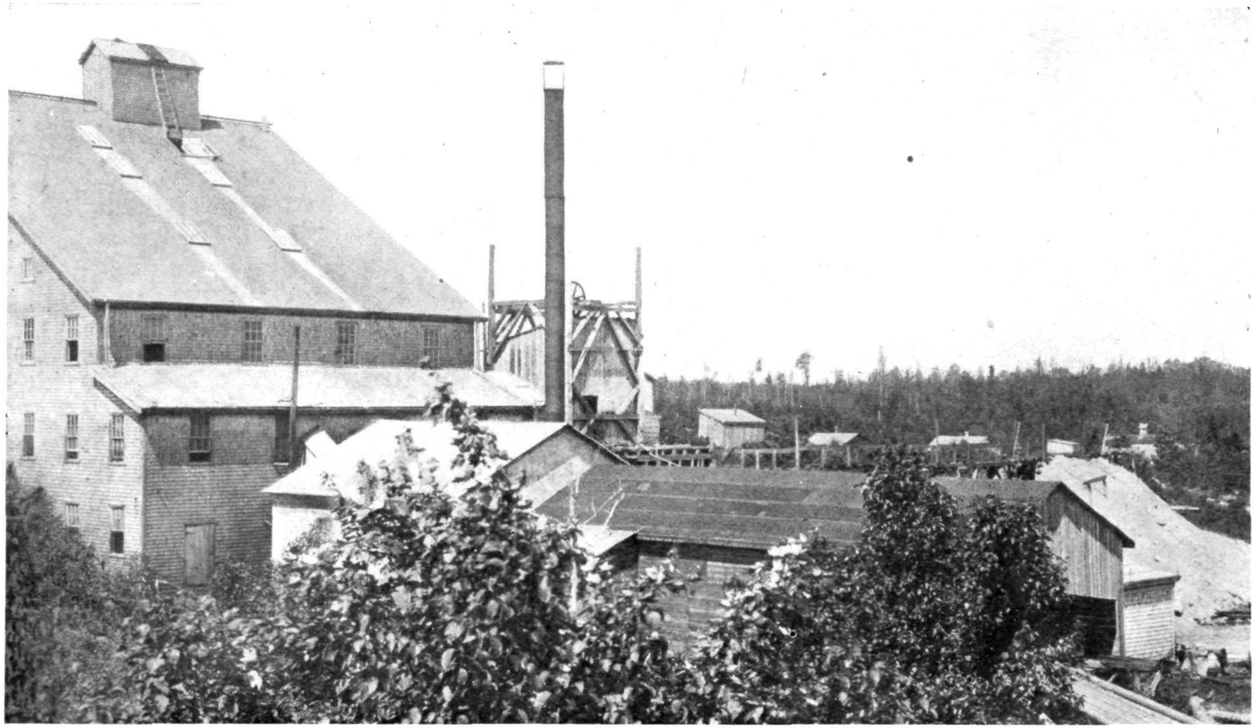
The above assays were made by the Ore Dressing and Metallurgical Laboratories, Mines Branch, Department of Mines, Ottawa.

Shipments in 1916 amounted to 544½ tons, and about 100 tons have been shipped so far in 1917. The haulage by ox-teams from the mine to Chester Basin, 27 miles, costs $8 per ton, and the ore is sold to J. S. Lampson and Bros., New York, at from $100 to $150 per ton, depending on the grade.

The best grade of ore appears to have been taken out from the present workings, but some opportunities are presented of opening up new ground four or five hundred feet east of the present shaft. The product of this mine commands a high price and would not be a source of supply for ferro-manganese. The 700 to 900-ton dump of screenings might give suitable material for ferro-manganese if cleaned on jigs and tables.

The New Ross Manganese Mine.—This property lies about 1½ miles southwest of the Rossville mine and on another similar and parallel vein or zone in the granite. The mine is now filled with water but at one time shipped some tonnage of manganite and was worked to a depth of 115 feet. It is said to have been flooded by tapping surface water from below. Hand jigs were used to concentrate the ore, and during the summer of 1916 some material was cleaned up and barrelled. There are 29 barrels of 600 pounds each at this mine still unshipped, possibly because this ore is too low in MnO_2 for the chemical market.

The International Manganese and Chemical Company of Boston.—The property of this company is situated one-quarter mile southwest of the



Concentrating mill of Rossville Manganese Company, Limited, near New Ross, N.S.
(Burned down in 1918)

New Ross mine, or about 9 miles north of the town of New Ross. This new operation is in the hands of Mr. B. Riddle, of Boston, who has put down a shaft 100 feet deep and done some drifting. Much calcite and iron oxide have been taken out which carry a low percentage of manganese, and in the drifts at the 100-foot level a few kidneys of high-grade ore have been met with. The company has some promising ground, and is apparently working on the westerly trend of the vein of the New Ross mine, one-quarter mile distant.

The shaft-house and the blacksmith shop were burned down in August of this year and development is held up for the present.

Another pit 25 feet deep has been sunk on an irony vein one-quarter mile northeast of the main shaft and, although non-productive at present, may encounter ore at depth.

Bog Manganese Deposits, Upper North Branch, Canaan River, Westmorland County, New Brunswick

By W. L. UGLOW

Location.—Deposits of bog manganese ore are located in Westmorland county, New Brunswick, along the main Canaan river and its Upper North and Middle North branches.

The present investigation has been confined to the deposits which occur on the west bank of the Upper North branch. As shown on the plan these bogs are five in number, extending throughout a distance of about 3,500 feet in a general northerly (magnetic) direction from the junction of the Upper North branch and the main Canaan river (Plate XXIV). The area in general is about half way between the Intercolonial and the Transcontinental systems of the Canadian Government railways.

Ownership.—Mr. Frank E. Jonah, of Moncton, N. B., has a 'working license' on the ground examined, and a 'license to search' over the rest of 10 square miles in a block along the river.

Accessibility.—The nearest railway facilities are at Canaan Station on the Intercolonial railway, a distance of about 4½ miles from the southerly end of bog No. 4. This distance is measured along a bush road, marshy in places, but generally flat with a good hard and sandy clay bottom, which connects the bogs with Canaan Station. With a comparatively small expenditure of money this road could be made into a good truck road for use in the summer season. It constitutes a fairly good winter road in its present condition.

Topography.—All the ground on which the bogs are located slopes gently toward the river bottom with gradients varying from 5 to 12½ feet in 100 feet. The lower edges of the bogs are generally not more than 10 to 15 feet above the level of the river.

Bogs No. 1, No. 2A, and No. 3 are largely of the meadow type, covered with marsh grass. In places there is scrubby spruce and tamarac, 2 to 6 inches in diameter, and a few alders.

Bog No. 2B is sparsely timbered with a light growth of tamarac and spruce 2 to 6 inches in diameter, with some small poplar and birch near its upper boundary.

Bog No. 4 is largely timber-covered, with a small meadow area in the centre. The timber over most of the bog is spruce and tamarac, 4 to 8 inches in diameter, while poplar, birch, and spruce, 6 to 12 inches in diameter, occur at the upper end.

Character of Bogs.—These manganese bogs are situated on valley slopes below the orifices of a series of mineral springs with which the manganese is genetically associated. The water from the springs has apparently deposited manganese dioxide, through a process of oxidation or bacterial action, on top of the original surface of sand, gravel, or clay. The manganese deposits are therefore fan-shaped with their narrow ends at the mouths of the springs and their thickest portions directly below the mouths. Laterally, and at the lowest portions, the manganese ore gradually pinches to nothing. The deposits are somewhat like blisters, which have pushed the soil upward thus making room for themselves between the hard bottom and the grass roots.

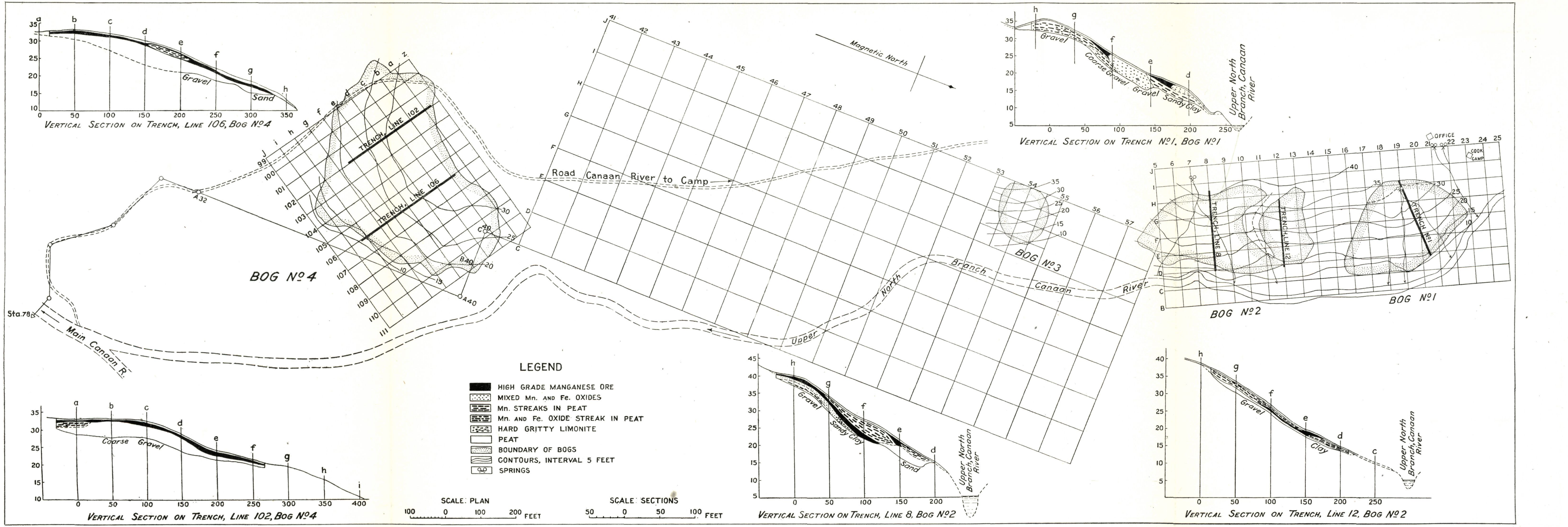
The bogs, by which is meant the material between the grass roots and the footwall of sand, clay, or gravel, vary in thickness from less than a foot to upwards of seven feet. Since the bog material has been deposited upon the old surface, it follows that where the old surface has depressions the bog material is generally thickest.

In some of the bogs, for instance in No. 4, the only manganese dioxide that can be observed occurs in a somewhat hard compact layer immediately beneath the grass and tree roots. Below this layer, to the bottom of the bog, the material appears to consist entirely of brown peat varying in character from logs and roots of considerable thickness, scarcely affected by the carbonizing processes, to the finest woody residue which has been greatly altered by these processes. In this type the manganese and peaty beds are quite distinct, and there is an abrupt change at the contact. Occasionally a little manganese dioxide is also found below the peat, lying immediately on the foot-wall of the bog.

A partial analysis of a representative sample (C106a) from this upper compact manganese layer of bog No. 4 gave:

Manganese	10·00
Iron	0·08
Moisture (at 110°C.)	76·22
Loss on ignition	7·86

This is equivalent to 62·81 per cent manganese and 0·50 per cent iron in the ignited ore.



Plan and sections, Bog Manganese deposits, Upper North branch, Canaan river, New Brunswick.

The results obtained from a representative sample (D102b) of the lower peaty layer of bog No. 4 were:

Manganese	0·22
Iron	0·17
Moisture (at 110° C.)	84·41
Loss on ignition	12·74

Hence, the lower peaty portion of this bog is considered as barren of ore.

In some of the other bogs, for instance in No. 1, manganese dioxide occurs throughout the whole thickness of the bog. In places it is relatively pure, occurring by itself, while in others it is mixed with both hard and soft types of bog iron, and with peat. These characteristics are shown in the vertical longitudinal trench sections (Plate XXIV). In this type there are no abrupt changes in the character of the material; everything is transitional.

Method of Examination.—The work of the field examination occupied the period extending from October 15 to November 24, 1917. Severe weather conditions accompanied by heavy rain and snow-falls (Plate XXV) which caused rapid rises in the river level, the construction of a bush camp as a necessary base of operations, and the necessity of ascertaining by actual practice the best method and instruments to use in order to obtain the most reliable results, considerably delayed the progress of the work and caused the examination to extend over a period of approximately six weeks.

A complete survey of the area containing the manganese bogs was made during the earlier portion of the field-work.

A line was surveyed with a transit and chain, connecting the five bogs with the road survey made by the Provincial Crown Lands Department at a point called 'Sta. 78, Traverse K,' as shown on Plate XXIV. This line determined the number and location of the bogs.

A set of co-ordinates was chosen for each bog corresponding closely with its longitudinal and transverse directions; and with these as bases the bogs were blocked out into squares, 50 feet to a side, using the transit and chain. Numbered and lettered stakes were driven into the ground at the corners of these squares.

During the progress of the work of blocking out these squares the actual edges of the manganese deposits were determined by means of a pointed stake which was driven into the ground at intervals in advance of the chain. The nature of the material adhering to the stake on its withdrawal indicated whether or not it was driven on manganese ground. The boundaries thus determined are shown on the map.

By means of a hand level, a contour map of each bog was made, the contour interval being 5 feet.

Sampling.—It was decided at the outset that a hole should be bored at every corner of the 100-foot squares; but the comparatively small size of the four more northerly bogs indicated that the small number of bore-hole samples thus obtained would not be sufficient to give a composite sample for each bog. Therefore, a hole was bored at the corners of the 50-foot squares on bogs No. 1, No. 2A, No. 2B, and No. 3, and at the corners of the 100-foot squares on bog No. 4.

The boring was begun with the Empire hand-drill, but this method soon proved inapplicable. The bog material is very wet, spongelike, and lacks compactness; and as soon as the drill casing entered this peaty, spongelike material, it sank rapidly without being rotated, squeezed the soft material ahead of the cutting shoe, forced out the water, and failed to cut any core at all. The manganese dioxide being in the form of an impalpable powder went into suspension in the water thus released by the compression of the spongy peat. The result was that the material pumped out of the casing gave neither a representative sample of the manganese content of the hole nor an approximation to the inside volume of the casing. The latter disadvantage meant that the samples obtained by the Empire-drill method gave no factors from which the specific weight (number of cubic feet per ton) and resultant tonnage of the material drilled could be calculated.

The problem of obtaining reliable samples was solved by the use of a peat-auger. This auger consists essentially of a 1½-inch cylindrical pipe with a closed and pointed end. The pipe is slotted longitudinally for 6 inches, and the right-hand lip is bent about three-quarters of an inch outwardly and away from the axis of the cylinder. The lip is sharpened, and when the auger is turned by means of a handle rod firmly attached to its top, cuts a slice of material which is forced into the inside of the pipe and there retained.

The auger was shoved into the ground until the top portion of the slotted portion was about flush with the bottom of the soil and grass roots, care being taken not to rotate the auger during this operation. The auger was then given a few turns in a right-hand direction, and this turning caused the cutting of a slice of the penetrated material, which filled the hollow slotted portion of the cup. The auger was then withdrawn from the hole and its contents extracted by means of a specially-shaped tool. This extracted material was saved as the sample of the first six inches of the hole. The auger was then carefully inserted in the same hole and shoved down another six inches without being turned. Then it was rotated as before, withdrawn, and the material extracted. This material formed the sample from the second six inches of the hole. This procedure was repeated for every six inches until the bottom of the bog was reached.

The entire core from each bore-hole put down in the above manner was collected and placed in a can having a penny-lever air-tight cover and shipped to the Ore Dressing and Metallurgical Division of the Mines Branch, Ottawa, for analysis.

Specific Weight.—The peat-auger method gave no means of determining the volume of a bore-hole from which the weight of material represented by the sample was obtained. Consequently it gave no data concerning the specific weight or the specific volume of the ore. Since such data are necessary

Bog Manganese deposit, Upper North branch of Canaan river, N.B.
Digging a trench in a snowstorm.

for an estimate of tonnage, some other method had to be devised to accomplish this end.

The following was adopted: Trenches were dug from the bottom to the top of each bog, as shown on Plate XXIV. These trenches were started in each case at the lower end of the bog, and were excavated to the floor or foot-wall of the deposit.

A wooden box with an inside volume of one cubic foot was constructed. Samples were cut from the walls of the trenches at 50-foot intervals, large enough in each case to completely fill the cubic-foot box.

A small set of weigh scales was carried from place to place as this work proceeded. The weight of the cubic-foot box when empty was determined, as well as its weight when filled with each separate sample. By subtraction the weight of a cubic foot of solid material was obtained. This result gave the specific weight of the ore in its natural state for each particular location sampled.

The specific weights of wet bog material were found to vary from 58 to 76 pounds per cubic foot.

Trench Sections.—The walls of these trenches afforded excellent sections through the bogs, and the data obtained from their examination were plotted on a series of trench sections, with an exaggerated vertical scale, so as to indicate plainly the varying character of the material (Plate XXIV). These sections show that the soil and the grass and tree roots can be readily stripped from the underlying ore stratum, and that the bottom or foot-wall of the bog consists of a sandy clay and gravel from which the overlying ore can be easily separated by shovelling. Within the ore horizons of the bog there are very few abrupt transitions from high-grade lenses of ore to seams high in iron or peat. The transitions which are shown in the sections as single lines are in reality gradational.

Bog No. 1.—This is the most northerly of the bogs that have been bored. It is of the meadow type, but contains a central patch of scrubby tamarac and spruce with some alders. The manganese dioxide occurs immediately at the grass roots beginning three to six inches below the surface.

The ore is of the mixed type. There are streaks of relatively pure manganese dioxide, in some places soft, and in others hard and gritty; but these grade off into peaty material, largely limonitic, with bunches of manganese dioxide and peat. Some high-grade ore occurs here and there immediately on the foot-wall of the bog.[1]

In this deposit 20 holes were bored, on the corners of the 50-foot squares shown on the map (Plate XXIV). A trench was dug to the base of the bog, beginning at its lower extremity and working upward to its head, near the spring source.

Bog No. 2A.—This bog is similar to bog No. 1, being predominately of the meadow type, with here and there a few alders and scrubby tamarac and

(1) See section of trench No. 1, Plate XXIV.

spruce. It is connected at its lowest northeast corner with bog No. 2B by a neck of bog ground carrying 6 to 12 inches of ore.

The ore is chiefly of the mixed type. In places streaks of high-grade ore run across the bog from the bottom to the top, while near the easterly and westerly edges two to four feet of peaty material lie on the sand and gravel. These streaks grade both laterally and vertically into a mixed type of hard and soft bog iron with both soft and gritty bog manganese.

In this deposit 21 holes were bored, on the corners of the 50-foot squares as shown on the map. A trench was excavated to the foot-wall of the bog along line No. 8.

Bog No. 2B.—This bog begins about 100 feet southeast of Bog No. 1. The surface is timbered partly with light spruce, tamarac, and poplar, and partly with heavier trees in its upper portion.

The ore is more or less segregated, being largely confined to a layer immediately below the grass and tree roots. Brown peaty material takes up most of the space between the bottom of the manganese stratum and the foot-wall of sand and clay.

In this deposit 5 holes were put down, on the corners of the 50-foot squares shown on the map. A trench was excavated to the foot-wall of the bog along line No. 12.

Bog No. 3.—This is a small, almost circular deposit of the meadow type lying between bog No. 2B and bog No. 4. It has a gradient of about 12½ per cent. Owing to its small size, this deposit was not trenched. Four holes were bored, on the corners of the 50-foot squares shown on the map.

Bog No. 4.—This is the largest and most southerly of the bogs. With the exception of a small central area, which is a meadow, the bog is timbered in the lower portions with tamarac and spruce 2 to 8 inches in diameter, and in the upper portions with birch, poplar, and spruce 4 to 12 inches in diameter.

Fifteen peat-auger samples were taken, at the corners of the 100-foot squares—one sample, marked (a), from the upper manganiferous portion of the hole, and another sample (b) from the lower peaty portion.

In this bog the manganese dioxide occurs almost exclusively in an upper narrow bed, varying in thickness from one or two inches to about 20 inches, and averaging 9·2 inches. Below this to the foot-wall of sand and clay is a thick bed of brown peaty material which appears to carry little or no values.[1] Samples were taken of the two beds separately to determine whether or not the peaty material contains any manganese dioxide.

Trenches on lines 102 and 106 disclosed the fact that there is an abrupt change at the base of the manganese bed, into an almost exclusively peaty material.

Tonnage Estimates.—The factors necessary for making tonnage calculations are the area and the depth of the ore together with its specific weight, or weight per cubic foot.

(1) See assay of sample D102b, p. 67.

The bore-holes at the corners of each square gave the depth of ore at those points. The cubic-foot-box samples taken from the trenches gave the specific weights at their respective locations. With these figures as a basis, the specific weights of the ore represented by the peat-auger samples were estimated, due emphasis being given to the location of the peat-auger samples with respect to the bog, and the lithological character of the samples as seen from the material extracted from the cup of the peat-auger.

In order that the depths, specific weights, and assays of the material from each bore-hole should be given equal weight or emphasis in a set of composite figures for each bog, each hole was considered as being located at the centre of an imaginary square of the same dimensions as the surveyed squares; and the figures for each hole were considered as representative of all the material underlying the imaginary square for which that hole is the centre.

In Figure 1 the squares designated by the full lines represent the squares actually blocked out in the field, and show the bore-holes at the corners; for example, G17 in the upper left-hand corner. The imaginary squares are represented by the broken lines, and have for their corners the centres of the surveyed squares. This places the bore-holes at the centres of the imaginary squares, and extends the sampled area beyond the boundaries of the surveyed block for a distance equal to half the side of a square. By this method bore-hole G17, for instance, would represent the block of ore underlying the cross-hatched square **m.n.p.q.**, and the figures for each hole would be applied in every case to surfaces of equal area.

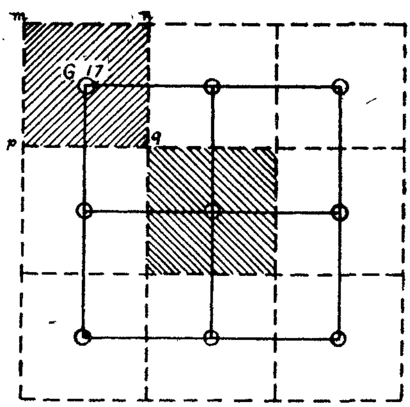


FIG. 1.

The area of bog represented by each bore-hole, therefore, would be the area of one of the squares. In bogs No. 1, No. 2A, and No. 2B this area would be 2,500 (50×50) square feet, while in No. 4, it would be 10,000 (100×100) square feet. Hence the area of each bog obtained by this method would be the product of the number of holes by the area of each square.

The volume, in cubic feet, of ore material in each block similar to **m.n.p.q.**, is obtained by multiplying the area of the block by the figure representing the depth of ore in the centre hole of the block.

The tonnage of each block is obtained separately, by multiplying the volume in cubic feet by the figure for the specific weight of that block and dividing this result by 2,000 (=pounds per ton). The sum of these block tonnages gives the tonnage of the bog.

This method does not confine calculations to the actual boundaries of the manganese deposit as shown on the map, but assumes a set of straight-line boundaries as shown by the broken lines, which as a general rule outline an area falling within the actual boundaries. The assumed broken-line boundaries outline an area which is believed to be underlain by *available tonnage;* and, therefore, this method takes little account of the thin unminable seams of manganese ore which extend to the edges of the deposit and there pinch out to nothing.

Tonnage of Bog No. 1.—The tonnage calculation for bog No. 1 is given in full as an example of the actual working of the method. Since the area of each block is the same, 2,500 square feet, this quantity is not used as a multiplier in the tonnage calculations of each block, but is employed together with the factor 2,000 at the end of the calculation shown hereunder:

Hole No.	Area of block square feet	Depth = (A) feet	Specific weight = (B) pounds	Pounds per ton	Product (A) × (B)
D17	2,500	2·5	55·1	2,000	137·7
18	"	2·0	58·4	"	116·8
19	"	5·0	61·8	"	309·0
20	"	2·5	61·8	"	154·5
E17	"	2·5	74·5	"	186·2
18	"	4·0	74·5	"	298·0
19	"	6·0	70·6	"	423·6
20	"	2·5	55·1	"	137·7
21	"	3·0	58·4	"	175·2
F17	"	3·0	68·0	"	204·0
18	"	6·0	68·0	"	408·0
19	"	4·5	70·1	"	315·3
20	"	4·0	74·5	"	298·0
21	"	4·0	74·5	"	298·0
G17	"	2·0	64·2	"	128·4
18	"	3·5	66·3	"	232·0
19	"	5·0	67·5	"	337·5
20	"	3·4	68·0	"	231·2
21	"	2·0	68·0	"	136·0
H20	"	2·5	64·2	"	160·5
Total 20	2,500	69·9	....	2,000	4687·6

Average depth of ore = 69·9 ÷ 20 = 3·495 ft.

$$\text{Available tonnage} = \frac{4687{\cdot}6 \times 2500}{2000} = 5859{\cdot}5 \text{ tons.}$$

Tonnage of Bog No. 2A.—The area represented by the broken-line rectangle enclosing F 7 and G 7 is not included in the estimate, as these two holes showed little or no manganese.

Number of holes	19
Combined depth of holes	63·0 ft.
Average depth of ore (63·0 ÷ 19)	3·317 ft.
Total of products of depths multiplied by specific weights of separate blocks	4387·8

$$\text{Hence, available tonnage} = \frac{4387{\cdot}8 \times 2500}{2000} = 5{,}485 \text{ tons.}$$

Tonnage of Bog No. 2B.—The same method was used for estimating the available tonnage of this bog as for bog No. 1.:

Number of holes	5
Combined depth of holes	11·0 ft.
Average depth of ore (11·0 ÷ 5)	2·2 ft.
Total of products of depths multiplied by specific weights of separate blocks	721·7

$$\text{Hence, available tonnage} = \frac{721{\cdot}7 \times 2500}{2000} = 902 \text{ tons.}$$

Tonnage of Bog No. 3.—Owing to the small size of this bog, its circular outline, and the distribution of the bore-holes, the following method of obtaining the tonnage was adopted:

A circle of 1-inch (50 feet) radius was described on the plan of the bog, with its centre at a point half-way between bore-holes Nos. I 54 and 54+. With the same centre another circle, of 1½-inch (75 feet) radius, was described.

Bore-holes Nos. I 54 and 54+ fall within the inner circle, and each shows a depth of ore of 3·0 feet. This figure, therefore, was taken as the average depth of ore for the area enclosed by the inner circle.

Bore-holes Nos. I 53+ and 54 fall within and on the boundary of the annular area between the two circles, and each shows a depth of ore of 1·5 feet. This figure, therefore, was taken as the average depth of ore for the area represented by the annular ring.

The outside circle very nearly marks the boundary of the bog, and is taken as showing the edge of available ore.

Inside circular area

Radius	50 ft.
Depth of ore	3 ft.
Area (50×50×3·1416)	7,855 sq. ft.
Specific weight of ore (average of specific weights of ore of bogs Nos. 1, 2A, and 2B)	67·4 lb.

$$\text{Tonnage} = \frac{7855 \times 3 \times 67{\cdot}4}{2000} = 722 \text{ tons.}$$

Outside annular area

Area = (area of large circle) − (area of small circle) = (75×75×3·1416) − 7855	9,820 sq. ft.
Depth of ore	1·5 ft.
Specific weight of ore	67·4 lb.

$$\text{Tonnage} = \frac{9820 \times 1{\cdot}5 \times 67{\cdot}4}{2000} = 496 \text{ tons.}$$

Hence, the total available tonnage for this bog = 1,218 tons

Tonnage of Bog No. 4.—The estimate of available tonnage from this bog is made up of figures which were derived from samples taken from the upper or manganiferous portion of the bog.

Number of holes	15
Area of each square (100×100)	10,000 sq. ft.
Combined depth of holes	21 ft.
Average depth of ore (21 ÷ 15)	1·4 ft.

The average depth of the peat-auger samples from the upper manganiferous portion of the bog is 1·4 feet. The average depth of the manganese layer, obtained from actual measurements along the sides of the trenches, is 0·77 feet.

Consequently the peat-auger samples penetrated 0·63 feet on the average into the lower barren peaty portion.

The average specific weight of the upper manganese layer is 68·8 pounds. The average specific weight of the lower peaty bed is 60·2 pounds.

Hence, the average thickness, 1·4 feet, of the peat-auger samples would be made up of 0·77 feet of the manganese layer and 0·63 feet of the peaty material. Therefore, the average specific weight of the peat-auger samples, i.e. the material from which the assays were made, would be:

$$\frac{(68\times0{\cdot}77)+(60{\cdot}2\times0{\cdot}63)}{1{\cdot}40} = 65{\cdot}0 \text{ lb.}$$

Total of products of depths multiplied by specific weights of separate blocks = 1365·0

$$\text{Hence, available tonnage} = \frac{1365\times10000}{2000} = 6{,}825 \text{ tons.}$$

Average Assays.—The average assay for each bog was obtained by weighting the assays for each bore-hole according to the tonnage of wet ore represented by the block, of which the bore-hole is the centre. That is to say, the figures for the assay of bore-hole G17 [1] were each multiplied by a 'factor' proportional to the tonnage of the block **m.n.p.q.** This 'factor' is the product of the depth figure and the specific weight figure of the same block. The totals of these weighted assays were divided by the sum of the 'factors' used, the final result being the average assay figure of the bog.

The complete assays, given in this report, for moisture, loss on ignition, manganese, and iron are to be interpreted as follows:

In bog No. 2A, for instance, the moisture content is 80·40 per cent. This is the percentage loss after thoroughly drying the sample at 110° C. Hence the dried sample is 19·60 per cent of the original. The percentage loss on ignition is reckoned on the basis of the dried sample as 100 per cent. That is, the loss on ignition for bog No. 2A is 42·10 per cent of the dried sample, or 8·2 per cent of the wet sample. The ignited ore (residue after ignition) is 11·35 per cent of the original wet sample.

The manganese and iron assays are reckoned on the basis of the ignited ore as an original sample. But the ignited ore itself is only 11·35 per cent of the weight of the corresponding wet ore. Hence, the percentages of manganese and iron in the wet ore would be 11·35 per cent of their percentages in the ignited ore, or:

Mn................40·49×0·1135 = 4·65 per cent
Fe................. 7·31×0·1135 = 0·83 " "

(1) See Fig. 1.

Similarly, the percentages of manganese and iron in the dry ore would be their percentages in the wet ore divided by 0·1960, or:

Mn................ 4·65÷0·1960 = 23·70 per cent
Fe.................. 0·83÷0·1960 = 4·23 " "

Average Assays of Bogs Nos. 1 and 2A

	Moisture per cent	Loss on ignition per cent	Manganese per cent	Iron per cent
Bog No. 1.	75·68	39·14	37·31	16·79
Bog No. 2A.	81·70	45·40	34·20	14·11

The calculation of average assays for bog No. 2B is given below as an example:

Average Assays of Bog No. 2B

Bore-hole	Factor 'F'	Moisture		Loss on ignition		Manganese		Iron	
		Per cent	Per cent × 'F'	Per cent	Per cent × 'F'	Per cent	Per cent × 'F'	Per cent	Per cent × 'F'
E12	68·7	77·82	5,347	55·55	3,817	38·73	2,661	4·32	297
F12	160·0	94·16	15,070	14·56	2,330	30·50	4,880	7·22	1,155
F13	160·0	73·44	11,752	38·82	6,210	50·58	8,092	6·95	1,112
G12	166·5	77·55	12,910	52·92	8,810	44·80	7 477	8·45	1,407
G13	166·5	77·71	12,940	55·40	9,220	38·51	6,414	7·85	1,307
Totals	721·7		58,019		30,387		29,524		5,278
Average per cent			80·40		42·10		40·94		7·31

Average Assays of Bog No. 3

The outside annular area contains 496 tons of wet ore. The average assay for this area is the average of the assays for bore-holes Nos. I 53+ and 54.

Bore-hole	Moisture per cent	Loss on ignition per cent	Manganese per cent	Iron per cent
I53+	80·00	63·13	43·70	8·64
54	73·21	53·36	50·81	4·80
Average per cent	76·60	58·24	47·26	6·72

The inside circular area contains 722 tons of wet ore. The average assay for this area is the average of the assays for bore-holes Nos. I 54 and 54+.

Bore-hole	Moisture per cent	Loss on ignition per cent	Manganese per cent	Iron per cent
I54 54+	72·87 80·18	40·83 61·03	49·43 25·87	7·97 1·75
Average	76·52	50·93	37·65	4·86

The average of these two results, weighted according to tonnage, gives for the whole bog:

	Moisture per cent	Loss on ignition per cent	Manganese per cent	Iron per cent
Total average	76·55	53·92	41·55	5·62

Average Assays of Bog No. 4

	Moisture per cent	Loss on ignition per cent	Manganese per cent	Iron per cent
Average	70·50	57·41	47·50	3·12

Dry and Ignited Ore.—The average assays of wet and dry ore in the various bogs, and the tonnages of dry and ignited ores, are calculated from the average assay figures and the figures for tonnage of wet ore previously given. The calculation for bog No. 2B is given as an example.

Bog No. 1

	Wet ore	Dry ore	Ignited ore
Tonnage	5859·50	1425·00	867·50
Manganese per cent	5·53	22·70	37·31
Iron per cent	2·49	10·22	16·79

Bog No. 2A

	Wet ore	Dry ore	Ignited ore
Tonnage	5485·00	1004·00	548·00
Manganese per cent	3·42	18·68	34·20
Iron per cent	1·41	7·70	14·11

Bog No. 2B

Tonnage of wet ore...........	902 tons
Moisture......................	80·40 per cent
Loss on ignition	42·10 " "
Manganese...................	40·94 " "
Iron.........................	7·31 " "

902 tons wet ore produce (902×0·1960)............176·80 tons dry ore
176·8 tons dry ore produce (176·8×0·579)...........102·40 tons ignited ore

Content of manganese (102·4×0·4094)............. 41·90 tons
" iron (102·4×0·0731).................... 7·47 tons

Manganese in wet ore (41·90÷902×100)........... 4·65 per cent
" dry ore (41·90÷176·8×100)......... 23·70 per cent

Iron in wet ore (7·47÷902×100)................ 0·83 per cent
" dry ore (7·47÷176·8×100)................ 4·23 per cent

Bog No. 3

	Wet ore	Dry ore	Ignited ore
Tonnage..............................	1218·00	285·70	131·70
Manganese per cent....................	4·49	19·15	41·55
Iron per cent.........................	0·61	2·59	5·62

Bog No. 4

	Wet ore	Dry ore	Ignited ore
Tonnage..............................	6825·00	2013·00	857·00
Manganese per cent....................	5·98	20·27	47·50
Iron per cent.........................	0·39	1·33	3·12

Ore Summary.—In order to obtain figures for the average assays of the wet, dry, and ignited ores for all the bogs together, the figures for wet, dry, and ignited ore assays for each bog are weighted by multiplying them by the figures for their corresponding tonnages. These weighted results or 'products' are added together for each kind of ore, and divided by the figure for the total tonnage of that kind of ore. The dividends in each case represent the net average assays.

For example, in the accompanying table the column headed 'Mn product', under 'Wet ore', consists of the tonnage figures multiplied by the percentages of manganese.

Bog Manganese Deposits, Canaan River, New Brunswick

Ore Summary

	Wet Ore					Dry Ore					Ignited Ore				
	Tons	Mn per cent	Mn product	Fe per cent	Fe product	Tons	Mn per cent	Mn product	Fe per cent	Fe product	Tons	Mn per cent	Mn product	Fe per cent	Fe product
Bog No. 1...	5859·5	5·53	32,400	2·49	14,586	1425·0	22·70	32,360	10·22	14,565	867·5	37·31	32,394	16·79	14,565
Bog No. 2A..	5485·0	3·42	18,755	1·41	7,733	1004·0	18·68	18,750	7·70	7,728	548·0	34·20	18,745	14·11	7,573
Bog No. 2B..	902·0	4·65	4,194	0·83	748	176·8	23·70	4,190	4·23	748	102·4	40·94	4,190	7·31	748
Bog No. 3...	1218·0	4·49	5,466	0·61	743	285·7	19·15	5,470	2·59	740	131·7	41·55	5,340	5·62	740
Bog No. 4...	6825·0	5·98	40,818	0·39	2,662	2013·0	20·27	40,800	1·33	2,677	857·0	47·50	40,700	3·12	2,673
Totals	20,289·5		101,633		26,472	4904·5		101,570		26,458	[illegible]506·6		101,369		26,299
Averages		5·01		1·305			20·71		5·40			40·45		10·49	

Physical Characteristics of the Deposits which will affect the Mining of the Ore.—The bogs have well-defined, hard compact foot-walls from which, in most cases, the material can be readily separated by shovelling.

The grass and tree roots as a general rule lie *upon* the manganese layer and are not imbedded *in* it. This makes stripping rather an easy problem.

No boulders or pebbles have been found within the manganiferous zones.

Wherever the manganese dioxide occurs isolated in relatively pure beds it can be readily separated from the underlying peat by shovelling.

The deposits have gradients of from 5 to 12½ per cent, which gives sufficient slope for drainage purposes.

Bog Manganese Deposits, Dawson Settlement, Albert County, N.B.

By W. L. UGLOW

Location.—These deposits of wad, or bog manganese, are located one-half mile south of Dawson Settlement, Albert County, New Brunswick, and about 5½ miles northwest of Hillsborough.

The investigation was confined to the two more important bogs which occupy an area of about 12½ acres on the slopes of the south bank of Weldon creek.

Mining Rights.—At the time of this investigation, Mr. Fred. M. Thompson, of the Albert Manufacturing Company, Hillsborough, N.B., possessed a 'license to search' over 10 square miles of country in which the bog manganese deposits occur.

Accessibility.—The nearest railway facilities are afforded by the Salisbury and Harvey railway which, at its closest point, is about 1½ miles from the deposits. This railway runs from Albert, on the Petitcodiac river, through Hillsborough to Salisbury, where it connects with the Moncton-St. John branch of the Canadian Government railways.

About 1897 a spur-track was constructed, 1½ miles in length, connecting the deposits with the Salisbury and Harvey railway. Little now remains of this except the right of way and the grade.

Stoney Creek crossing on the Salisbury and Harvey railway is also distant about 1½ miles. A good road with two hills of easy grade runs from the base of the bogs at Weldon creek to this crossing.

History.—The following notes are taken from a short description, by T. C. Denis, of the Dawson Settlement deposits.(1)

> The deposit began to attract attention in 1887. and several attempts have been made to work it. At first, the ore was merely dried in kilns and shipped for the manufacture of

(1) Mines Branch, Dept. of Mines, Summary Report for 1909, pp. 61-62.

ferro-manganese, but owing to its pulverulent state, the product is said to have been very troublesome in the furnaces. In 1897, the Mineral Products Company erected a large plant for the drying of the ore and the manufacture of briquettes. These were shipped to Bridgeville, in Nova Scotia, to be used by the Preston Charcoal Iron Company in the manufacture of ferro-manganese. The enterprise was reported for a couple of years as being successful, when, for some unknown reason, work was completely abandoned, and the mine and briquetting plant have been idle since 1900.

It is said the plant cost about $30,000, including the construction of a mile and a half of tramway connecting the mine with the Salisbury and Harvey railway.

Topography.—The manganese bogs occur near the base of the southern slope of the broad valley of Weldon creek. Above the bogs this slope continues upward with an even gradient to a height of at least 250 feet above the creek. The northern slope, on which no manganese bogs have been discovered, rises more gradually to a broad summit along which runs the main highway from Baltimore to Hillsborough, N.B.

North of the creek the land is practically all under cultivation and many excellent farms are to be found. South of the creek the hilltops are bush-covered.

The two manganese bogs, which are separated by a barren strip of ground about 100 feet in width, are largely cleared of timber, except small portions near their upper and central boundaries. The ground was stripped of timber, ploughed, and drainage ditches excavated, during a period of exploration and development of the bogs about twenty years ago. These ditches have caved-in to a considerable extent, but their courses are yet clearly distinguishable.

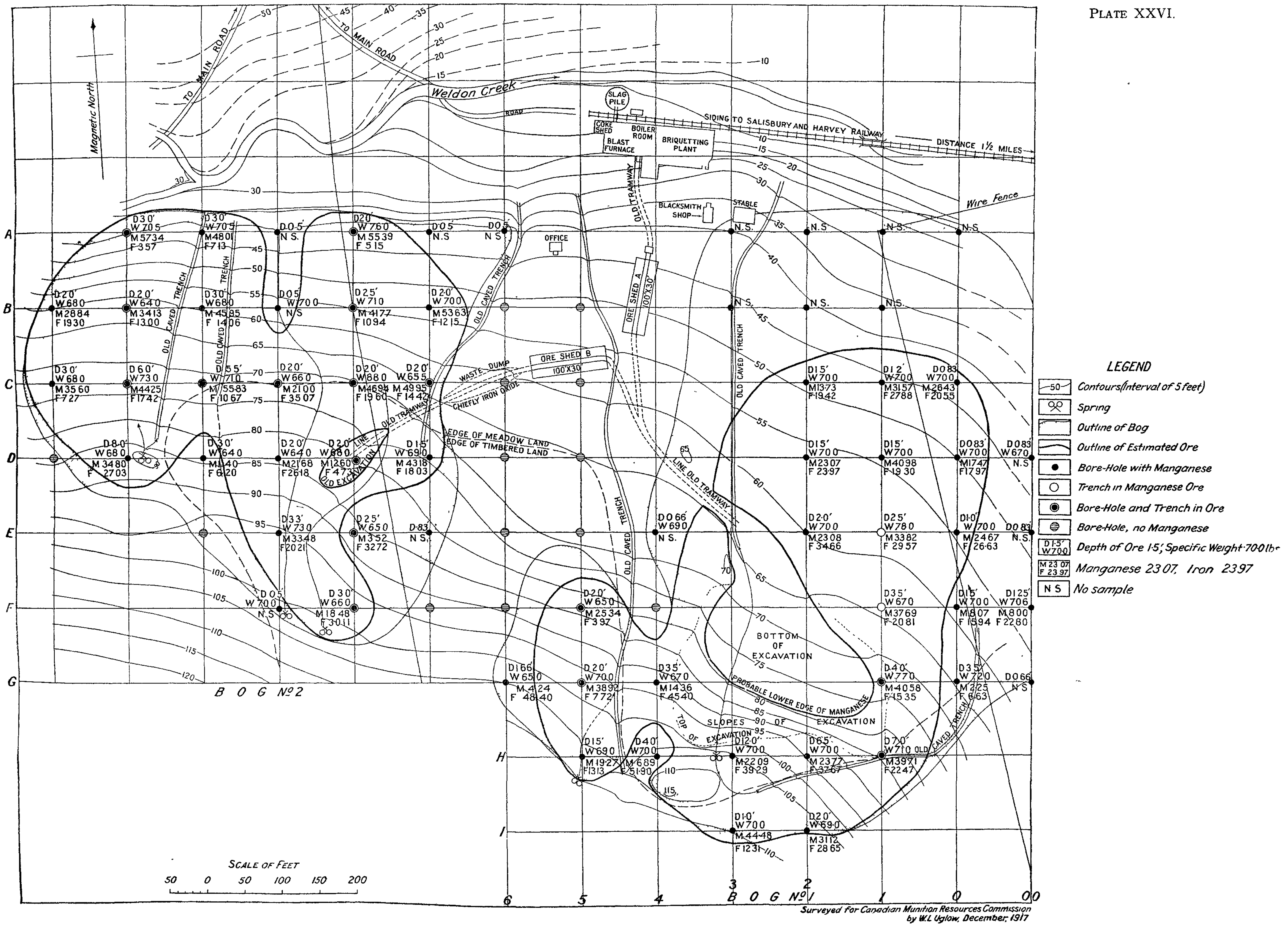
The lower extremities of the bogs are in general not more than 20 feet above the level of the creek, and from their bases the bogs extend up the hillside for a horizontal distance of 600 to 800 feet, with gradients of 9 to 14 per cent.

Character of Bogs.—The manganese bogs are situated for the most part below the orifices of a series of mineral springs, from which the manganese has been, and is yet being, deposited. The upper limits of the bogs lie, in places, 50 to 100 feet up the slopes above the present mouths of the springs. On bog No. 1 the main spring has its outlet near the highest point of the manganese knoll, and the drainage runs in two opposite directions, one of which is that of the up-grade of the valley slope.(1)

The deposits consist of a mixture of manganese dioxide, presumably pyrolusite, and bog iron or limonite. Both minerals occur in the form of an impalpable powder, sometimes intimately mixed, sometimes forming separate bands more or less pure. Large quantities of peat are commonly associated with the ore.

Pure manganese dioxide contains 63·2 per cent metallic manganese;

(1) See Plate XXVI, near H3.



Plan of Bog Manganese deposits, Dawson Settlement, N.B.

hence ignited ore assaying 48 per cent metallic manganese contains 75·95 per cent manganese dioxide.

The water from the springs has apparently deposited manganese dioxide on top of the original surface of sand, gravel, and clay, by means of a process of oxidation or bacterial action. The manganese deposits are somewhat fan-shaped, spreading out from a point slightly above the mouths of the springs and with their thickest portions within a few feet of the mouths. Manganese dioxide and limonite are still being deposited by the springs, and the continuance of this process is causing knolls of ore to be built up in close proximity to the orifices, thereby increasing the length of the upward journey of the ore-depositing waters through previously deposited wad and bog iron.

Laterally, and at the lower extremities of the bogs, the manganese dioxide and limonite gradually pinch to nothing. The deposits are consequently like blisters or laccoliths, which have arched the soil upward and made room for themselves between the hard bottom and the grass roots.

The bogs, by which is meant all the material between the grass roots and the bottom of sand, gravel, or clay, vary in thickness from less than a foot to upwards of 15 feet. The greatest depth found during this investigation was 15 feet, although it is reported that depths of 25 and 30 feet were encountered in the course of boring operations some years ago. This discrepancy may be accounted for by the fact that the hard bottom is of a rolling character, and some of the bore-holes showing the greater depth may have gone down into local depressions in the foot-wall.

In some parts of the bogs the manganese dioxide is confined to a relatively pure layer immediately beneath the veneer of vegetation, followed in depth by a bed of peat down to the sandy or clayey bottom. In other places the wad occurs throughout the whole thickness of the peat bog, and in this form it is usually mixed with a considerable quantity of bog iron.

Analyses show that the manganiferous material from these bogs carries from 60 to 85 per cent moisture (at 110° C.), and that the remaining 15 to 30 per cent of dry material carries from 16 to 70 per cent of peat, which is lost on ignition. Even the best grade of ore in its natural state seldom carries more than 10 per cent of manganese.

Method of Examination.—The field examination occupied the period from December 1 to 16, 1917. The work was somewhat impeded by very heavy snowfalls, but the experience obtained during the earlier investigation of the Canaan manganese bogs more than compensated for the loss of time due to the inclemency of the weather.

A complete survey of the area containing the deposits was made on a scale of 50 feet to 1 inch. This included the blocking-out of the area by means of a transit and chain into 100-foot squares on a single set of co-ordinates. The corners of the squares were numbered and lettered as shown on the map. A tie-line was also run, connecting the bog survey with the main road.

During the progress of the survey, the actual edges of the manganese deposits were determined by means of a pointed stake which was driven into the ground at intervals in advance of the chain. The nature of the material adhering to the stake on its withdrawal indicated whether or not it was driven into manganese ground. The boundaries thus determined are shown on the map.

A topographic map was made by means of a transit and rod, using a 5-foot contour interval. All buildings, trenches, excavations, springs, streams, and timberlines were located.

Holes were bored on the corners of the 100-foot squares, by means of a peat-auger, as shown on the map. In each case the holes were bored to the bottom of the bog, that is, until the hard sandy or clayey bottom was reached. At some corners, namely E 1, F 1, and G 1, peat-auger samples were not taken, as accurate samples were obtained from the trenches. At other corners, such as A 0, A 1, A 2, A 3, B 1, B 2, B 3, and E 4, the bog was bored, but no samples were taken because of the thinness of the ore streak. Such holes, therefore, are not included in the tonnage estimate.

A special boring-auger, with a cup or cylinder 18 inches instead of 6 inches in length, was made for this work in the shops of the Albert Manufacturing Company, of Hillsborough. The method of using this auger for sampling, and the determination of specific weights, together with a description of tonnage calculations are given in the Canaan report.(1)

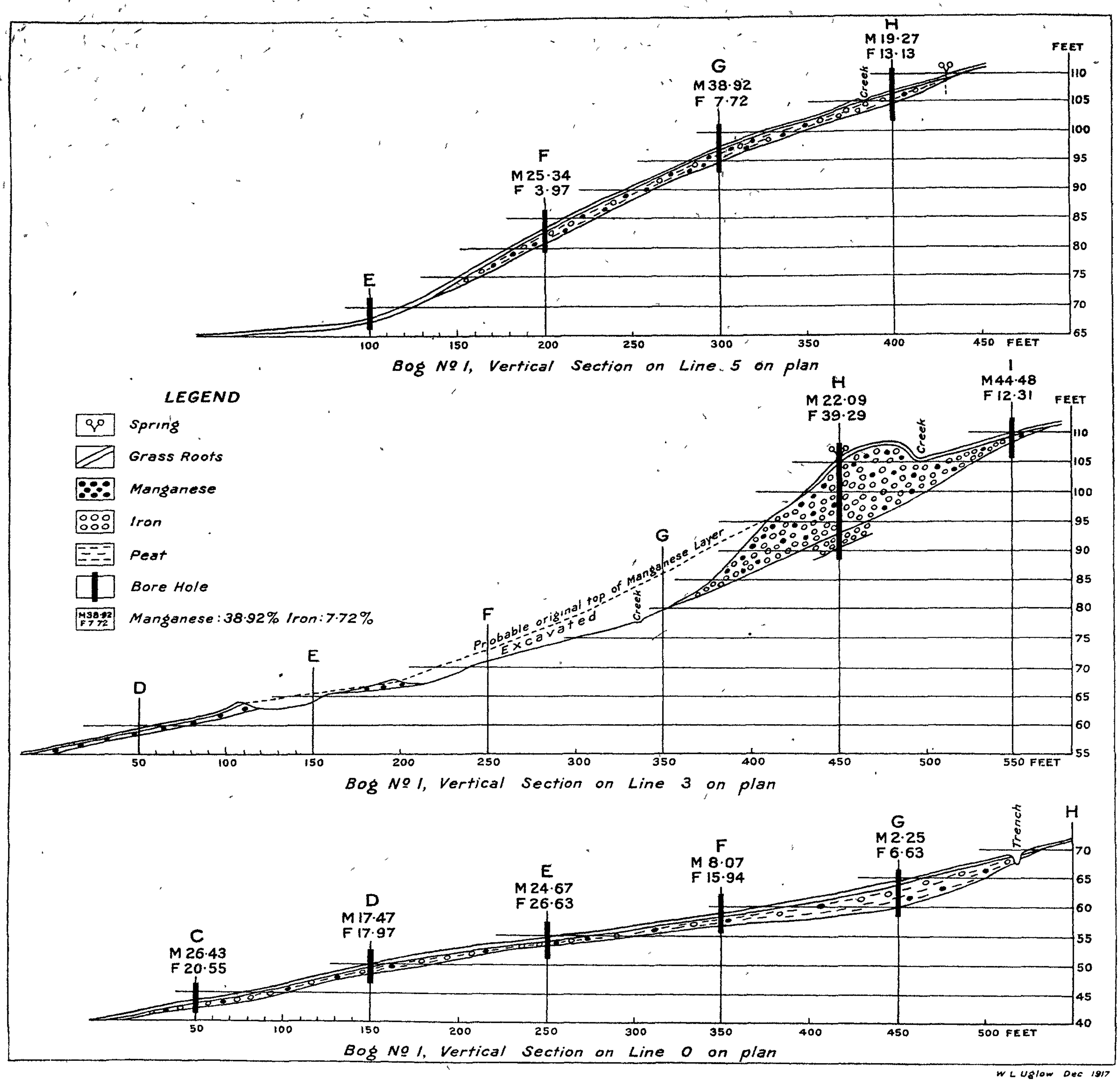
Bog No. 1.—This is the easterly of the two bogs and the only one mined between 1898 and 1900 by the Mineral Products Company. A large excavation was made by the company in the centre of the bog, and the ore taken from here for the manufacture of briquettes and ferro-manganese was trammed to the ore sheds and to the mill. The extent of this excavation is shown on the accompanying map and the section on line 3 (Plates XXVI and XXVII).

Relatively pure manganese dioxide, such as was found at Canaan, N.B., is rare at Dawson Settlement. As a general rule manganese and iron are considerably mixed. Peat is abundant in the deeper portions.

The bog comes to a peak in a small knoll about 50 feet south of H 4. No bore-hole was put down at this point, but it is presumed that it was near here that the maximum thickness of 25 to 30 feet of material was encountered during the boring operations of the Mineral Products Company.

The area of bog comprised within the outline of the sampled ground is 222,050 square feet. This area was bored by 18 holes, and sections exposed by 6 trenches. Data obtained from these holes and trenches give an average depth of 2·89 feet of ore over the whole bog.

(1) See p. 65.



Vertical sections on lines 0, 3, and 5 on plan, Bog Manganese deposits, Dawson Settlement, N.B.

The excavated area in the centre of the bog was not sampled or included in the bog area and tonnage estimates, because all ore had been removed by the Mineral Products Company.

Tonnage of Bog No. 1

Area contained within heavy boundary-line shown on map...222,050 sq. ft.
Number of holes.. 20
Total depth of all holes .... 57·82 ft.
Average depth of ore.................................... 2·89 ft.
Total of products of depths multiplied by specific weights.. 4,067
Average specific weight (4,067÷57·82)...................... 70·30 lb.

Hence, tonnage of crude wet ore = $\frac{220050 \times 2 \cdot 89 \times 70 \cdot 3}{2000}$ = 22,370 tons.

Average Assays of Bog No. 1

Bore-hole	Factor 'F'	Manganese		Iron		Moisture		Loss on Ignition	
		Per cent	Per cent × 'F'	Per cent	Per cent × 'F'	Per cent	Per cent × 'F'	Per cent	Per cent × 'F'
C 0	58	26·43	1,533	20·55	1,192	76·70	4,450	62·65	3,634
C 1	81	31·57	2,558	27·88	2,258	58·55	4,742	18·52	1,500
C 2	105	13·73	1,442	19·42	2,040	60·63	6,367	23·22	2,438
D 0	58	17·47	1,013	17·97	1,042	62·30	3,613	73·09	4,240
D 1	105	40·98	4,303	19·30	2,027	67·93	7,132	34·47	3,620
D 2	105	23·07	2,422	23·97	2,516	54·07	5,680	16·00	1,680
E 0	70	24·67	1,727	26·63	1,865	64·41	4,509	37·93	2.656
E 1	195	33·82	6,595	29·57	5,764	52·57	10,250	20·19	3,938
E 2	140	23·08	3,232	34·66	4,853	66·72	9,340	28·82	4,070
F 1	234	37·69	8,820	20·81	4,870	62·32	14,580	23·20	5,430
F 5	130	25·34	3,294	3·97	516	83·07	10,800	80·65	10,482
G 1	308	40·58	12,500	15·35	4,728	66·05	20,670	39·30	12,100
G 4	234	14·36	3,360	45·40	10,624	63·02	14,750	21·85	5,112
G 5	140	38·92	5,448	7·72	1,081	84·20	11,785	68·08	9,532
H 1	497	39·71	19,742	22·47	11,168	65·56	32,585	16·74	8,320
H 2	455	23·77	10,815	37·67	17,138	65·71	29,900	28·86	13,130
H 3	840	22·09	18,550	39·29	33,000	65·64	55,150	18·97	15,934
H 5	104	19·27	2,004	13·13	1,366	75·63	7,865	57·58	5,987
I 2	138	31·12	4,294	28·65	3,953	64·03	8,833	22·00	3,036
I 3	70	44·48	3,114	12·31	862	58·64	4,106	26·76	1,873
Totals...	4,067		116,766		112,863		267,107		118,712
Averages		28·71		27·75		65·68		29·19	

Bog No. 2.—This is the westerly and smaller of the two bogs. The ore in this deposit remains practically untouched, and has been partially drained by three old trenches. The ore is similar to that of bog No. 1; generally mixed with peat and some bog iron, but in places comparatively pure. Sections on lines 8 and 11 are shown on Plate XXVIII.

The deposit was tested by 19 bore-holes and 10 trenches which showed manganese ore varying in depth from 1½ to 8 feet, and averaging 3·04 feet. The total area, as shown by the shaded outline on the map (Plate XXVI), comprises about 258,000 square feet; while the area included in the tonnage estimate, as shown by the heavy outline, comprises 195,700 square feet.

Tonnage of Bog No. 2

Area contained within heavy boundary-line shown on map....195,700 sq. ft.
Number of holes.. 19
Total depth of all holes................................ 57·80 ft.
Average depth of ore.................................... 3·04 ft.
Total of products of depths multiplied by specific weights......3947·40
Average specific weight (3947·4 ÷ 57·8)....................... 68·30 lb.

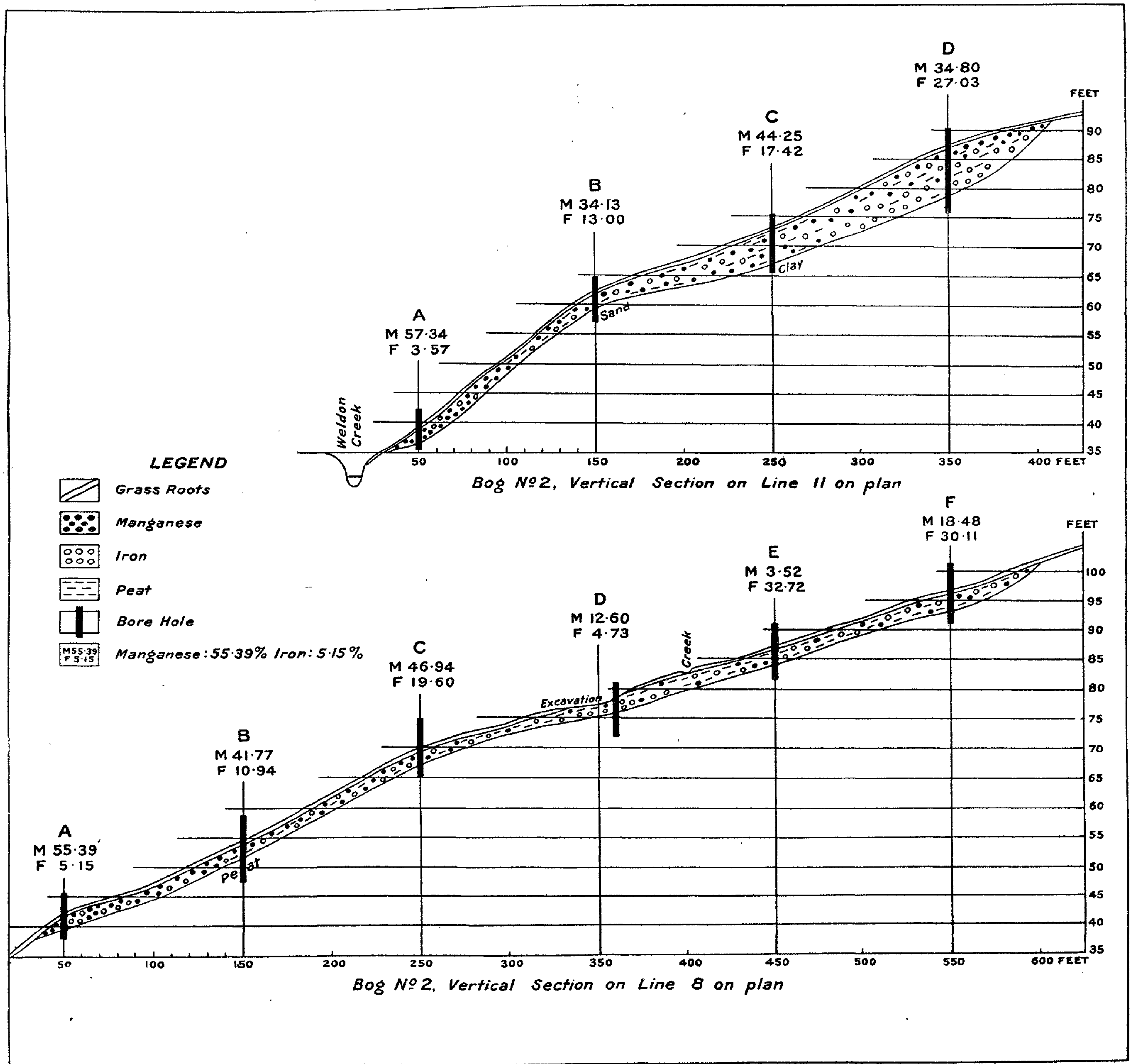
Hence, tonnage of crude wet ore $= \frac{195700 \times 3{\cdot}04 \times 68{\cdot}3}{2000} = 20{,}320$ tons

Average Assays of Bog No. 2

Bore-hole	Factor 'F'	Manganese		Iron		Moisture		Loss on ignition	
		Per cent	Per cent × 'F'	Per cent.	Per cent × 'F'	Per cent	Per cent × 'F'	Per cent	Per cent × 'F'
A 8	152·0	55·39	8,418	5·15	782	73·42	11,160	37·62	5,718
A 10	211·5	48·01	10,150	7·13	1,508	73·23	15,485	54·03	11,426
A 11	211·5	57·34	12,122	3·57	755	66·31	14,020	26·82	5,67[illegible]
B 7	140·0	53·63	7,506	12·15	1,701	61·06	8,547	16·09	2,25[illegible]
B 8	177·5	41·77	7,413	10·94	1,942	81·26	14,424	64·07	11,375
B 10	204·0	45·95	9,372	14·06	2,869	76·00	15,510	41·71	8,507
B 11	128·0	34·13	4,368	13·00	1,664	80·00	10,240	69·35	8,877
B 12	136·0	28·84	3,922	19·30	2,625	83·05	11,290	68·27	9,283
C 7	131·0	49·95	6,541	14·42	1,889	69·44	9,096	36·01	4,717
C 8	176·0	46·94	8,260	19·60	3,450	59·83	10,531	19·50	3,432
C 9	132·0	21·00	2,772	35·07	4,629	75·28	9,938	45·73	6,03[illegible]
C 10	390·5	55·83	21,800	10·67	4,168	75·10	29,328	26·28	10,26[illegible]
C 11	438·0	44·25	19,381	17·42	7,629	66·60	29,172	27·46	12,02[illegible]
C 12	204·0	35·60	7,260	7·27	1,483	82·81	16,895	59·61	12,16[illegible]
D 7	103·5	43·18	4,469	18·03	1,866	69·68	7,213	35·21	3,644
D 9	128·0	21·68	2,776	26·18	3,350	74·00	9,472	35·48	4,515
D 11	544·0	34·80	18,926	27·03	14,705	69·60	37,865	24·04	13,075
E 9	141·9	33·48	4,750	20·21	2 867	84·02	11,925	27·13	3,850
F 8	198·0	18·48	3,660	30·11	5,960	85·04	16,840	54·87	10,865
Totals...	3947·4		163,866		65,842		288,951		147,692
Averages		41·51		16·68		73·20		37·415	

Total Tonnage.—The total tonnage of crude wet ore contained in bogs Nos. 1 and 2, is, according to the estimates made, 42,690 tons.

Tonnage and Assays of Ore in Ore Sheds.—During the period of operations conducted by the Mineral Products Company the ore excavated was stock-piled in two ore sheds, each 100 feet long and 30 feet wide. It is probable that this ore has been in the sheds for at least 18 years, and at present the piles are from 6 to 10 feet in height. The roofs of the sheds are now in bad repair and any additional moisture which this ore may have absorbed has come from leakage through the roofs and walls.



Vertical sections on lines 8 and 11 on plan, Bog Manganese deposits, Dawson Settlement, N.B.

The average moisture content is about 69·5 per cent in the crude state in the ground, and about 56·7 per cent in the sheds; therefore, the crude ore has lost only 18·4 per cent of its moisture by drainage and evaporation during a period of 18 years. This gives some idea of what could be accomplished in the matter of de-watering the ore in the ground by a series of drains.

Ore Shed A.

Area of ore in shed (30×100)	3,000	sq. ft.
Average depth of ore	3·116	ft.
Volume of ore	10,350	cu. ft.
Specific weight of ore	52·00	lb.
Tonnage of ore $\frac{(10350\times52\cdot0)}{2000}$	269·10	tons
Average assay of ore: Manganese	28·86	per cent
Iron	26·30	"
Moisture	55·28	"
Loss on ignition	24·94	"

269·1 tons undried ore produce [269·1×(1·0−0·5528)]	120·30	tons dry ore
120·3 tons dry ore produce [120·3×(1·0−0·2494)]	90·30	tons ignited ore
Content of manganese (90·3×0·2886)	26·06	tons
" iron (90·3×0·2630)	23·75	"
Manganese in undried ore (26·06÷269·1×100)	9·68	per cent
" dry ore (26·06÷120·3×100)	21·66	"
Iron in undried ore (23·75÷269·1×100)	8·83	"
" dry ore (23·75÷120·3×100)	19·74	"

Ore Shed B

Area of ore in shed (30×100)	3,000	sq. ft.
Average depth of ore	6·8	ft.
Volume of ore	20,400	cu. ft.
Specific weight of ore	57·0	lb.
Tonnage of ore $\frac{(20400\times57\cdot0)}{2000}$	581·4	tons
Average assay of ore: Manganese	37·76	per cent
Iron	22·27	"
Moisture	58·24	"
Loss on ignition	21·14	"

581·4 tons undried ore produce [581·4×(1·0−0·5824)	242·80	tons dry ore
242·8 tons dry ore produce [242·8×(1·0−0·2114)]	191·50	tons ignited ore
Content of manganese (191·5×0·3776)	72·30	tons
" iron (191·5×0·2227)	42·60	"
Manganese in undried ore (72·3−581·4×100)	12·44	per cent
" dry ore (72·3−242·8×100)	29·78	"
Iron in undried ore (42·6−581·4×100)	7·33	"
" dry ore (42·6−242·8×100)	17·55	"

Briquettes.—A pile of manganese-ore briquettes, which were made in the briquetting machine at Dawson Settlement, is still lying under cover at the plant. It was estimated that there are about 11 tons of these briquettes. The forms are cylindrical, 2·5 inches in height, with a diameter of 2·8 inches.

Calculations based on one briquette selected at random gave the following data:

Volume	0·00955 cu. ft.
Weight	0·609 lb.
Specific weight	63·8 lb.

As placed end on end in the pile with their sides in contact, the rectangular block which would enclose them contains 21·48 per cent of vacant space.

A moisture determination made on the selected briquette showed 15·35 per cent. This indicates a loss of moisture of about 78 per cent due to the pressing and to later evaporation.

Ore Summary.—In order to obtain figures for the average assays of the wet, dry, and ignited ores from the bogs and the ore sheds taken together, the figures for wet, dry, and ignited-ore assays from each bog and ore shed are weighted by multiplying them by the figures for their corresponding tonnages. These weighted results or 'products' are added together for each kind of ore and divided by the figure for the total tonnage of the corresponding kind of ore. The dividends in each case represent the average assays of the total available ore.[1]

For example, the column headed 'Mn. product' under 'Wet ore' consists of the product of the figures for tonnage multiplied by the figures for per cent of manganese.

In this connection it is interesting to note the discrepancy between these results and the figures quoted by T. C. Denis,[2] which are given herewith:

Area of manganese ground	17 acres, or 740,700 sq. ft.
Average depth or ore	6 ft. 7¾ in.
Specific weight	1,900 lb. per cu. yd., or 70·4 lb. per cu. ft.
Tonnage	175,000 tons.

Plant and Equipment.—At the time of its operations, the Mineral Products Company installed a plant (Plate XXIX) for briquetting the crude ore and for smelting to ferro-manganese, built tramways connecting the bogs with the ore sheds and the smelter, and mined a few thousand tons of ore. At the present time the tramways are completely wrecked, but parts of the mechanical equipment are still in fair condition.

The plant was equipped with one Penfield briquetting-machine (foundation now destroyed); one 80-horsepower boiler (not in good condition); one high-speed Leonard Ball automatic engine of 75-horsepower; one blast furnace (5 to 10 tons daily capacity); one Green's No. 5A rotary pressure-blower; one revolving screen, 8 ft. long; one elevator hoist; and one Gummer drier.

(1) See table on p. 87.
(2) Mines Branch, Department of Mines, Summary Report for 1909, p. 61.

Old briquetting and smelting plant.
Bog Manganese deposit, Dawson Settlement, N.B.

Ore Summary

Location	Crude Wet Ore					Dry Ore					Ignited Ore				
	Tons	Mn per cent	Mn product	Fe per cent	Fe product	Tons	Mn per cent	Mn product	Fe per cent	Fe product	Tons	Mn per cent	Mn product	Fe per cent	Fe product
Bog No. 1..	22,370	6·98	156,143	6·74	150,774	7677	20·33	156,073	19·65	150,853	5436	28·71	156,068	27·75	150,859
Bog No. 2..	20,320	6·96	141,427	2·80	56,896	5446	25·98	141,487	10·44	56,856	3408	41·51	141,466	16·68	56,845
Ore Shed A..	269·1	9·68	2,605	8·83	2,376	120·3	21·66	2,606	19·74	2,376	90·3	28·86	2,606	26·30	2,375
Ore Shed B..	581·4	12·44	7,233	7·33	4,262	242·8	29·78	7,231	17·55	4,261	191·5	37·76	7,231	22·27	4,265
Totals......	43,540·5		307,408		214,308	13,486·1		307,397		214,346	9125·8		307,371		214,334
Averages....		7·06		4·92			22·79		15·89			33·68		23·49	
Briquettes...	11·0														

Physical Characteristics of the Deposits which would affect the Mining of the Ore.—The bogs have well-defined, hard, compact foot-walls, from which in most cases the material can be readily separated by shovelling or scraping. Care should be taken to avoid the inclusion of any of the foot-wall material with the ore, on account of its high content of silica.

As a general rule, the grass and tree roots lie *upon* the manganese layer and are not embedded *in* it. This facilitates the stripping of the deposits.

No boulders or pebbles have been found within the manganiferous zones.

Wherever the manganese dioxide occurs in relatively pure beds, it can be readily separated from the underlying peat by shovelling.

The deposits have average gradients of 9 and 14 per cent which give sufficient slopes for drainage purposes.

Manganese Mines, Colchester County, Nova Scotia.

By W. L. UGLOW

Location.—The property known as 'Manganese Mines' is located in Colchester county, Nova Scotia, about 9 miles northeast of Truro. It is about 3 miles north of Valley station on the Truro-New Glasgow division of the Canadian Government railways.

Ownership.—The land on which the mining property is located is owned by Mr. J. R. Fraser. The mining rights of the land are owned by Mr. P. G. Archibald and are now under lease to Mr. Ralph P. Bell, Chronicle Building, Halifax. This lease is for three years, two of which are still to run.

Topography.—The surrounding country is good farm land, well cleared and gently rolling.

Geology.—The rocks in the vicinity are covered with drift from 2 to 6 feet thick, and only on the side of a nearby valley are the formations at all exposed. These consist of a reddish sandstone, a reddish-brown shale, and a bed of reddish brecciated limestone. The strata dip at angles up to 60°, but the strike was not ascertained.

Mineralogy.—The ore consists of a mixture of pyrolusite, psilomelane, and some manganite. The pyrolusite is of the coarsely radiated type, while the psilomelane is chiefly fine-grained to dense compact. Manganite occurs sparingly, also some rhodochrosite.

Occurrence of Ore.—Ore in place was not seen by the writer, but from information gained during discussions with a few men who helped to open up the prospect, and from a perusal of a recent report on the property, it seems certain that the ore occurs as a replacement in the sandstone horizon at its contact with the shale.

According to the best information which could be obtained, the ore is in bunches and lenses, fairly pure in the centre but grading into sandstone at the edges. These individual lenses are reported to be not more than 1 foot in width, and of varying and irregular extent.

Development.—The chief work done on the property consists of a shaft which is vertical for the first ten feet and then continues as an incline on the foot-wall of the ore body at an angle of 25°. The incline was stopped about 16 years ago, at an inclined depth of 20 feet. Both incline and vertical shaft are now full of water.

A small open-cut, now caved-in, was seen along the supposed strike of the ore horizon at a distance of about 600 feet from the shaft. No ore was visible on the small dump at this place.

On the side of the above-mentioned valley, about 1,200 feet from the shaft, there is said to be an exposure of the same ore horizon showing a few thin stringers of manganese minerals. A mantle of snow and ice prevented an examination of this locality.

Shipments.—In 1890 a shipment of ore was made from the shaft and is reported to have been sold for $500. The weight of this shipment could not be ascertained.

In 1917 six barrels of ore, weighing about 1,000 pounds apiece were shipped to the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa, for examination. This ore was obtained from the old dump which had been lying at the collar of the shaft since 1890. It was crushed, washed, and hand-picked before shipping.

Analyses.—Two samples were taken at Ottawa from the six barrels. The average of the two analyses is as follows:

Moisture	5·81
Manganese	47·94
Iron	0·90
Silica	15·77
Phosphorus	0·027
Sulphur	0·017

Available Tonnage.—There is practically no immediate tonnage of manganese ore available. A small dump of ½-inch to 1-inch material, weighing possibly 1,000 pounds, is still lying outside the picking shed. It has not been cleaned, but might assay 30 per cent manganese.

Conclusion.—Whether or not the property merits further exploration could not be determined without an underground examination. With the exception of the fact that upwards of 3 tons (perhaps even 7 or 8 tons) of ore have been taken out of the incline, there appeared to be no feature sufficiently encouraging to warrant the expenditure of such a sum of money as would be required for exploration purposes.

Cowichan Manganese, Vancouver Island, British Columbia.

By GEO. C. MACKENZIE.

Location.—These manganese deposits are situated in the Victoria mining division on Vancouver island, British Columbia, near the summit of the divide between the Chemainus and Cowichan rivers. They extend for a distance of over 25 miles in a northwesterly direction on the north side of Cowichan lake. The claims at the southeast end of the lake are situated about one mile from, and approximately 2,000 feet above, the Cowichan Lake branch of the Esquimalt and Nanaimo railway. Other claims are situated at a point about halfway along the north shore of the lake and still others 7 miles north of the north end of the lake and from 5 to 7 miles from the right of way of the Canadian Government railway.

Ownership.—Twelve manganese claims, comprising 480 acres, have been staked and recorded by Mr. C. H. Dickie and associates, of Duncan, B. C. The ground on which the claims lie is the property of the Esquimalt and Nanaimo railway and the Empire Lumber Company of Philadelphia, Pa. The railway company requires a royalty of 1 cent per unit of metallic manganese on each ton of ore shipped, whereas the lumber company demands 10 per cent of the net value of ore shipments.

Topography.—The surrounding country is rugged and hilly, many of the hills rising abruptly to over 3,000 feet above sea-level. The country is heavily wooded with magnificent timber, chiefly fir, spruce, and hemlock.

Geology.—The geology of the district has been described by Messrs. C. H. Clapp and J. A. Allan.(1) The manganese deposits are apparently associated with the sedimentary quartzite rocks of the Sicker series, and at the east end of the lake are found near the contact of the Sicker series and Cowichan group.

Mineralogy.—Manganese ore of merchantable value is found as a mixture of secondary oxides, principally pyrolusite, psilomelane, and manganite, derived from the alteration of rhodonite, the silicate of manganese, which occurs in strong outcrops throughout the manganiferous area. A sample of highly oxidized ore examined by Mr. F. G. Wait, of the Mines Branch, was found to contain 2·5 per cent of water. The silicate, rhodonite, from which the oxide has been derived, occurs in dense, hard, massive form, ranging in colour from white through various shades of gray to a deep pink, and in places is so intermixed with the oxides as to render doubtful the economic value of such ore. On the Hill 60 claim oxidation of the silicate has taken place on a considerable larger scale than on some of the other claims, resulting in outcrops of hard and massive oxides containing from 15 to 57 per cent metallic manganese. On the Black Prince claim at the northwest end of the lake, the oxides and silicates are more thoroughly intermixed, possessing a more or less banded structure and generally

(1) Geol. Surv. Can., Memoir 13, 1912.

containing less than 40 per cent metallic manganese. The carbonate of manganese, rhodochrosite, probably present, was not actually determined.

Hill 60 Group.—This group, consisting of three claims with a total area of 120 acres, is situated on the crest of a hill 4 miles east of the village of Cowichan Lake, about 2000 feet above, and 1 mile north of, the Esquimalt and Nanaimo railway. The nearest shipping point on the east coast is Ladysmith, distant about 40 miles by rail from the claims.

The ore outcrops for a distance of over 100 feet along the crest of the hill with a strike of S. 80° W. (magnetic) and a dip of approximately 70° to the southeast (Plate XXX). Both dip and strike of the ore conform with the bedding of the country rock. An overlying mantle of talus, loose earth, and moss has been removed, exposing the secondary oxides over an area of 1,250 square feet. The ore consists mainly of a mixture of hard, compact oxides of manganese, grading from highly siliceous material along the walls, containing less than 40 per cent metallic manganese, to a relatively pure oxide at the centre of the ore body, containing over 48 per cent of metallic manganese. This central portion of highly-oxidized ore may possibly have a width of 21 feet but is naturally very irregular in outline.

At the time of my inspections no rock excavation had been made and therefore samples could only be taken from the surface. The assays of these samples are shown in the attached table,(1) together with foot-percentage averages calculated from the sections accompanying the plan (Plate XXXI).

The outcrop can be traced for a distance of over 1000 feet both east and west of the discovery post of the Hill 60 claim, and is clearly defined on the side of a steep cliff bordering a gully at the westerly end of the claim some 200 feet below the discovery post. No work has been done at this point and, therefore, although oxidized ore is strongly in evidence on the side of the cliff, no idea can be formed of the persistence of the oxides below the surface until the owners have done some development work.

In a letter to the writer, dated June 13, 1919, Mr. Wm. M. Brewer, Resident Engineer, Western Mineral Survey District, states that on June 7, 1919, he made a further examination of the Hill 60 manganese deposit and reports as follows:

> The Provincial Government, on my recommendation, is assisting the owners to build a wagon road and the work is progressing very satisfactorily. In the meantime Mr. Dickie and his partners have done some more development work. This consists of a cross-cut trench on the easterly side of the fault-line marked on your plan, and about the line of your sampling in August, 1918, as shown on plan.
>
> The trench or open-cut is made as a cross-cut. It is a continuation of the cut made in the fall of 1918, but started 7 feet above the floor of the old cut. It is about 9 feet long by 5 feet wide, in good manganese all the way. The face is still in manganese of apparently as good grade as your samples, Nos. 3 to 7. The face of the new cut is about 9 feet high and the top of it about 16 feet above the floor of the old cut.
>
> The ore on the dump taken from this new cut shows an average of 51 per cent manganese, with lower silica content than your samples, according to an assay certificate shown me by Mr. Dickie. This assay was made by the Tacoma company to whom Mr. Dickie is to ship ore at the rate of about 100 tons per week, he informs me. From the results of this new work I should judge there are about 3,000 or 4,000 tons in the deposit available for immediate shipment, above the floor of the old cut.
>
> The deposit looks as if it might develop into a larger ore body than any of us figured last year. They are starting to mine with power-drill as soon as they can haul the machinery over the new road which should be finished in about thirty days.

(1) See table facing p. 94.

The development work so far accomplished does not afford sufficient data on which to base a reliable tonnage estimate, but if good merchantable ore containing over 48 per cent manganese is assumed to continue for 10 feet in depth with a surface area of 100 by 12 feet, the amount of *probable* ore can be set down as 1,200 gross tons, assuming 10 cubic feet to the gross ton. The ore is of ideal physical structure for furnace purposes and will stand transportation without crumbling.

The deposit is so situated on the hillside that development by means of adits would prove the ore body with moderate expenditure. During the development stage it will be necessary to construct a wagon road from the Hill 60 claim to the main wagon road running between Duncan and Cowichan Lake. This road need not be longer than four miles, and to facilitate transportation of mine supplies, should be constructed on a grade not exceeding 10 per cent. After the property has reached the production stage and some considerable tonnage of the ore is proved, the installation of a gravity rope-tramway will permit delivery of the ore to the railroad at a cost of approximately 50 cents per gross ton.

It is impossible to forecast the cost of mining, with any degree of accuracy, until some considerable tonnage of ore has been developed; but if we assume favorable mine conditions, such as ample stoping widths, no hoisting, and the production of 48 per cent manganese ore without the necessity of much sorting, the cost at the tramway head during the production stage should not exceed $4 per gross ton. Delivery on board cars at the railway siding by rope tramway is estimated at 50 cents per gross ton. Freight charges from the mine siding to Ladysmith and Vancouver, respectively, have been quoted by the Canadian Pacific Railway at $1 and $1.50 per net ton. Therefore, the total cost of the ore delivered at tide-water may be roughly estimated at from $5.65 to $6.25 per gross ton delivered at Ladysmith or Vancouver.

Cottonwood Group.—These three claims are situated near the head-waters of Cottonwood creek which enters Cowichan lake about half-way along its north shore. They comprise 120 acres on which the manganese zone has been prospected to some small extent but no development work accomplished. These claims were not examined, but it is understood that while possessing potential value the outcrops of ore are not as good as those on the Hill 60 group.

Black Prince Group.—This group, covering an area of 240 acres, consists of six claims situated about 7 miles north of the northwest end of Cowichan lake, near the headwaters of Shaw creek. They are of secondary importance as compared with the Hill 60 group, but are considered to be more valuable than the Cottonwood group. A little prospecting work has been done, disclosing a number of outcrops of manganiferous ore banded with quartzites of the Sicker series. The oxides of manganese are of the same chemical and physical character as at Hill 60, and although up to the

Cowichan manganese, Vancouver island, B.C.
Outcrop on Hill 60 claim.

present no large body of clean oxide has been uncovered, it is well within the range of possibility that careful prospecting will establish its presence.

The principal outcrops of banded ore on the Black Prince claim strike N.23° W. (magnetic) with a dip of about 30° to the southwest, although this fact could not be established definitely. They can be traced along the strike for a distance of several hundred feet where the absence of vegetation allows the formations to be seen.

The outcrop was sampled for 47 feet across its width, the results of analyses by the Mines Branch, Department of Mines, Ottawa, being as follows:

Analyses of Black Prince Manganese Ore

Sample No.	Width feet	Manganese per cent	Iron per cent	Silica per cent	Phosphorus per cent	Sulphur per cent
1	5·75	22·9	1·03	57·24	0·031	0·148
2	8·75	28·1	1·08	49·40	0·029	0·132
3	8·75	27·0	0·86	51·86	0·029	0·162
4	8·75	35·6	1·14	37·36	0·031	0·206
5	8·75	40·8	0·80	30·18	0·029	0·140

Representative samples consisting of 430 pounds of siliceous banded manganese ore were forwarded to the Ore Dressing Laboratories of the Mines Branch, Department of Mines, at Ottawa, in order to ascertain the possibility of milling this material for the production of high-grade manganese concentrates. The milling test described in the following report by Mr. W. B. Timm, indicates that very little success will be attained by ordinary specific-gravity methods of concentration. Evidently the silica is so intimately associated with the oxides of manganese that it is not freed within the limits of commercial crushing.

ORE DRESSING AND METALLURGICAL LABORATORIES,
MINES BRANCH, DEPARTMENT OF MINES

OTTAWA, February 5, 1919.

A shipment of 430 pounds of manganese ore in two lots was received October 22, 1918, from Cowichan lake, Vancouver Island, B.C.

Lot No. 1 consisted of three sacks from the Black Prince claim and gave the following analysis:

Manganese (metallic)	22·09
Iron (metallic)	3·22
Silica	58·16
Phosphorus	0·061
Sulphur	0·165

Lot No. 2 consisted of one sack from the Pacific claim, and gave the following analysis:

Manganese (metallic)	15·66
Iron (metallic)	6·39
Silica	66·92
Phosphorus	0·089
Sulphur	0·166

Concentration tests by jigging and tabling were made on these two lots to determine whether the ore could be treated successfully in this manner.

Each lot was crushed to pass 3 mesh or to ¼-inch size, and sized on 6, 12, 20, and 30 mesh screens. The sizes coarser than 30 mesh were jigged, while the sizes through 30 mesh were tabled.

The weights and assays of the resulting products were as follows:

Lot No. 1

Mesh	Product	Weight	Manganese	Iron
		lb.	per cent	per cent
− 3+6	Jig concentrates	17·5	37·60	2·68
− 3+6	Jig tailings	106·0	19·40	2·50
− 6+12	Jig concentrates	12·0	32·54	2·40
− 6+12	Jig tailings	57·0	19·44	2·50
−12+20	Jig concentrates	7·0	25·07	1·70
−12+20	Jig tailings	17·5	21·70	1·70
−20+30	Jig concentrates	7·0	24·63	0·74
−20+30	Jig tailings	7·5	23·30	0·79
−30	Table concentrates	4·5	37·45	1·00
−30	Table tailings	24·0	19·78	0·70

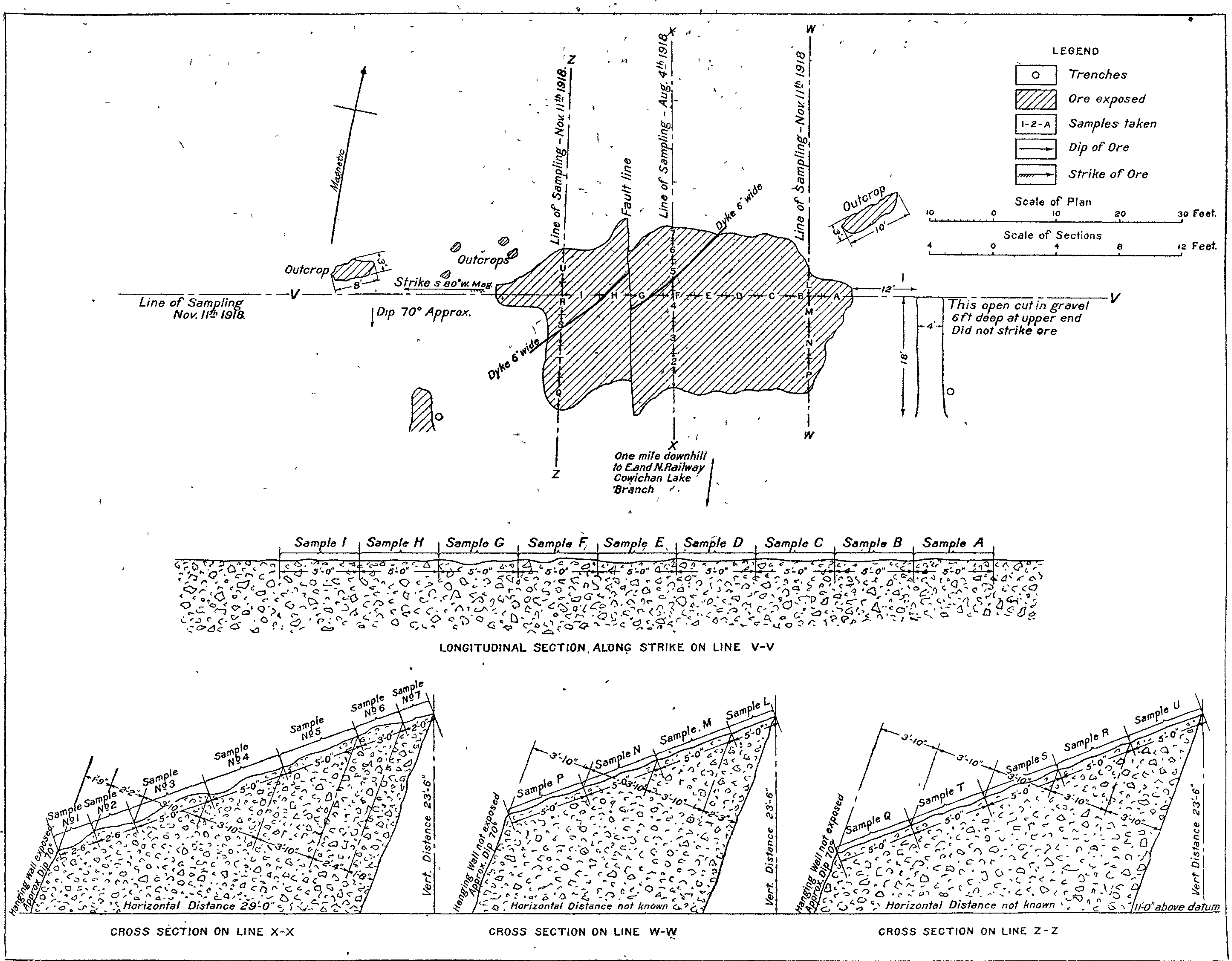
Lot No. 2

Mesh	Product	Weight	Manganese	Iron
		lb.	per cent	per cent
− 3+6	Jig concentrates	7·5	26·65	4·25
− 3+6	Jig tailings	34·5	12·30	4·20
− 6+12	Jig concentrates	2·5	25·33	3·40
− 6+12	Jig tailings	14·5	12·87	3·52
−12+20	Jig concentrates	2·0	20·84	2·70
−12+20	Jig tailings	3·5	11·59	2·85
−20+30	Jig concentrates	0·5	16·65	1·25
−20+30	Jig tailings	2·5	16·31	1·50
−30	Table concentrates	0·5	32·12	2·65
−30	Table tailings	4·0	14·87	1·40

Conclusions.—The above results show conclusively that the ore cannot be concentrated by specific-gravity methods using jigs and tables. A partial separation was made, but the ratio of concentration was very low in most cases, and the percentage of manganese in both concentrates and tailings unsatisfactory.

(*Sgd.*) W. B. TIMM.

Commercial Possibilities.—High grade ferro-manganese, silicon-manganese, and spiegeleisen can all be produced from the manganese ores of this district. Ferro-manganese of 70 to 80 per cent manganese will require ores containing not less than 48 per cent of that metal and not over 15 per cent of silica. Ores containing less manganese and more silica constitute ideal raw material for the manufacture of silicon-manganese, while the lowest grades of ores are suitable only for the production of spiegeleisen containing less than 30 per cent of manganese. The manufacture of these alloys in British Columbia by either blast-furnace or electric-furnace methods is contingent upon several factors which are described in the report which follows.



Plan and sections of Hill 60 claim, Cowichan Lake manganese, showing location of samples.

Analyses of Cowichan Manganese Ore

(Made by Ore Dressing and Metallurgical Laboratories, Mines Branch, Department of Mines, Ottawa)

Sample No.	Section	Width of samples, feet	Metallic manganese		Silica		Metallic iron		Phosphorus		Sulphur		Lime		Alumina	
			Per cent	Foot per cent	Per cent	Foot per cent	Per cent	Foot per cent	Per cent	Foot per cent	Per cent	Foot per cent	Per cent	Foot per cent	Per cent	Foot per cent
1	X—X	1·75	15·88	27·79	62·84	109·97	2·82	4·93	0·048	0·084	0·073	0·127				
2	"	2·16	23·15	50·00	49·60	107·13	2·80	6·04	0·046	0·099	0·058	0·125				
3	"	3·83	52·25	200·11	13·12	50·24	0·84	3·21	0·058	0·222	0·056	0·214				
4	"	3·83	57·15	218·88	10·04	38·45	0·87	3·33	0·047	0·180	0·085	0·325				
5	"	3·83	52·20	199·92	16·88	64·65	0·90	3·44	0·041	0·157	0·167	0·639				
6	"	2·33	53·50	124·65	16·92	39·42	1·17	2·72	0·041	0·095	0·107	0·249				
7	"	1·66	45·90	76·19	25·66	42·59	1·83	3·03	0·048	0·079	0·122	0·202				
A	V—V	5·00	41·64	208·20	23·32	116·60	0·99	4·95	0·080	0·400	0·080	0·400	0·05	0·25	1·10	5·50
B	"	5·00	32·90	164·50	41·60	208·00	1·50	7·50	0·077	0·385	0·110	0·550	1·20	6·00	0·58	2·90
C	"	5·00	46·12	230·60	23·05	115·25	0·89	4·45	0·051	0·255	0·074	0·370	0·05	0·25	1·02	5·10
D	"	5·00	38·55	192·75	24·18	120·90	1·01	5·05	0·059	0·295	0·103	0·515	0·08	0·40	0·67	3·35
E	"	5·00	43·18	215·90	30·19	150·95	1·50	7·50	0·073	0·365	0·095	0·475	0·98	4·90	0·58	2·90
F	"	5·00	48·59	242·95	21·60	108·00	1·24	6·20	0·053	0·265	0·090	0·450	0·80	4·00	0·50	2·50
G	"	5·00	46·79	233·95	18·20	91·00	1·68	8·40	0·081	0·408	0·070	0·350	0·70	3·50	1·08	5·40
H	"	5·00	50·32	251·60	14·56	72·80	1·52	7·60	0·057	0·287	0·085	0·425	0·23	0·15	0·96	4·80
I	"	5·00	48·20	241·00	15·50	77·50	1·38	6·90	0·060	0·300	0·100	0·500	1·60	8·00	1·80	9·00
L	W—W	2·25	48·00	108·00	21·70	48·82	2·80	6·30	0·066	0·148	0·090	0·202	0·70	1·57	0·87	1·95
M	"	3·83	43·35	166·03	24·80	94·98	1·14	4·36	0·075	0·287	0·068	0·260	Trace	....	0·58	2·22
N	"	3·83	53·37	204·40	6·00	22·98	1·00	3·83	0·075	0·287	0·072	0·275	0·60	2·29	0·82	3·14
P	"	3·83	55·46	212·41	8·40	32·17	1·48	5·66	0·061	0·233	0·082	0·314	0·70	2·68	1·17	4·48
Q	Z—Z	3·83	21·82	83·57	53·50	204·90	2·28	8·73	0·037	0·141	0·140	0·536	0·90	3·44	2·38	9·11
R	"	3·83	46·50	178·09	18·90	72·38	2·10	8·04	0·056	0·214	0·170	0·651	1·00	3·83	0·56	2·14
S	"	3·83	51·80	198·39	10·65	40·78	1·78	6·81	0·070	0·268	0·160	0·612	1·40	5·36	0·69	2·64
T	"	3·83	25·30	96·89	29·35	112·41	3·07	11·75	0·070	0·268	0·103	0·394	2·00	7·66	2·13	8·15
U	"	3·83	34·68	132·82	32·00	122·56	2·62	10·03	0·133	0·509	0·176	0·674	1·30	4·97	1·12	4·28
Averages		3·89		43·78		23·28		1·549		0·064		0·101		0·77		1·02

Possibilities for Manufacturing Ferro-manganese in Canada

By GEO. C. MACKENZIE

Ferro-manganese was probably the first of all the ferro-alloys to be manufactured on the commercial scale. Containing from 75 to 85 per cent of metallic manganese, less than 5 per cent carbon, a small amount of silicon and the balance iron, its production requires the use of ores rich in manganese and low in both silica and iron. The first production recorded was made in crucibles, which quickly gave place to the practice of manufacturing in blast furnaces; and latterly the electric furnace has been used with considerable success wherever electric power could be developed cheaply.

Neither Canada nor the United States has so far developed a substantial tonnage of high-grade manganese ores, suitable for the manufacture of this alloy. Both countries possess some quantity of low-grade ores that are useful for the production of spiegeleisen, of lower manganese content, although this alloy is not so desirable from the steel-makers' point of view.

The consumption of ferro-manganese in Canada for steel production alone during the past three or four years was in excess of 1,000 tons monthly, all of which had to be imported at considerable cost and difficulty from Great Britain and the United States, at prices ranging from $200 to over $300 per gross ton. This situation was complicated further by the fact that both the British and American high-grade alloys had to be manufactured from Brazilian and East Indian ores, the Russian ores being entirely off the market.

With the termination of hostilities in November, 1918, the demand for munition steel was considerably lessened, thereby relieving, to some extent, the pressing requirements for ferro-manganese for this purpose. This relief will probably be of short duration because the production of merchant steel must be accelerated to replace the destructive waste of war, and at the same time overtake the shortage of steel throughout the world. It may, therefore, be assumed that considerable time will elapse before large movements of Brazilian and Indian ore can take place owing to lack of shipping space. Russian ore will again be available only when normal conditions are restored in that unhappy country, and, therefore, this cheap ore will in all probability not be available for some years to come.

At the present time there is no production of ferro-manganese in Canada, although the Algoma Steel Corporation, Limited, at Sault Ste. Marie, Ont., continues to manufacture spiegeleisen in blast furnaces, and the Electro Metals, Limited, of Welland, Ont., have commenced the production of silicon-manganese in electric furnaces.

By far the largest production of ferro-manganese in both Great Britain and the United States is made in blast furnaces which are operated slowly and at high temperature in order to reduce the oxide of manganese as completely as possible. This method of manufacture, from a strictly metallurgical standpoint, is wasteful of both manganese and fuel. Not more than 80 per cent of the available manganese is recovered, and as the process of reduction requires slow driving the fuel consumption is always high. The electric furnace, operating at much higher temperature and requiring no air for combustion, offers less opportunity for the manganese to escape reduction, and under good operating conditions less than 10 per cent is lost. Carbon is only employed for the chemical reduction of the oxide, which means a saving of over 60 per cent of the fuel requirements of the blast furnace. These economies in fuel and manganese are, however, offset considerably by the expense of supplying the necessary electricity and also by the limited scale of electric-furnace operations.

One gross ton of ferro-manganese requires the expenditure of from four to eight thousand kilowatt hours, depending upon the grade of manganese ore, the type and size of furnace, and the skill of the furnace operators. At this rate of power consumption the electric furnace could not compete with the blast furnace under pre-war conditions when good fuel was abundant and cheap and the ferro-manganese brought only from $40 to $70 per ton. Whether these conditions will ever obtain again is uncertain. It is also uncertain that the market price of ferro-manganese will fall below $100 per ton for some time to come and as long as this price obtains and electricity can be secured for at least one-quarter of a cent per kilowatt hour, the electric furnace will continue to be a serious competitor of the blast furnace.

Because of the shortage in supplies of ferro-manganese, the Commission undertook an investigation in the fall of 1917 to ascertain what could be accomplished in the manufacture of ferro-manganese in Canada from domestic manganese ores.

After a careful examination of all the important localities in New Brunswick and Nova Scotia where manganese ores were known to occur, it became evident that there would be very little prospect of securing an adequate supply of ore for metallurgical purposes. There is a small production of high-grade manganese ores from certain localities in the Maritime Provinces, but this production is sporadic and does not amount to more than a few hundred tons annually. At the time the Commission started its investigation there was absolutely no production of metallurgical ore in Canada. It was evident, therefore, that if ferro-manganese was to be produced from domestic ores it would have to be accomplished by concentration of certain lean or low-grade ores that were known to occur in various localities.

In order to show what could be accomplished in this direction, the Commission secured a carload of low-grade ore from the waste dumps of the Rossville Manganese Company, Limited, at New Ross, and also a carload of low-grade run-of-mine ore from the Chisholm mine in Hants county, both in Nova Scotia. These carloads were shipped to Ottawa and concentrated in the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines.

The New Ross ore yielded concentrates containing from 28 to 40 per cent manganese and from 15 to 27 per cent iron. The silica content varied between 4 and 20 per cent. The carload of run-of-mine ore from the Chisholm mine yielded various grades of concentrates containing from 36 to 51 per cent manganese, and from 4 to 13 per cent iron; the silica in these products ranging from 9 to 26 per cent. Samples of the best quality of concentrates were submitted to the Imperial Munitions Board with the suggestion that experiments be carried out at the plant of the British Forgings, Limited, Toronto, to ascertain if ferro-manganese could be produced therefrom. The Imperial Munitions Board was advised by its experts in Toronto that these concentrates could not be used as their pulverulent condition would lead to serious furnace trouble causing a heavy loss in manganese and rendering uneconomic the reduction to metallic ferro-manganese.

Notwithstanding this discouragement, negotiations were entered into with Mr. R. Turnbull, of Welland, who offered facilities at the plant of the Electro Foundries, Limited, Orillia, and accordingly 6 tons of these concentrates were shipped to Orillia to be smelted experimentally. In order that the Orillia experiments should make a good start and that the furnace operators might become familiar with the electric smelting of manganese ore before the reduction of the fine concentrate was attempted, 2½ tons of metallurgical coarse ore from the old manganese mines in the vicinity of Truro, N.S., were secured and shipped to Orillia at the same time as the concentrates.

The furnace used in the experiments was of the same type employed for the production of ferro-molybdenum, but the electric energy supplied to the furnace was reduced to the low pressure of from 30 to 35 volts, this alteration being necessary to avoid arcing in the furnace which would have caused loss of manganese by volatilization.

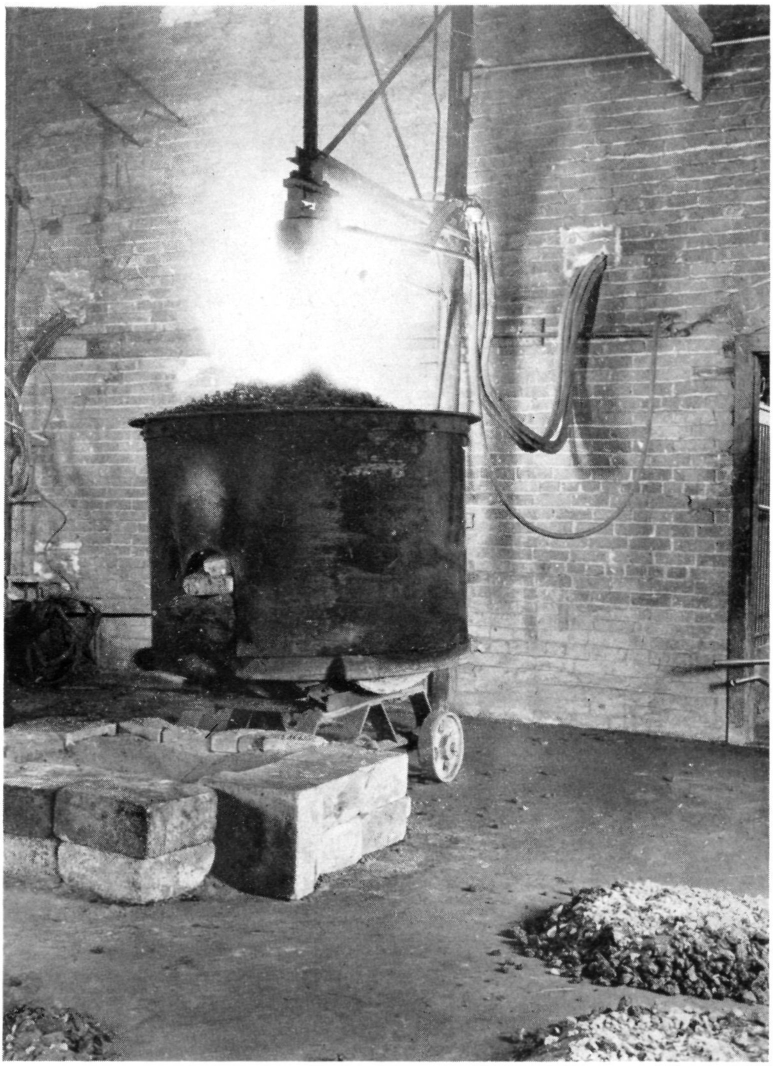
The furnace consisted of a sheet-iron shell 5 feet in diameter and 4 feet high carried on a cast-iron base. The shell was lined with carbon blocks on the bottom and sides carried up above the line of the metallic bath, while the slag and reduction zones were lined with magnesite brick. The crucible of the furnace was 28 inches square and 24 inches deep. (Plate XXXII.)

This furnace is known as a single-phase type. The carbon blocks at the bottom of the crucible served as one electrode, while the other electrode was formed by a 10-inch graphite suspended vertically over the crucible. The furnace was controlled by automatic regulators which adjusted the flow of electric current by means of special apparatus installed in the transformer room.

Smelting operations were started on June 8, 1918, at 10 a.m., and were finished on June 10, at midnight, the furnace running continuously during that time.

The first charge consisted of coarse ore with 20 per cent of charcoal and 19 per cent of lime; 5 per cent of steel turnings was added to supply the necessary iron. After a few hours of operation it became evident that the charcoal was offering too much electrical resistance, and the fuel was changed to foundry coke to increase conducivity. A few hours later petroleum coke replaced the foundry coke in order still further to increase conductivity, and

PLATE XXXII.



Single-phase electric furnace used in ferro-manganese experiments. Electro Foundries, Limited, Orillia, Ont.

it was found that the petroleum coke gave by far the best results, the furnace running much faster and with less irregularity. On June 9, the ore charge was changed to 70 per cent coarse ore and 30 per cent New Ross concentrate. The addition of the New Ross concentrate was continued until the morning of June 10, when, as there did not appear to be any difficulty in smelting operations, the ore charge was changed again to 100 per cent fines, consisting of 60 per cent Chisholm concentrate and 40 per cent New Ross concentrate. The furnace was run on this all-fines charge from the morning of the 10th until midnight of the same day, and smelted this fine material without any electrical or mechanical trouble whatsoever.

Appended herewith is a log of the furnace operations together with analyses of the metal and slag produced. It will be noted that the slag is very high in manganese which, however, was found to be present almost entirely as ferro-manganese in the form of shots and pellets of metal held mechanically by the slag. This was due to the faulty composition of the slag which contained considerably more lime than was necessary. The slag was so high in lime and the carbon supplied to the furnace was in such generous proportions that a large quantity of calcium carbide was formed, which, of course, added to the power consumption and would be avoided in practice.

For these experiments the furnace was not equipped with instruments to record the consumption of power, but an instantaneous reading was made on June 10, which showed the furnace to be taking 215 H.P., equivalent to 160 kilowatts. Throughout the experiments the voltage was maintained at from 30 to 35 and the amperage between 5,000 and 6,000. During this short furnace-run, there was no difficulty encountered in smelting finely-divided manganese concentrates, but in order to demonstrate this more conclusively an experimental test of at least one week is desirable and the furnace should be equipped with power-recording instruments. The fine concentrates which were smelted are not regarded as high-grade ore, from a chemical standpoint, as their silica content was above normal, but beyond adding to the power consumption this should not have any effect on the production of high-grade ferro-manganese; always providing that the manganese content of the charge is from four to five times greater than the iron content of the same.

Subsequent to the completion of the experimental smelting of finely-divided manganese concentrates, the discovery of the Cowichan manganese ore deposits on Vancouver island interested the Commission in the possibilities of manufacturing ferro-manganese on the Pacific Coast. With the view of presenting the commercial opportunity of establishing such an industry in British Columbia, the Secretary secured from the Canadian Pacific railway freight quotations on ore between Cowichan and points on the coast, and also quotations on ferro-manganese from Vancouver to points in Eastern Canada where steel works are located.

There is at present a negligible market for this alloy in British Columbia, and while the market is better in the Western United States, competition with Californian ferro-manganese would require to be met and overcome. The fact that India has commenced manufacturing this alloy on a considerable scale should not be overlooked, although ocean freight rates would, for a time at least, operate to the advantage of the Canadian product.

In presenting the following estimated cost of production, acknowledgment is due Mr. E. Darte, of the Electro Metals, Limited, Welland, Ont., who very kindly aided the Secretary in arriving at cost figures which are considered to be conservative and as accurate as information at hand will permit.

The estimates are based upon the items given under the head of 'Conditions' and the conclusion is reached that, with an expenditure of approximately $300,000 for plant and equipment, the cost of producing 80 per cent ferro-manganese at Vancouver would be $70.39 per gross ton and the cost c.i.f. Montreal and Quebec would be $91.44 per gross ton (2,240 pounds). The conditions which govern the selection of a site for an industry of this kind are electric energy, ore supply, fuel and other supplies, and the cost of labour. Transportation of raw stock and product at reasonable cost is necessarily vital, and the location on tide-water provides opportunity of receiving supplies and shipping product by the same means. The most important item in the cost data is, however, electric energy, and unless this can be supplied to the works for a reasonable figure the undertaking has small chance of competing with the established blast-furnace practice in Great Britain and in the United States.

Conditions.—The plant is assumed to be equipped to smelt 24,000 tons of ore per annum, producing 12,000 tons of ferro-manganese, or between 30 and 35 tons per day. All tons are gross (2,240 pounds) unless otherwise noted.

Furnaces to be three-phase and of 3,000 K.W. capacity.

The ore supply to contain not less than 48 per cent metallic manganese nor more than 15 per cent silica and to cost $6.26 per ton delivered. Manganese recovery to be 80 per cent of total metallic content.

Steel or iron scrap containing not more than 0·2 per cent phosphorus to be delivered at $15 per net ton.

Electric power connected to be not less than 9,000 kilowatts and delivered at low tension terminals of transformers at a rate of one-quarter of a cent per K.W.H., or $16.40 per H.P. year of 365 days.

Electric power consumption to average not more than 5,350 K.W.H. per ton of product.

Carbon electrodes to be used at a cost delivered of 10 cents per pound and consumption of electrodes to average 150 pounds per ton of product.

Foundry coke of good quality to be delivered at a cost of $10 per net ton.

Limestone containing not less than 95 per cent $CaCO_3$ delivered at $2 pe net ton.

Unskilled labour at 50 cents per hour for an 8-hour day, skilled labour at proportionate increases.

FERRO-MANGANESE EXPERIMENTS

LOG OF FURNACE OPERATIONS AT ORILLIA, ONTARIO, JUNE 8, 9, 10, 1918

MATERIALS CHARGED TO FURNACE

Mix No.	Charges to furnace	Description of ore mixture	Per cent	Pounds	Reducing agents	Per cent	Pounds	Limestone (local) and fluorspar	Per cent	Pounds	Scrap charged	Per cent	Pounds	Analyses and Weights: Manganese, Per cent	Manganese, Pounds	Iron, Per cent	Iron, Pounds	Silica, Per cent	Silica, Pounds	Lime, Per cent	Lime, Pounds	Carbon, Per cent	Carbon, Pounds
1	4	Bell coarse ore	100	400	Charcoal	20·7	149	Local lime	19·1	140	Steel turnings	5·4	40	47·94	191·76	0·90 99·00	3·60 39·60	15·77	63·08	4·42 54·48	17·68 76·27	70	106·4
2	2	Bell coarse ore	100	200	Foundry coke	19·4	70	Local lime	19·4	70	Steel turnings	5·5	20	47·94	95·88	0·90 99·00	1·80 19·80	15·77	31·54	4·42 54·48	8·84 38·13	80	56·0
3	3	Bell coarse ore	100	300	Petroleum coke	18·5	99	Local lime	19·6	105	Steel turnings	5·6	30	47·94	143·82	0·90 99·00	2·70 29·70	15·77	46·51	4·42 54·48	13·26 57·20	90	90·1
4	5	Bell coarse ore	100	500	Petroleum coke	18·7	165	Local lime	18·7	165	Steel turnings	5·6	50	47·94	239·70	0·90 99·00	4·50 49·50	15·77	78·85	4·42 54·48	22·10 89·80	90	148·5
5	8	Bell coarse ore	100	800	Petroleum coke	19·0	263	Local lime	17·3	240	Steel turnings	5·7	80	47·94	383·52	0·90 99·00	7·20 79·20	15·77	126·16	4·42 15·48	35·36 37·15	90	237·6
6	15	Bell coarse ore New Ross concent. No. 1	70 30	1050 474	On Petroleum coke No limestone 1st	3rd cha 21·7 charge	rge, New 480	Ross No. 1 Local lime	increased 10·2	by 2 lb. 210	per charge			47·94 28·62	503·37 135·65	0·90 27·32	9·40 129·50	15·77 9·77	165·58 46·30	4·42 54·48	46·41 114·40	90	432·0
7	10	Chisholm concent. No. 1 New Ross concent. No. 3	60 40	600 400	Petroleum coke	22·0	300	Local lime Fluorspar	3·6 4·7	50 10				51·74 38·48	310·44 153·92	4·27 19·11	25·60 76·44	9·40 4·34	56·40 17·36	54·48	27·24	90	270·0
				4724			1526			990			220		2158·06		478·54		631·78		583·84		1340·6

MATERIALS TAPPED FROM FURNACE

Mix No.	Metal: Pounds	Metal: Manganese, Per cent	Metal: Manganese, Pounds	Metal: Iron, Per cent	Metal: Iron, Pounds	Slag: Pounds	Slag: Manganese, Per cent	Slag: Manganese, Pounds	Slag: Iron, Per cent	Slag: Iron, Pounds
1										
2	124	68·20	84·5680	24·30	34·03	51	29·36	14·97	7·87	4·01
3	120	73·75	88·5000	19·25	23·10	59	33·75	19·91	9·48	5·59
4	118	74·80	88·2640	18·10	21·36	107	24·22	25·91	7·26	7·77
5	181 98 113 87	72·30 74·30 74·50 75·25	130·8630 72·8140 84·1850 65·4675	19·10 18·30 17·80 16·80	34·57 17·93 20·11 14·61	10 114 149 194	61·70 21·65 6·04 37·92	6·17 24·68 8·99 73·66	17·05 6·00 1·70 8·59	1·71 6·84 2·50 16·66
6	59 169 153	74·49 73·36 69·75	43·9491 123·9784 106·7175	18·51 19·82 22·10	10·92 33·49 33·81	58 26 169	26·10 57·51 8·25	15·14 14·95 13·94	5·90 14·65 2·80	3·42 3·81 4·73
7	200 127 147	74·20 74·95 71·75	148·4000 95·1865 105·4725	19·00 17·75 20·20	38·00 22·54 29·69	44 85 87	15·57 20·66 36·39	6·85 17·56 31·64	4·42 4·33 11·07	1·94 3·68 9·63
	1696	73·02	1238·3655		334·16	1153		274·37		72·29

	Pounds	Per cent
Iron recovered in metal tapped	334·16	69·83
Iron lost in slag tapped	72·29	15·11
Iron recovered in metal remaining in furnace	8·08	1·68
Iron recovered in metal washed from slag	18·20	3·80
Iron not accounted for	45·81	9·57
Total iron charged	478·55	99·99

	Pounds	Per cent
Manganese recovered in metal tapped	1238·36	57·39
Manganese lost in slag tapped	274·37	12·71
Manganese recovered in metal remaining in furnace	24·18	1·12
Manganese recovered in metal washed from slag	64·25	2·97
Manganese not accounted for	556·90	25·80
Total manganese charged	2158·06	99·99

Note.—Ratio of iron to manganese in metal at 1: 3·706 and in slag at 1: 3·79; being practically the same, it may be assumed that a large part of the manganese unaccounted for was lost in the slag in the form of ferro-manganese in fine shot and grains, due to faulty slag.

When the furnace was torn down, two barrels of mixed slag and ore were saved but were not weighed or assayed.

In order to show the relative proportion of the various items entering costs, the estimated conditions are detailed as follows:

Costs per gross ton of Ferro-Manganese

Ore, 2 tons delivered at \$6.26 per ton	\$ 12.52
Steel or iron scrap, 400 lb. at \$15 per net ton	3.00
Power, 5,350 K.W.H. at 0.25 cents per K.W.H.	13.37
Electrodes, 150 lb. at 10 cents per lb.	15.00
Limestone, 800 lb. at \$2.50 per ton	1.00
Coke, 1,500 lb. at \$10 per ton	7.50
Labour	10.00
Management and office expenses	2.50
Interest on investment at 7 per cent	1.75
Depreciation at 15 per cent on cost of plant	3.75
	\$ 70.39

Note.—With power at 0·7 cents per K.W.H., add \$24.08 to the above costs.

The type of furnace to be used will depend upon several factors in connection with power supply. If 3-phase electrical energy of low frequency, such as 25 cycles, can be secured, the installation of 6 single-phase furnaces would be most desirable because this simple type of furnace is cheaply installed and admits of easy control. If the power supplied is of 60 cycles the furnaces should be of 3-phase type, and 3 only will be required. Whichever type is installed, experience has demonstrated that open tops are the most satisfactory for ferro-alloy work and should be insisted upon notwithstanding the claims of inventors of more complicated closed-top furnaces.

Carbon electrodes, if of good quality, will be found less costly per ton of product than graphite electrodes, and as the carbons can be secured in much larger sizes than the graphite, excessive current density with objectionable arcing is avoided. If carbons of not less than 24 inches diameter are employed there will be small loss of manganese through volatilization, which naturally is a desirable attainment.

The furnace transformers should possess ample power capacity over furnace requirements, in order that temporary irregularity of any one furnace may be corrected without affecting the power consumption of other units of the smelter. It is also important that the transformers be equipped with a wide range of stops to permit the operators to secure any electrical pressure required between 30 and 100 volts.

Under normal conditions the furnaces would be run at a pressure of between 30 and 40 volts, but occasions will arise when the use of a higher voltage is both desirable and necessary.

The most desirable reducing agency to employ would probably be petroleum coke, but it is doubtful if it could be secured at reasonable cost. Charcoal is highly recommended, but in this case also the cost would probably be prohibitive. Good foundry-coke breeze of nut size and free from dust will be found satisfactory, providing care is taken to avoid large lumps as these increase conductivity beyond a desirable point and prevent proper control of the flow of the current between electrodes.

The plant should be located on tide-water and provided with switch connection to the main railway lines. At least ten acres of ground will be required to contain the necessary smelter buildings, workshops, offices, and stock yard for raw material. Ample road space should be allowed between buildings, and the plant arranged for the mechanical handling of all raw materials and smelter products. Provision must be made for a slag dumping-ground of sufficient capacity to serve during the life of the works. In addition to the office and laboratory buildings there will be required a smelter building of sufficient size to allow 3,600 square feet of floor space for each electric furnace of 3,000 K.W. capacity and an additional 3,600 square feet for a repair and machine shop. The walls of the smelter building should be carried high enough to allow 40 feet clear between the girders and the floor, and be of sufficient strength to carry a 10-ton travelling crane from one end of the building to the other.

The ferro-manganese product would be cast in carbon-lined moulds or pits and, when cold, broken, packed into small kegs of 200 lb. capacity, and placed in a stock room for subsequent shipment to the market.

Table of Prices

FERRO-MANGANESE AND SPIEGELEISEN

(Compiled from *The Iron Trade Review*)

Year	Average prices, ferro-manganese per gross ton at Baltimore, U.S.A.		Average prices, spiegeleisen per gross ton at Baltimore, U.S.A.	
	High	Low	High	Low
	$	$	$	$
1910	43.22	39.00		
1911	37.93	37.05		
1912	64.36	43.92	no quotations	no quotations
1913	65.08	52.40		
1914	71.77	39.42		
1915	108.55	82.29	28.00	27.88
1916	312 00	135.69	65.70	45.57
1917	340.96	279.96	75.46	66.03
1918	284.00	250.00	74.53	62.00

Statement showing the quantities of certain Ferro-alloys entered for consumption in Canada during the fiscal years ended March 31, 1910 to 1918, inclusive, by countries

(From Department of Customs, Ottawa)

FERRO-SILICON, SPIEGELEISEN, AND FERRO-MANGANESE

		Tons of 2000 lb.
1910	Great Britain	14,502
	Holland	1
	United States	449
	Total	14,952

1911	Great Britain	18,694
	Belgium	28
	United States	74
	Total	18,796
1912	Great Britain	17,928
	Sweden	24
	United States	322
	Total	18,274
1913	Great Britain	19,288
	Germany	2,173
	United States	1,508
	Total	22,969
1914	Great Britain	13,617
	Newfoundland and Labrador	75
	German	11,051
	United States	3,812
	Total	28,555

After 1914 the classification was amended as follows;

SPIEGELEISEN AND FERRO-MANGANESE.

		Containing 15 per cent or less manganese (dutiable) Tons	Containing over 15 per cent manganese (free) Tons
1915	Great Britain	457	6,153
	France	.....	1
	Germany	1,918	.....
	United States	.....	11,354
	Totals	2,375	17,508
1916	Great Britain	9	7,114
	United States	239	5,440
	Totals	248	12,554
1917	Great Britain	1,143	5,461
	United States	9,723	5,746
	Totals	10,866	11,207
1918	Great Britain	2,677	5,411
	United States	13,288	7,438
	Totals	15,965	12,849

MOLYBDENUM

General

This metal has received an unusual amount of attention during the past four years because of the hardening quality it imparts to steel.

In the peaceful arts the metal has found application as a constituent of tool steels, although its rival tungsten, because of an established production, has been preferred for this purpose. Molybdenum steels are being used in automobile construction and it is expected that the attention of steel workers will be directed toward more extensive application of these special alloys. Molybdenum wire is used in the manufacture of electric lamps and to a more limited extent in the scientific-instrument trades. Salts of molybdenum form valuable chemical reagents and are also used for colouring pottery.

The world's production of molybdenum ores in 1917 was much greater than that of any previous year. In 1910 metallic molybdenum sold for about $1.50 per pound; while in the spring of 1918 the price of molybdenum wire was over $40 per pound, and ferro-molybdenum containing from 50 to 70 per cent molybdenum was valued at $4 per pound of molybdenum content.

In 1911 the Mines Branch, Department of Mines, published a report entitled 'The Molybdenum Ores of Canada,' by Dr. T. L. Walker, of Toronto University. This report described all the then-known deposits of molybdenum ores in Canada. At the time it was published there was a comparatively small open demand for the metal. Prior to 1914 the chemical industries absorbed the greater part of the production, but we are beginning to learn that certain armour-manufacturing plants in Germany were even then making use of molybdenum in the manufacture of war munitions.

In 1911 the world's production came mostly from Australia, which in that year was credited with 121 tons. Norway produced 2½ tons and Canada practically nothing. In 1914 the Mines Branch, Department of Mines, again took up the subject, and made experiments in its Ore Dressing and Metallurgical Laboratories on the concentration of molybdenum ores. In the spring of 1915 the Mines Branch was in a position to offer its services to the Imperial Munitions Board to obtain supplies of this mineral should they be required by the Imperial authorities. The desirability of encouraging Canadian production was for several months impressed upon the Imperial authorities, but it was not until early in 1916 that the Imperial Munitions Board was authorized to purchase any considerable quantity of molybdenite in Canada.

The situation at that time was that only a very few of the known localities had been developed to the point of production, and because no facilities existed for milling or concentrating, the Imperial Munitions Board looked to the Department of Mines for assistance. The department responded by turning the Ore Dressing and Metallurgical Laboratories of the Mines Branch into practically a small commercial mill and, during 1916, from nearly 2,300 tons of ore received from various localities, produced 40·5 tons of molybdenite concentrate which was turned over to the Imperial Munitions Board at the official British price of $1.09 per pound of pure molybdenite, f.o.b. Ottawa. During 1917 the laboratories milled 1,600 tons of crude ore, producing 31·4 tons of molybdenite in the form of concentrate. Early in 1917 two of the largest mines, the Dominion Molybdenite Company, Limited, at Quyon, Que., and the Renfrew Molybdenum Mines, Limited, at Mount St. Patrick, Ont., installed concentrating mills. The Quyon mill continued in operation until the spring of 1919, when it was shut down for repairs and alterations, but the Mount St. Patrick mill was shut down early in 1918 for reasons not disclosed by the operators.

The total Canadian production compared with other countries is shown in the accompanying tables supplied by the Mines Branch, Department of Mines.

Fom the begining of the war until the end of 1917, molybdenite, metallic molybdenum, its alloys and salts, were under an embargo in Canada which prohibited their export to any country outside the British Empire. All sales of ores from the British Empire made to the Imperial authorities were based on the official price of 105 shillings per unit (1 per cent of a long ton) of the pure mineral, delivered f.o.b. Liverpool.

*Production of Molybdenite in Canada**

Calendar Year	Ores mined	Ores treated	Ores and Concentrates shipped		MoS_2 contents of shipments	MoS_2 paid for	
	Tons	Tons	Tons	Value (a)	Pounds	Pounds	Value (b)
1902......	3	......	3·3	$ 400	....	....	$ ....
1903......	600	......	85·0	1,275	....	....	....
1904–1913..	......	......	....	....	....	....	....
1914......	166	......	16·5	2,063	3,814	3,814	2,063
1915......	2,242	216	39·0	28,920	29,210	29,210	28,450
1916......	13,522	9,106	610·0	188,316	156,461	156,461	156,461
1917......	26,871	22,605	1,554·3	320,006	330,316	288,705	288,705
1918......	34,030	33,935	461·3	428,807	378,482	378,029	434,733

*Supplied to the Commission by the Mines Branch, Department of Mines, Ottawa.
(a) Value as given by the operators. (b) Estimated at the average market value of molybdenite.

The prices in countries outside the Empire were always higher than the official British quotations. The open-market price in the United States during 1917 was approximately $2.25 per pound of pure mineral delivered at buyer's works. Canadian producers contended that this difference in price unduly favored production outside the Empire. The British Government was, however, securing practically all its requirements within the Empire, and the higher price in the United States was chiefly due to the inadequate supply in that country.

During the first week of January, 1918, the Imperial Munitions Board was informed that the immediate requirements of the British Government were supplied and that Canadian production might be exported under license to the United States and France.

The principal Canadian producer was the Dominion Molybdenite Company, Limited, Quyon, Que., which disposed of the greater part of its product up to the end of 1917 to the Imperial Munitions Board, and since that date has exported its product to the United States and France. The Renfrew Molybdenum Mines, Limited, Mount St. Patrick, Ont., exported its product to France before shutting down early in 1918.

The Dominion Molybdenite Company sold its product to the Imperial Munitions Board in the form of ferro-molybdenum made in electric furnaces at smelter plants situated at Orillia and Belleville, Ont.

The Canadian producers who had been prevented by the embargo from selling their mineral in the United States up to the end of 1917 were allowed to export their total production after the embargo was removed, and although the United States price of $2.25 per pound of molybdenite continued until the end of January, 1919, the Canadian shipments were heavier than the market could absorb and in February, 1919, the price fell to 85 cents per pound of molybdenite.

There are properties in British Columbia, Ontario, Quebec, and Nova Scotia, some of which have produced a little ore while others are merely prospects. Amongst these may be mentioned that of the Molybdenum Mining and Reduction Co., Limited, on Alice arm, Observatory inlet; the Molly mine, on Lost creek, Nelson mining division; the Index mine, Lillooet mining division, all in British Columbia. Other less important discoveries have been made at Stave lake, Pitt river, and Grande Prairie. In Ontario small producers are the Spain mine, Renfrew county; the Chisholm mine, Addington county; the Lillico-Burrows mine, Haliburton county; the Horscroft mine, Victoria county; the O'Brien mine, Renfrew county, and some others. In Quebec there are the Chaput and Payne, the Davis, the Chabot, and the Chatelane, in Ottawa and Pontiac counties. In Nova Scotia properties have been developed at New Ross, Lunenburg county, and at Gabarus bay, Cape Breton, and small shipments made. Attention has recently been directed to certain deposits in Manitoba, more particularly to those in the vicinity of Falcon lake.

The establishment of the new molybdenum ferro-alloy industry in Canada is important. Canada, with her abundant hydro-electric power, should take an important position in the electric-furnace production of all classes of ferro-alloys.

Some difficulty was experienced in persuading the Imperial authorities to accept ferro-molybdenum instead of the raw mineral. It was contended that the English smelters were equipped to handle the ores and therefore a duplication of these facilities in Canada was unnecessary. This objection was met by pointing out the desirability of manufacturing the ferro-alloy in this country because it allowed the Canadian producer a larger profit on his undertaking.

*Estimated World's Production of Molybdenum Ores**

(*In short tons*)

	1915					1916				
	Ores and Concentrates shipped		MoS_2 contents.	Per cent of Mo.	Mo. content	Ores and Concentrates shipped		MoS_2 contents.	Per cent of Mo.	Mo. content.
	Tons	Value	Tons		Tons	Tons	Value	Tons		Tons
Australia:										
New South Wales (1)	35·5	$ 82,427	a	b 54·0	19·2	60·3	$ 107,388	a	b 54·0	32·6
Queensland (2)	109·0	219,292	a	54·0	58·8	91·1	167,262	a	b 54·0	49·2
Southern Australia (3)	......	......	....	....	....	......	....	....	....	.....
Canada	39·0	28,920	14·6	22.4	8·8	610·0	188,316	78·2	7·7	46·9
Japan (4)	11·1	a	a	a	a	37·0	a	a	a	a
Norway (4)	87·0	a	65·2	b 45·0	39·1	140·0	a	a	b 45·0	63·0
Peru (4)	3·0	a	a	b 49·0	1·5	6·0	a	a	b 49·0	3·0
Spain (4)	29·0	a	a	b 20·0	5·8	147·2	a	a	20·0	29·4
United States (4)	3498·9	114,866	a	2·6	90·9	1228·0	205,000	a	8·0	103·4
	1917					1918				
Australia:										
New South Wales (1)	78·7	$ 153,826	a	b 51·0	40·1	104·1	$ 203,670	a	b 51·0	53·0
Queensland (2)	124·5	236,608	a	b 51·0	63·5	123·0	236,457	a	b 51·0	62·7
Southern Australia (3)	0·9	1,747	a	b 51·0	0·5	0·2	477	a	b 51·0	0·1
Canada	1554·0	320,006	165·1	6·4	99·1	461·3	428,807	189·2	44·6	113·5
Japan (4)	a	a	a	a	a	a	a	a	a	a
Norway (4)	a	a	a	a	b 100·0	a	a	a	a	b 100·0
Peru (4)	7·0	a	a	a	a	a	a	a	a	a
Spain (4)	a	a	a	a	a	a	a	a	a	a
United States (4)	a	495,350	a	a	175·1	2280·0	1,257,000	a	18·9	430·8

* Information gathered from official reports and supplied to the Commission by the Mines Branch, Department of Mines, Ottawa.
(a) Figures not available. (b) Estimated.
(1) From the Annual Report of the Department of Mines, New South Wales
(2) " " " " " " " Queensland.
(3) " " " " " " " Southern Australia
(4) " " " " " Mineral Industry New York.

Molybdenite in Nova Scotia.

By J. C. GWILLIM

(August, 1917)

In going over the following property I was accompanied by, and received much benefit from the experience of, Mr. E. R. Faribault of the Geological Survey, who also is writing some account of the property. I have therefore tried to confine myself to a description sufficient to illustrate its possibilities as an ore producer for more or less immediate necessities.

Nova Scotia Molybdenum Co., Limited.—The deposit is on the farm of Bernard Walker, 4 miles northwest of New Ross, or 20 miles by a good road from Chester Basin, a station on the Halifax and Southwestern railway, on tide-water.

Walker's farm lot and adjacent lots, over a large area, are covered by mining rights or options now in the hands of Messrs. C. J. Burchell, C. L. Normandin, and others, of Halifax.

The district is a rolling, half wooded, half cultivated, boulder-strewn country, about 350 feet above sea-level. There is very little rock in place and hence it is hard to find outcrops of mineral. Granite country-rock, granite boulders, soil and trees, alone are visible.

Some of the boulders carry molybdenite in a matrix of quartz and salmon-coloured feldspar, and can be traced in a north and south direction for a mile or more. In a depression on Walker's farm, a shaft has been sunk through the overburden and has struck the molybdenite ore body in place. This shaft, 8 by 12 feet, now 15 feet deep, passed through granite boulders, float ore, and soil. At about 11 feet it reached solid rock which is part of a pegmatite dyke—a mass of quartz and feldspar, with patches of flake molybdenite scattered through it. From this place and from the float boulders, 750 lb. of ore containing 1·66 per cent of molybdenite have been shipped to the Mines Branch, Ottawa. Another shipment of 1500 lb. was made to the Mines Branch more recently, which contained 1·05 per cent of molybdenite.

The evidence of molybdenite ore at this place is confined to the finding of the mineral in occasional boulders of pegmatite scattered over the area along the north and south line, and to its presence in the bottom of a 15-foot shaft, where no walls or boundaries of an ore body can be seen. Hence the extent of the deposit is unknown, but it is probably associated with a pegmatite dyke of very considerable length and thickness. The average ore in the bottom of the shaft contains under 1 per cent of molybdenite, but may be sorted to 2 per cent. Further development to define the width, length, and probable grade of this occurrence is necessary before its merits as a probable producer can be ascertained, In any case it will take some time to develop it to a point where a mill would be required.

Note by G. C. Mackenzie.—Since the above report was written, as the result of further development of the property two lots of ore said to represent the run of the mine were received by the Ore Dressing and Metallurgical Laboratories, Mines Branch, Department of Mines, for concentration. Weights and assays were as follows:

1. March 27, 1918. 13,854 lb. containing 0·54 per cent of molybdenite.
2. March 27, 1918. 27,260 lb. containing 0·46 per cent of molybdenite.

The ore proved to be an ideal one, as regards crushing and concentration.

Molybdenite in Quebec.

By J. C. GWILLIM

(June-July, 1917)

Late in June and during the first half of July, 1917, examinations, necessarily brief, were made of certain molybdenite properties in Pontiac, Ottawa, and Timiskaming counties, Province of Quebec, to ascertain their possibilities as immediate sources of supply.

Only three days were spent on those in the vicinity of Kewagama lake. The geological conditions there have been fully described by Dr. J. Austen Bancroft in his reports to the Quebec Mines Branch.(1)

Pontiac County.

Squaw Lake Property.—This is situated at the eastern end of Squaw lake, 25 miles northwest of Shawville, and comprises lots 19 to 26 (inclusive) range VIII, Huddersfield township, Pontiac county. There is a good road from Shawville to Story's farm, on the Pickanock river, a distance of 35 miles, and a new road, 2½ miles long, now under construction, leads west from there to the camp.

The property is owned by the Canadian Wood Molybdenite Company, Limited.

The work done consists entirely of surface cuts and strippings, at intervals, for about 1,500 feet along the ore-bearing zone. A tent camp has been established beside the lake on the north end of lot 26. All the men were working on the road or clearing the camp ground.

The ore occurs in a zone or belt of rusty Grenville rocks (gneiss and altered limestone) which has a southeasterly trend across the north ends of lots 25 and 24. A gray granite-gneiss adjoins it and pegmatite dykes intrude the ore-bearing formation; hence it appears to be a contact deposit in which the older rocks have been mineralized by pyroxene, iron sulphides, and molybdenite.

The geological conditions are favourable to the occurrence of molybdenite over a considerable area, but without some more development work nothing can be said regarding conditions at depth.

(1) 'Report on the Geology and Mineral Resources of Keekeek and Kewagama Lakes Region.' J. Austen Bancroft, in 'Report on Mining Operations in the Province of Quebec, 1911,' pp. 186-200, Further notes are given in the Report for 1912, pp. 232-236.

The presence of molybdenite ore of milling grade, up to 15 feet in width, has been shown at intervals for 1,500 feet. If the ore at depth is as good as that in the surface strippings, there should be a sufficient quantity to justify the erection of a mill on the ground. At present the property is a good prospect.

Smith-Tipping Property.—This is on the south half of lots 4 and 5, range XII, Clarendon township, Pontiac county. It lies on Tipping's farm, 8 miles northeast of Shawville and 1½ miles east of Charteris.

J. A. Smith, 291 Lyon street, Ottawa, holds this ground.

There is about 300 feet of open-cut work along the hillside close above the flats of Tipping's farm, but no work was being done at the time of my visit.

It is a contact deposit between altered limestone and gneiss, beside and below a bluff of red granite. The ore-bearing portions are not continuous and not very wide. There are a few tons of ore on the dump, containing less than one per cent of molybdenite.

This is a prospect, with no indications of yielding either cobbing or milling ore. It may deserve some further development, but it would not pay to extract the ore so far exposed.

Davis Property.—This is on lot 3, range X, Litchfield township, Pontiac county. It lies 6 miles northeast of Fort Coulonge, and is reached by a fair road and then by crossing a farm to the foot-hills.

The owner is Edward Davis, of Fort Coulonge, Que.

A pit, 6 feet deep by 8 feet long, has been sunk in the wash-covered hillside. There are also a few small cuts and strippings which show no sequence or continuity. The pit is in altered gneiss, crystalline limestone, and pyroxenite contact-material, with gray biotite-granite-gneiss above and to the south of it. A thin pegmatite dyke cuts into the pit and is probably responsible for a slight development of molybdenite. Across the depression, on a knoll to the north of it, is an outcrop of silicified limestone with some development of pyroxenite and, occasionally, flakes of molybdenite.

Nothing was seen on this property which appeared to be worthy of development, but the ground is worth further prospecting.

Ottawa County.

Wood-Ormond Property.—This is on lots 6 and 7, range VIII, Eardley township, Ottawa county. It is reached by following the main road due north from Breckinridge Station for 3 miles and then climbing 300 feet up the steep face of the escarpment of red granite hills. Aylmer lies about 9 miles southeast of the property.

The owner is H. E. Wood, of Denver, Colorado, U.S.A.

A level entry open-cut, 8 feet long, 10 to 12 feet wide, and 28 feet deep, has been blasted into the hillside. A steep trail leads up to this working.

The molybdenite is closely associated with an inclusion of dark hornblendic rock from 6 to 10 feet wide, and occurs as peculiar 'chunky' or nugget-like crystals in this rock and, rarely, in the adjacent granite.

The mineralized hornblende at this place appears to be only a local body of apparently small dimensions, but other patches of it occur in the vicinity. I do not think it will become commercially valuable.

Chaput-Payne Properties.—These are on lot 1, range VI, and the south half of lot 1, range VII, Eardley township; also lot 28, range X, Hull township, all in Ottawa county.

E. Chaput apparently owns 50 acres on lot 1, range VII, Eardley township. J. H. Payne holds the other lots and ground to the northeast and south of Chaput.

The properties lie on the face of the southern Laurentian escarpment, 500 feet above the Ottawa valley, and 3 miles northeast of Breckinridge Station. A wagon road leads to the foot of the hill, up which there is a trail, about one-half mile long, to the camp.

The Chaput Ground.—On the Chaput property there is a pit about 25 feet in diameter and 15 feet deep, half-full of water, in a mass of pyroxenitized rock. A band of pink calcite, dipping southeastward, occurs in this rock. From this pit 1·13 tons of ore, containing 3·93 per cent of molybdenite, were shipped to the Mines Branch, Ottawa. Work has now been discontinued.

An open-cut beside the creek, 300 feet southeast of the above pit, has exposed low-grade ore containing molybdenite in finer flakes than that in the pit. Work is being done here.

The pit appears to be in an altered limestone containing much pyroxene and some mica seams, also a band of calcite which lies along the line of the best ore. The flake molybdenite is coarse and can be hand-sorted. Ore was seen in the walls of the pit, especially toward the south and southeast. Work has been discontinued for the present.

The open-cut was made on a banded member of the Grenville series, and the molybdenite is in a finer and more disseminated condition. The ore, so far a milling one of under 1 per cent molybdenite, occurs chiefly along seams and parting planes in the rock. It is now being developed.

The Payne Ground.—No. 1 pit or cut is a small opening on lot 28, range X, Hull township, a few hundred yards northeast of Chaput's open-cut, and in a similar, but rather more compact, gneiss-like rock with most of the molybdenite along parting planes. The ore is a low-grade mill-rock with no definite boundaries, and is penetrated by and adjacent to pegmatite dykes.

No. 2 cut, on lot 1, range VI, Eardley township, is a few hundred feet south of Chaput's open-cut, and on the same creek. This cut is also similar to Chaput's open-cut, but shows more pyroxene. The ore appears to be of slightly better grade at this point, but the ore body is indefinite. Two men were working here, and had taken out about one ton of mill-rock from a small opening.

No. 3 pit, of small size, is in the more granular pyroxenitized rock, of much the same character as that in Chaput's pit. The molybdenite, as in that pit, is in coarse flakes. Work has been discontinued for the present.

The Chaput-Payne ground is a remnant of mass of rocks of the Grenville series, caught up in the surrounding red granite. The pits and openings on it are scattered over a large area and all show molybdenite. Granite or pegmatite dykes cross this area and probably indicate the best lines of mineralization; but so far the work is in the prospect stage, and no outline of the mineralized area can be given, as the rocks are covered by soil and brush. This ground is well worth careful prospecting and development, with the possibility of opening up a considerable tonnage of low-grade milling ore. It is conveniently situated for working by open-cuts, with a gravity tram, or other system of conveyance, to the plain 500 feet below it.

Timiskaming County.

St. Maurice Syndicate.—This property, of 720 acres, consists of 5 mining claims situated on Indian peninsula, Kewagama lake, Preissac township, Timiskaming county.

It lies 20 miles directly southwest of Amos, which is on the Transcontinental (Government) railway at the crossing of the Harricanaw river.

The property may be reached from Amos by motor-boat or small steamer to a portage or landing on the western shore of Askikwaj or Seals Home lake, thence by hand-car over 2 miles of tramway (Plate XXXIII) to Kewagama lake, and finally by motor-boat to the mines. The portage is about half-way, and the total distance is 50 miles.

There is an alternative route from Spirit lake, a point on the railroad 5 miles west of Amos, southward by rough road or trail and canoe to Kewagama lake, thence across a portage of 1½ miles to the camp. This route is only 20 miles long, and may be made into a fair winter-road.

Indian peninsula is chiefly composed of a granite mass which rises to a height of from 200 to 300 feet above the level of the lake. The surrounding area is of low relief; much of it is water and the remainder is thickly wooded with spruce, birch, and poplar. It is at the height of land, about 1,000 feet above sea-level.

On Indian peninsula, the ancient rocks of the Abitibi or Keewatin period are intruded by a mass of light-coloured granite. This has ruptured these older schistose rocks, forming in them segregations of quartz, spurs of granite, and aplite dykes, near the contact. The granite mass itself is also fractured, along northwest and southeast lines, giving rise to a series or system of remarkably regular quartz veins, which can be traced in some cases for many hundreds of feet. Later diabase intrusions cut the granite

Tramway, St. Maurice Syndicate, Kewagama lake, Quebec.

St. Maurice Syndicate camp on Indian bay, Kewagama lake, Quebec.

and schists, but do not appear to have had much to do with the formation of the quartz and its contained molybdenite, which seem to have been derived from the granite, as a later phase of its cooling.

In all cases the molybdenite is associated with quartz and a greenish-white, foliated mica. The quartz, which usually carries molybdenite, is of two types:

Type A.—Very regular veins, dipping at high angles, which traverse the granite in a northwesterly direction. These veins are chiefly within 2,000 feet of the granite and schist contact. As seen on the Sweezey claim, they are from 2 to 5 feet wide, definite, usually parallel, and persistent. Many cuts and pits have been made in them. Molybdenite is present in most cases, especially on the foot-wall side of the veins, but the average molybdenite content will run less than one-half of one per cent.

Type B.—Segregations or sporadic masses of quartz, plastered on the granite contact or here and there in the adjacent schists. There is a mixed zone or belt of schist, granite, and aplite dykes, about 100 feet wide, along the granite contact on the eastern portion of the Sweezey claim, which contains such quartz masses. This is probably the most promising ground on the property. Many rock cuts and pits, up to 20 feet deep, have been made along this belt or zone—but it is not yet thoroughly prospected, as it forms a depression in which overburden conceals the rock at many places. Many of the working-places are filled with water. In the upper portions of these, the molybdenite shows the usual tendency to occur with mica on the walls, or as veinlets across the quartz. There are some pay-streaks a few inches wide and a few feet long, but much of the quartz is barren. On the whole, the molybdenite content is higher than in type A, but below an average of 1 per cent of molybdenite. The ore itself is very free from other sulphides, such as pyrite and pyrrhotite, and appears to be readily capable of concentration to a high-grade product by oil flotation.

The work done consists of many rock open-cuts, some earth trenches, and a few pits up to 20 feet deep. Most of this work has been done on the eastern side of the Sweezey claim along the contact zone of the granite and older schists, but there are many pits and shallow blastings on the system of quartz veins which crosses the granite farther southwest on this claim, within 1,500 feet of the contact. The work done on the Hervey, O'Brien, Doucet, and Huestis claims is of less importance. On the Sweezey claim about 1,000 tons of rock have been removed, with a production of under 50 tons of 1 per cent molybdenite ore. In 1911 the syndicate sent the following shipments of ore to Queen's University for testing purposes:

1.	1,113	lb.,	containing	7·4	per cent	of molybdenite.
2.	300	"	"	2·3	"	"
3.	760	"	"	1·8	"	"

There is a boiler-house, boiler, engine, and a small crushing-plant on the Sweezey ground. A wagon road, one-quarter mile long, leads from it to the main camp on Indian bay. At the camp, which is in a clearing, there is a dock, large mess-house, stable, material for a bunk-house, and some tents for present accommodation (Plate XXXIII). There are also two small buildings on the shore between the Hervey and O'Brien claims. Lying on the property and on the portage between Kewagama lake and Askikwaj or Seals Home lake, is some mine equipment, including a boiler, parts of a saw-mill, pumps, mine cars, and piping. The company has a large flat-bottomed motor-boat on Kewagama lake, but has to hire transportation from Amos to the portage between Askikwaj and Kewagama lakes.

The Hervey, O'Brien, Huestis, and Doucet mineral claims were not closely examined, but a casual inspection showed them to have some value as potential molybdenite producers. They are traversed by 'type A' quartz veins.

The Sweezey claim merits further prospecting and development, The work done has shown a wide distribution of molybdenite in quartz bodies, but in the aggregate these produce only a low-grade milling ore. It seems advisable to thoroughly cross-cut the contact zone on the Sweezey claim for say 100 feet, from the granite outward, and to follow up the best showings elsewhere with more work, keeping account of the proportion of the molybdenite content to the rock excavated. Such development work does not call for heavy machinery at the present time, and any expenditure should be devoted to proving the existence of a sufficient tonnage of milling-ore containing say one-half to one per cent of molybdenite.

In 1901 the occurrence of molybdenite on Indian peninsula was reported by J. F. E. Johnston, of the Canadian Geological Survey.

In 1905 it was visited by J. Obalski, Superintendent of Mines for Quebec, who reported favourably, but found transportation and access to be difficult.

In 1910 it was examined by Dr. T. L. Walker, of the University of Toronto, for the Department of Mines, Ottawa.(1) Two examinations were later made by him for other parties. He gives an average of 0·93 per cent of molybdenite as the result of his sampling of the quartz ore-bodies.

Later in 1910, A. E. Lehman, civil and mining engineer, of Philadelphia, Pa., made an elaborate report on this property. He estimated the production to one yard deep on the exposures would total 21,000 tons of ore containing 7 per cent of molybdenite, an estimate which, in my opinion, is much too high.

In 1911 and 1912 Dr. J. Austen Bancroft, of McGill University, made an examination of this district for the Quebec Department of Mines.(2)

In December, 1915, W. B. Timm, of the Mines Branch, Ottawa, inspected the property; and in 1916 it was visited by Theo. C. Denis, Superintendent of Mines for Quebec.

At this date, July, 1917, the property is under option and the management of W. E. Simpson.

(1) Mines Branch, No. 93, Molybdenum Ores of Canada, 1911, pp. 35-38.
(2) Report on Mining Operations in the Province of Quebec, 1911, pp. 186-201; and 1912, pp. 232-236.

Peninsular Mining Syndicate.—According to Dr. T. L. Walker,(1) this Montreal syndicate, in 1910, had 8 claims in the interior of the peninsula between the O'Brien and Sweezey claims of the St. Maurice Syndicate. Local report at this date (July, 1917) says that little has been done on them and that they have lapsed in their ownership. Apparently there are many quartz veins of 'type A,' lightly mineralized with molybdenite.

Dion Claim.—This adjoins the southeastern corner of the Sweezey claim and lies along the course of the granite and schist contact. Some work, consisting of a shaft and a rock pit, was done here by S. W. Cohen, under an option from Dion. The shaft, sunk on a pegmatitic phase of the granite, is full of water. It is said to have produced 8 bags of ore containing 3·9 per cent of molybdenite. There are still a few hundred pounds of such cobbed ore on hand, in which the molybdenite occurs as rather stout small rosettes, free from other sulphides. The open-cut shows little promise of commercial ore, and the shaft is sunk on a water-course, but this ground is favourably situated for ore occurrences.

Height of Land Mining Company.—This property is on the western shore of the Kewagama river, a little north of its outlet from Kewagama lake, in Preissac township. It is on the canoe and winter-road route from Kewagama lake to Spirit Lake on the Transcontinental railway, 5 miles west of Amos.

The property was visited on July 1, 1917. The shafts were full of water and little could be seen in the open-cuts or along the outcrop. The ground was staked by C. S. Richmond, and at one time was under lease to Forbes and Campbell, who were to expend $1,000 per month and pay a royalty of 25 per cent of the gross output. During this lease they are said to have picked out 1,200 lb. of ore averaging 98·5 per cent of molybdenite.

Dr. T. L. Walker gives some account of this property, and says that J. A. Dresser, who visited it in 1907 before any work was done, states that the pegmatite mass to the west of this river was from 30 to 50 feet wide, and could be traced for 400 yards along the river bank. To the west the rock was biotite schist, while across the river granite was the chief type.

My own observations were confined to an inspection of the upper and lower workings, a few hundred feet apart and close to the river on its west bank.

At the upper workings there is a large clearing with several buildings. Here a shaft, 80 feet deep, starts in schist and reaches the quartz below, on which there is said to be an east and west drift or cross-cut 70 feet long. The dump shows a much-shattered quartz containing less than 0·1 per cent of molybdenite. Apparently the quartz is at the contact of granite and a micaceous schist, and is said to outcrop in the river and to dip under the shaft, 60 feet west of the river.

(1) Mines Branch, No. 93, Molybdenum Ores of Canada, 1911, p. 34.

At the lower workings there is a shaft 50 feet deep, a hoist, shop, and ore-house; also an open-cut, 70 feet long and 12 feet deep, on the outcrop which dips to the west under a micaceous schist at an angle of 60°. About 7 tons of ore, containing 1 per cent of molybdenite, is in a shed which is equipped with a small rock-crusher.

It is impossible to give any opinion on this property, as there are no data, beyond reports. According to these reports, 130 feet of shaft-work, some drifts, and a few open-cuts, have produced 1,200 lb. of ore containing 98·5 per cent of molybdenite, and 7 tons containing 1 per cent; which cannot have balanced the cost of work done.

Molybdenite in Ontario.

By J. C. GWILLIM

(May-June, 1918)

This report contains brief descriptions and my impressions of some Ontario molybdenite properties which were visited, in Frontenac, Addington, Renfrew, Haliburton, and Victoria counties.

Lieut. G. M. Ponton accompanied me to those in Haliburton and Victoria counties.

Descriptions and references to other properties, not visited, in the above counties, will be found in the report by Dr. T. L. Walker,(1) published by the Mines Branch, Department of Mines, Ottawa, and in that by Mr. A. L. Parsons,(2) published by the Ontario Bureau of Mines.

Frontenac County.

Macdonell Property.—This is on the south half of lot 7, concession VI, Olden township, Frontenac county. It lies 5 miles southeast of Mountain Grove by a good road, or 6 miles southwest of Sharbot Lake by a poor one.

The property is owned by G. M. Macdonell of Kingston, Ont.

The work done consists of a pit 12 feet long and 5 feet deep.

The ore occurs in a small patch of limestone and pegmatite near the main granite contact. There has been a slight alteration of the rock to pyroxenite, with some flake molybdenite.

A shipment of 238 lb. of ore, sent to the Mines Branch, Ottawa, assayed 0·4 per cent of molybdenite.

This occurrence is not of commercial value so far as developed. The adjacent contacts might be prospected, but are not promising. The property, like many others, shows some occurrences of molybdenite and is therefore worthy of prospecting for pay-ore, which as yet has not been found.

(1) Mines Branch, No. 93, Molybdenum Ores of Canada, 1911.
(2) Ontario Bureau of Mines, Annual Report, vol. 26, 1917.

Smith Property.—This is on lot 6, concession VI, Olden township, Frontenac county. It lies 5 miles southeast of Mountain Grove by a good road, and 6 miles southwest of Sharbot Lake by a crooked, poor one.

The property is owned by Edward Smith of Perth, Ont.

The work done consists of a pit 20 feet long, 4 feet wide, and 8 feet deep, from which 14 sacks of ore were shipped to the Mines Branch, Ottawa, during May and June, 1917. One lot of 12 sacks contained 0·275 per cent of molybdenite, and the other lot of 2 sacks, 0·06 per cent of molybdenite.

The ore occurs in a patch of rocks of the Grenville series in granite gneiss. The pit is in a hornblendic rock, the extent of which has not yet been demonstrated, but granite occurs a few feet to the north and south of the pit. This narrow unprospected belt of Grenville rocks appears to run southeasterly for an indefinite distance. The pit shows no indications of commercial ore.

Like the Macdonell property, nearby, this so far is merely an occurrence of molybdenite but merits further development, such as a complete cross-cutting of the ground from the southern to the northern granite contacts.

Addington County.

Chisholm Mine.—This is on lot 5, concession XIV, Sheffield township, Addington county. It may be reached from Wilkinson station on the Canadian Pacific railway over 5 miles of rough road; or by 7 miles of a better road for horses and motors, leading northeast from Enterprise.

The workings consist mainly of two pits, each about 80 feet in diameter, which are joined by a narrow shelf not yet quite as deeply excavated. These may be called the western and eastern pits. Each has a derrick, and is from 10 to 15 feet deep on the average, but shelves toward central depressions which are now filled with from 1 to 5 feet of water. A rough estimate of rock removed is over 10,000 tons.

The following shipments have been made to the Mines Branch, Ottawa:

1.	Crude ore.	17·80 tons,	containing	1·41	per cent of molybdenite.
2.	Cobbed "	2·71 "	"	5·16	" "
3.	" "	2·41 "	"	6·19	" "

Besides these, several hundred tons have been milled and shipments made elsewhere.

The ore occurs in a fairly well-defined remnant of Grenville limestone almost surrounded by the regional reddish granite. Apparently spurs of this granite have penetrated, unequally, through the contact, but the pits show no granite. The ore body proper appears to outcrop in several places as a rusty iron-stained pyroxenite; but at most places the edges of the pits show a capping of crystalline limestone, while their deeper portions are in the more altered material containing much pyrite, with subsidiary pyrrhotite. The molybdenite occurs with the iron sulphides or closely associated. The bottoms and lower portions of the sides of the pits, beneath the crystalline limestone, appear to be promising ground, although evidently not well mineralized with molybdenite, except in two or three places. The area of Grenville limestone may be roughly 300 by 200 feet and extensions may pass southwestward and northwestward from the western pit. There are also other areas of crystalline limestone in the vicinity.

It is probable that ore-bearing ground similar to that already excavated will be found beneath these pits and also under the few feet of limestone capping which shows on their edges. There is no certainty regarding the depth of the ore-bearing ground. This remnant of Grenville limestone may be shallow, and the granite may closely underlie the present pits. Any work done will approach the sides and bottom of the granite basin where the mineralization will probably be more intense; but there is no means of knowing whether or not the molybdenite content of the ore will increase.

Renfrew County

International Molybdenum Company.—This company is operating on lots 16 and 17, concession XI, and lot 17, concession X, Brougham township, Renfrew county. The property lies 18 miles in a direct line southwest of Renfrew, or 24 miles by a fairly good road.

The work done consists of many open-cuts scattered over a considerable area. In some of these, small pockets or stringers of molybdenite ore have been followed downward by inclined workings. Many of these workings are now idle and filled with water, so that only the dumps and surface conditions can be seen. The principal working, now operating, is a pit on the eastern part of the property about 50 feet deep. Here, from 50 to 100 tons of rock per day are being raised, of which under 5 per cent is ore containing perhaps 1 per cent of molybdenite. The future work, if such is carried on, will be to extend this pit westward along the zone of mineralized rock. All the other workings are on small ore-shoots, adjacent to local intrusions of pegmatite. They can be followed only by underground work.

The earlier work has been done on a number of small, fairly high-grade seams or segregations which have but little continuity, appearing here and there at points where pegmatite dykes have cut the older gneiss and crystalline limestone. At these workings there is no one well-defined contact of the granite with the older Grenville series, such as is common in productive molybdenite deposits. As before stated, these scattered workings are now idle, and are probably not worthy of further development. The working pit to the east of these is in a much more extensive ore-bearing gneiss formation which has been fissured and mineralized with iron sulphides, molybdenite, and other minerals. Pyroxenite is associated with the gneiss. The average grade of the ore here is so low that it cannot stand the charge of mining, sorting, hauling 15 miles to Ashdod station, and expense of freight and treatment. It is possible that enrichments may occur along this zone of mineralization westward from the working-pit, and so justify operations. Concerning prospecting, I can suggest no likely places; the only way is to follow any outcrop or ore body as long as it proves sufficiently remunerative. Generally speaking, the property is on the contact of intrusive granite gneiss with the Grenville gneiss and crystalline limestone, and is therefore potentially a molybdenite producer. The contact, however, is patchy and ill-defined, and the mineralization diffused over a large area on many local contacts, no one of which shows an ore body of sufficient magnitude and grade to justify expensive developments. Apparently the only policy to pursue is that adopted in the past, namely, to dig out these sporadic deposits as long as they seem profitable. It would be worth while to have someone study the ground who is conversant with this type of occurence, and after that, if advisable, to diamond-drill or prospect at some points. The present indications are that the ore costs more than it is worth, and the prospects of betterment are not encouraging.

Renfrew Molybdenum Mines, Limited.—The property owned by this company comprises the Hunt mine, situated on lots 8 and 9, concession XI, Brougham township, Renfrew county, 11 miles from Ashdod station on the Kingston and Pembroke railway, together with several adjoining claims.

At the time of Mr. G. C. Mackenzie's report of November, 1915, which was published in the Summary Report of the Mines Branch for that year, the work underground consisted of a cross-cut adit 92 feet long, with drifts northwest and southeast along the ore body for 120 feet. There was 80 feet of 'backs' or ore above the drifts, and the ore body had been traced on the surface by open cuts for 360 feet. Several drill-holes, which should have crossed the southward pitch of the ore body, do not appear to have encountered either it or the granite contact where it might have been expected. The drill-holes proved that an unexpected development of the older crystalline limestone and gneiss occurs at points over 150 feet, nearly vertically, beneath the outcrop.

The work done since 1915 consists chiefly of a vertical shaft, now 80 feet deep; an extension of the drift westward to a point a little beyond the last outcrop in that direction; and some raises and stopes. There are also about 60 feet of cross-cuts southward from the bottom of the shaft, and a cross-cut 130 feet long from the 40-foot level northward into the hill. Granite would be expected at the face of this cross-cut, but crystalline limestone, showing a curious re-entrant tongue in the granite, was found instead. The drifts at the 40-foot level, which now aggregate nearly 400 feet along the ore body, show it to be apparently continuous, and it is stated to be upwards of 25 feet wide in places. The shaft passes downward into barren rock and the southern cross-cut at the 80-foot level intersects the ore body on its southward dip at a point where it is cut off by a lower granite intrusion or thrust fault. The cross-cut northward at the 40-foot level is entirely in crystalline limestone until the granite contact is met with. Here there is a good development of ore, and the assumption, supported by some direct evidence, that this tongue of limestone has a mineralized contact with granite a few feet above, and a few feet below, the cross-cut, appears to be justified.

At the present time, the condition appears to be that the ore body is continuous for nearly 400 feet along its strike at the 40-foot level, but turns—at least in one place—under the granite above the limestone cross-cut for a distance of 130 feet northward. It then, apparently, turns back beneath the same cross-cut to a point in the shaft below the 40-foot level, and is found again dipping southward in the southern cross-cut at the 80-foot level, where it is cut off by underlying granite.

Mr. Charles Spearman, who is in charge of the property, thinks that there is a fault-plane here, along which the rocks on its lower side have moved downward to the north, and, therefore, that the ore body will again be intersected if the present shaft is continued.

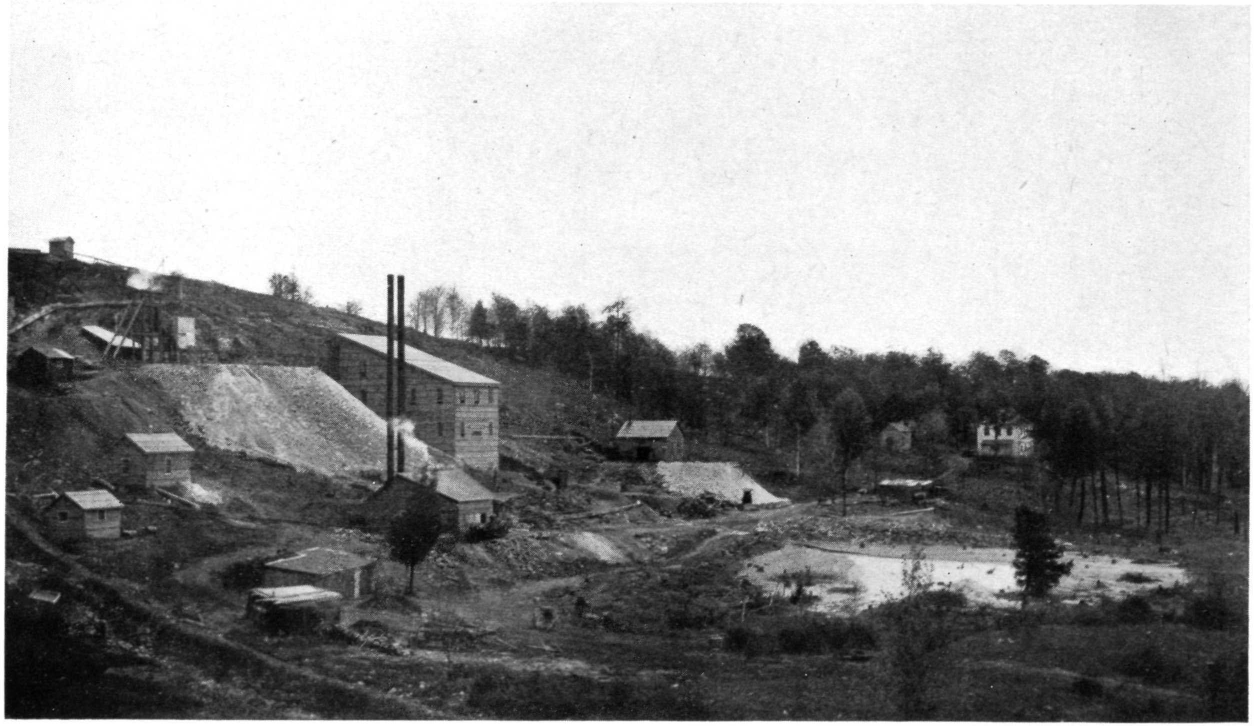
It is proposed to continue the shaft to prospect this doubtful ground, and also to sink a new shaft several hundred feet to the westward of the west end of the present workings, on the main line of the contact. This, I think, will all be good development work, and may greatly increase the ore in sight.

At present, the mine looks well on the 40-foot level, with several months' ore supply. There are about 80 men working. The equipment includes boilers, compressor, hoist, and air-drills; also a mill which produces about 300 lb. of concentrate per 10-hour day from a feed which probably runs about 1 per cent molybdenite. (Plate XXXIV.)

The ore deposit is of the contact pyroxenite type, well-defined and following the granite along the hillside with considerable regularity in direction. The convolutions of the ore body greatly increase its area within a short distance of the surface, since the line of contact makes a detour around the tongue of limestone.

The few hours spent on this property justify only a very general opinion. The contact of the reddish granite with the older Grenville limestone and gneiss is complicated but, nevertheless, very productive of ore. Ore has not yet been proved below the 80-foot level. The fact that the drill-holes do not encounter granite shows that the contact may recede northward again below the granite.

The 'fault', or granite intrusion, encountered to the south of the 80-foot level, may simply be another flat-lying spur of granite projected southward, more or less horizontally, into the older rocks. I am inclined to think that the granite consists of sheets and masses intruded at low angles into the surrounding strata and that it is not a more or less vertical dyke or dome-like mass extending downward indefinitely. On my supposition, the contact downward will be most irregular and possibly ultimately pass beneath the apparently deep-seated granite ridge. Such convolutions of the contact may not destroy its mineralizing value, but will greatly confuse any one who does not follow the geology closely. The prospecting done elsewhere on the granite contact has not, as yet, indicated any commercial ore body.



Hunt mine, Renfrew Molybdenum Mines, Limited, Mount St. Patrick, Ont.

Haliburton County.

Lillico-Burrows Mine.—This is on lots 14 and 15, concession XII, Monmouth township, Haliburton county, 1½ miles northwest of Tory Hill station on the Irondale branch of the Canadian Northern railway.

The work has been done on a hill or plateau at an elevation of 300 feet above Tory Hill station.

Pegmatite dykes, reddish granite, and gneiss occur over a large area. Pits have been sunk, and at two places there is a fair showing of molybdenite, associated with pyroxenite, pyrrhotite, and pyrite, in flat-lying beds which are probably altered gneiss.

Work is now being concentrated on the Western or No. 1 open-cut, where a considerable excavation, with level entry, is possible.

There is perhaps a carload of ore containing from 1 to 2 per cent of molybdenite on the dumps at the Nos. 1 and 2 pits. The molybdenite flakes are large and bright.

The property seems to be worthy of prospecting, with some chance of finding shoots of higher-grade ore.

R. J. Lillico made two shipments of ore to the Mines Branch, Ottawa, in 1917, as follows:

1. Mar. 31.	1,561 lb., containing	5·20	per cent of molybdenite.
2. May 18.	48,518 " "	0·98	" "

Padwell Mine.—This is on lot 11, concession XV, Monmouth township, Haliburton county, 4 miles northwest of Tory Hill station, and a little west of Essonville P.O.

A pit, 80 feet long, 30 feet wide, and 20 feet deep, has been opened in crystalline limestone. The limestone is penetrated by pegmatite dykes; and greenish bands or patches of pyroxenite occur, carrying molybdenite —but now there is little of that mineral left in the walls or bottom of the pit. Five carloads of ore are said to have been taken from this place, part of which went to Renfrew. George Padwell made two shipments of ore to the Mines Branch, Ottawa, in 1916, as follows:

1. August.	52,568 lb., containing	1·605	per cent of molybdenite.
2. Nov. 29.	58,712 " "	1·22	" "

At present no work is being done and there is practically no ore in sight, but the property is worth prospecting, as conditions are favorable.

Wilberforce Deposit.—This is on lot 32, concession XVI, Monmouth township, Haliburton county, immediately west of Wilberforce station on the Irondale branch of the Canadian Northern railway, close to the south side of the track.

P. J. Dwyer is working this deposit with two or three men, and on March 12, 1917, shipped 58·57 tons of ore, containing 0·205 per cent of molybdenite, to the Mines Branch, Ottawa.

Here there is a low knoll of rock composed of a white feldspar spotted rather evenly with crystals of green pyroxene. A great deal of blasting has been done, and large blocks of the displaced rock lie close to the excavations. These blocks contain bright flakes of molybdenite fairly evenly distributed. The molybdenite content is probably under one-quarter of one per cent, but the rock mass is large and the distribution of the mineral fairly regular and not confined to lines of fissuring or weakness. The surface area of this rock knoll or mass is about 400 by 100 feet. It can be worked cheaply by level-entry open-cut. It is not likely that the grade of the ore can be raised by hand-sorting. Conditions at depth should be tested by means of vertical bore-holes or pits.

Lot 32, concession XVII, immediately north of the above property shows some molybdenite in a somewhat similar rock. It is owned by P. J. Dwyer.

Victoria County.

Ponton-Russell Property.—This is situated near Norland, 6 miles north of Coboconk. It is a mining claim in Mud Turtle lake, in front of lot 5, concession XI, (owned by other interests), Laxton township, Victoria county.

The ore body dips under the lake, and a shaft, said to be 45 to 50 feet deep, has been sunk, in a bad situation, on the water's edge. It is full of water and no work has been done for three years. There is perhaps a carload of ore on the dump. This ore, which presumably came out of the shaft, is a mixture of pyroxenite, feldspar, iron sulphides, and molybdenite. Its molybdenite content is possibly from 1 to 1½ per cent.

Horscroft Mine.—The property consists of a strip of the lake shore, 60 feet wide, on lot 5, concession XI, adjoining the Ponton-Russell property. Back of it is the Adair farm, owned by or under option to other interests.

The ore body is the same as that in the Ponton-Russell ground and dips at once into it under the lake.

T. Horscroft has made 6 shipments of ore to the Mines Branch, Ottawa, as follows:

1-4.	20,910 lb.,	containing	2·187	per cent	of molybdenite.
5.	24,726 "	"	1·01	"	"
6.	17,028 "	"	1·76	"	"

The Ponton-Russell, Horscroft, and Adair properties should be grouped. If worked, a shaft should be sunk, back from the lake, and a cross-cut driven to the Ponton-Russell shoot.

Molybdenite in British Columbia.

By J. C. GWILLIM

(August, 1916 - February, 1917)

Many occurrences are cited in the reports of both the Geological Survey and the Mines Branch, Department of Mines, Canada, and also in the annual reports of the Minister of Mines, British Columbia. A memoir by Dr. T. L. Walker entitled, 'Report on the Molybdenum Ores of Canada,' was published in 1911 by the Mines Branch. It contains information concerning molybdenite deposits in British Columbia, from none of which had shipments been made up to that date. The first shipments of molybdenite ore, consisting of two carloads assaying 16·5 and 12·2 per cent molybdenite, were made in 1914-15 from the Molly mine on Lost creek, 8 miles south of Salmo, B.C.

With the war demand and increased prices since 1914, several other producers have appeared, the most notable being the property on Alice arm, 90 miles northeast of Prince Rupert; and the Index mine on the summit between Texas and Cottonwood creeks, 15 miles southeast of Lillooet.

Molybdenite seems to be usually associated with granitic rocks, of which there are enormous developments in British Columbia. These rocks may carry molybdenite in quartz veins; or disseminated in pegmatite dykes; or diffused from seams, as at the Index mine. In other cases the intrusion of these comparatively recent granites has affected the overlying, adjacent, or engulfed older rocks, especially limestones, and made them carriers of molybdenite.

The many occurrences within or about these granitic or acid intrusions indicate a probability of finding this mineral here and there in commercial quantities, but by far the majority of the discoveries, so far, are simply 'occurrences' of small magnitude, or, if large, of a grade under 1 per cent, and probably of too low a grade to mill.

There seems to be, however, some promise in British Columbia of a future molybdenite industry if the demand for the metal at a good price continues.

For present purposes the ores may be classified as:

(1) Quartz veins with flake or amorphous molybdenite rather free from other sulphides, as at Pitt lake, Knight inlet, and Alice arm.

(2) Impregnations of granite or adjacent rocks, sometimes associated with garnet and copper or iron sulphides, as at the Index and Molly mines, the Golconda mine near Olalla, and the Kennallan mine near Grande Prairie.

(3) Pegmatite or granitic zones with large bright flakes and very little of other sulphides, as at Stave lake and on Jervis inlet.

So far the shippers belong to classes 1 and 2. The others may become milling properties, but show little evidence of producing hand-sorted or high-grade ore.

The present price of approximately $1 per pound for the molybdenite content is encouraging to miners who can pick out a grade of ore containing above 5 per cent molybdenite. Such ore can be shipped in carload lots (30 tons) to the concentrating works in Ontario for about $15 per ton; the milling charges being another $5 to $6 per ton. This leaves about $70 for the costs of mining, sorting, and transportation to a railroad. The rate on less than carload lots is about $30 to $40 per ton, all being based on a valuation of under $100 per ton. The high freight rates on less than carload lots might be avoided by some system of central accumulation agencies, which would collect the scattered output of the various small producers for bulk shipment to the concentrating mills.

Mills for handling large low-grade deposits require large, well-developed ore bodies and more certainty of market and prices than is apparent just now.

The occurrences of molybdenite in British Columbia which have been investigated by enquiry or personally inspected are cited hereunder with short comments.

Such properties as have shipped or appear likely to ship in the near future are described at more length in the reports which follow the citations. The Province has been divided into districts for the purpose of general location.

Upper Coast District.

Alice Arm, Molybdenum Mining and Reduction Company, Limited.—Property situated 4 miles west of the end of Alice arm and on the north shore. This is a milling property already developed to some extent and equipped with a tramway and mill. (See p. 128 for detailed description.)

Caribou Group.—J. Wells, owner. Situated on Lime creek, across the arm, opposite the preceding property and at an altitude of 4,000 feet. The quartz in a wide granite stockwork of interlacing quartz stringers carries less than one-half of one per cent of bright flake molybdenite. Hand-sorting is impossible.

Portland Canal.—The Molly B. claim on the east side of Bear river near the town of Stewart is an occurrence of amorphous and flake molybdenite. Property not inspected.

Head of Bear River.—This locality is 17 miles above the Red Cliff mine and is an occurrence of flake molybdenite. No exact information obtained.

Ocean Falls.—A. Heino has a prospect on the mainland near Hunter island, consisting of flake molybdenite in quartz stringers. Heino is said to have brought 1 ton of 2 to 3 per cent ore to Vancouver.

Ketchikan.—E. A. Richardson, owner. Property situated 150 miles from Ketchikan, Alaska. Owner claims to have a large and valuable deposit. Specimen shown was a small piece of quartz with a little molybdenite attached.

Baker Island.—Near Prince of Wales island. Specimens shown were pegmatite with possibly 1 per cent of molybdenite. The ore on this property is said to be 100 feet wide.

Northern Interior District.

Atlin.—Between Bennett and Tutshi lakes, near Pavey station on the White Pass and Yukon railway. Owners believe they have ore of commercial grade and quantity.

White Pass.—H. A. Butler of Parksville, B.C., writes of a well-defined ledge near Glacier station, 8 feet wide, which carries a good percentage of molybdenite free from impurities.

Hazelton.—Specimen of quartzite rock carrying several per cent of molybdenite said to have come from within 4 miles of Hazelton.

Kitsumgallum Lake.—An occurrence of flake molybdenite in reddish quartz 5 miles north of the lake.

Skeena River.—A considerable deposit of molybdenite is reported to occur on Treasure mountain near Kitsalas cañon, or Usk station.

Kleanza Creek.—F. Jones and associates of Victoria, have been developing several quartz veins which carry molybdenite flakes, at a point 7 miles south of the Skeena river on the Telkwa trail. They proposed to hand-sort a shipment, but ceased work on the approach of winter.

Lower Coast District.

Jervis Inlet.—A. E. Blackwood and associates recently staked a wide showing of molybdenite near Pleasant lake, 5½ miles south of the inlet. Specimens show heavy flake molybdenite scattered through quartz and granite.

Knight Inlet.—J. D. Grayson and J. B. Otto of Victoria have narrow quartz veins which show heavy flake molybdenite. They proposed to hand-sort this ore, but left the property for a more promising deposit elsewhere.

Sechelt Inlet.—Vague reports of good showings of molybdenite near Clowham lake.

Burrard Inlet.—Gideon Bower of Vancouver is reported to know of occurrences of molybdenite in this locality.

Cypress Creek.—Assays of ore from this locality are said to have given high returns in molybdenum.(1)

(1) Annual Report, Minister of Mines, British Columbia, 1913, p. 301.

Vancouver Island.

Buttle Mountain.—Molybdenite is reported to occur on the Marguerite, Evangeline, and Josephine claims, about 5 miles north of Cowichan lake and on the north side of the mountain.(1)

Nanaimo.—J. H. Hawthornwaite of Victoria reported an occurrence in the hills.

Lower Mainland.

Lillooet.—The Index mine, 15 miles southwest of Lillooet on a ridge of 8,500 feet altitude between Texas and Cayuse creeks. This mine shipped 8 tons 300 pounds of sorted ore containing 15·7 per cent of molybdenite and is the most promising recent discovery in the Coast granites. (See p. 131 for detailed description.)

Stave River Group.—This property is owned by M. and D. Bouchir of Hatzie Prairie, B.C., and lies 7 miles north of the north end of Stave lake, on Stump creek. It has attracted attention during the past three years, but no ore has been shipped. This occurrence is of the pegmatite type with flake molybdenite along seams and in quartz veinlets.

Chilliwack Lake.—An occurrence on the mountain west of the north end of the lake. Owned by C. O. Lindeman. Specimens show molybdenite in an oxidized earthy powder.

Pitt River.—This property, owned by A. Hewitt and associates, is situated on Cañon creek, 10 miles from the north end of Pitt lake. Flake molybdenite is reported to occur in a series of quartz veins over a large area of granitic rock. It is claimed that the ore can be sorted up to 10 per cent.

Cheam View.—This occurrence, owned by Messrs. Knight, Dupres, and others, of Sardis, is on the south side of the Fraser river not far from Hope. Lenses or segregations of quartz in granite carry pockets of fairly high-grade mineral, but the extent of the deposit is small.

Lytton and Spuzzum.—Good flake molybdenite is reported from these places in various government reports. These localities were not seen.

Middle Interior District.

Grande Prairie.—This property, owned by C. A. Mackay and others, lies 20 miles south of Ducks on a low ridge 1 mile west of Salmon river. It has been examined by engineers for the Provincial Government.(2) This is one of the promising prospects, on which a considerable amount of work been done. The ore body is narrow but fairly-well mineralized and might be hand-sorted to some extent. (See p. 132 for detailed description.)

(1) Geol. Surv. Can., Ann. Rep., vol. X, 1897, p. 122A.
(2) Annual Report, Minister of Mines, British Columbia, 1915, p. 216.

Nicola.—A prospect 2 miles south of Mamette lake. Owned by Martin Bresnik and Jacob Zinc of Merritt, B.C.[1]

Southern Interior District.

Olalla.—The Golconda mine, owned by McEachern Bros., is 1 mile west of Olalla on a hillside 1,100 feet above the town. Several tons of high-grade ore have been taken from a small shaft which follows a narrow shoot or pocket of ore of uncertain direction; some chalcopyrite is associated with the ore and the country rock is a dark, basic, intrusive rock. (See p. 133 for detailed description.)

Champion Creek.—This locality was not visited. Dolph Galarneau has a prospect which shows low-grade or milling ore in a vein or band 8 to 12 feet wide and appears to have some promise. Samples taken across the ore body by G. Blair of Vancouver, contained over 2 per cent of molybdenite. The Champion Creek deposits were visited and described some years ago by Chas. Camsell.

Camp McKinney.—W. E. Younkin of Bridesville, has a narrow seam of micaceous material up to 18 inches wide which carries up to 11 per cent molybdenite. The property is 5 miles northeast of Camp McKinney and at an altitude of 7,500 feet.

Dayton Camp.—This occurrence of flake molybdenite is in a quartz vein 1 foot wide at a point 7 miles from Bridesville on the Camp McKinney road. A small shaft has been sunk on the vein by W. E. Younkin, the owner.

Susap Creek.—A prospect only, near Similkameen station on the Great Northern railway.

Ashnola Creek.—A prospect 5 miles up this creek which shows an occurrence of flake molybdenite in quartz.

Franklin Camp.—Chas. Camsell in his memoir on the geology of this camp refers to molybdenite prospects.[2]

Granite Creek.—A prospect only, situated one-half mile up the creek, 6 miles east of Tulameen. Owned by Michael Gaynor.

Greenwood.—A reported occurrence in the Argo tunnel, 1,700 feet from the entry, was examined and a sample taken which gave 0·21 per cent of molybdenite.

Kootenay District.

Lost Creek.—The Molly mine, 15 miles southeast of Salmo, has already produced from a shoot of high-grade ore in granite about 150 tons containing from 3 to 16 per cent of molybdenite. This mine, owned by H. C. Bennett

(1) Annual Report, Minister of Mines, British Columbia, 1915. p. 233.
(2) Geol. Surv. Can., Memoir 56, 1915, p. 172.

and associates, was for a time operated by the International Molybdenum Company of Renfrew, Ont. (See p. 132 for detailed description.)

Bear Creek.—A deposit near Salmo, on a southern branch of Sheep creek, was not seen, but is said to have several tons of ore exposed, of fair grade.

Tunnel (Lower Arrow Lake).—This property, owned by Fred Nothiger, lies near the railroad west of the Lower Arrow lake at an elevation of 5,500 feet. It shows many minor occurrences of molybdenite in granite. A considerable amount of prospecting and tunnel work has been accomplished, and four or five tons of sorted ore when sampled were found to contain 3·5 per cent of molybdenite.

Upper Arrow Lake.—An occurrence on the west shore nearly opposite Nakusp. Specimens consisted of quartz, containing a little flake molybdenite. Owned by R. J. Elliott of Nelson.

Rosebury.—At this place J. Tier has a much-faulted quartz vein 4 feet wide showing rosettes and flakes of molybdenite scattered through the matrix. Another occurrence, not visited, 2 miles up Wilson creek, is owned by J. C. Martin.

East Kootenay.—Molybdenite associated with bismuthinite is reported to occur on the St. Mary river.

DETAILED DESCRIPTIONS OF SOME OF THE PROPERTIES.

Molybdenum Mining and Reduction Company, Limited., Alice Arm, B.C.—Prof. J. M. Turnbull of the University of British Columbia, accompanied me when I inspected this property and has furnished me with a report, given further on, which deals more particularly with the tonnage possibilities.

The mine is situated on the north side of Alice arm, 15 miles from Anyox, and 4 miles from the end of the Arm at an elevation of 1,200 feet above tide-water. The wharf and mill are at the seashore. The mine, on the steep hillside, is connected with the mill by a double-rope tramway about one-half mile in length. (Plate XXXV.)

The country rock is a much dislocated slate formation containing many dykes and is at no great distance from the intrusive granite masses which appear further up the mountain-side.

The ore occurs in irregular veins or segregations of quartz occasionally dislocated by shearing and dyke intrusions which, no doubt, have had some effect upon the deposition of the molybdenite. At the surface, in a gulch, these quartz bodies show a considerable mineralization by molybdenite, especially on the breaking or cleavage joints. It is difficult to estimate the percentage of molybdenite in such cases, because the quartz does not carry evenly-distributed values. Such ore was supposed to contain from 2 to 4

Outcrop on property of Molybdenum Mining and Reduction Company, Alice Arm, British Columbia.

per cent molybdenite, and to the eye appears to be of that grade, but J. F. Mackenzie of the International Molybdenum Company found, by analysis, that some of the apparently nearly pure amorphous molybdenite, so common on the breaking-faces, carried over 40 per cent silica. To this was due an over-estimation of the values in a recent shipment of 350 tons, which was expected to contain over 3 per cent of molybdenite. The underground workings show a very considerable development of quartz, containing less than one per cent of molybdenite, also some ore of as high a grade as that on the surface, although perhaps less of it. I am told by W. F. Teetzel, that the shipment of 350 tons came from the raise and slope above the tunnel level, at a point marked No. 1 on Mr. Turnbull's sketch which accompanies his report. (See Fig. 2, p. 130).

Much of the molybdenite is of an earthy pulverulent character, sometimes slickensided. Fine flake is also carried by the quartz, necessitating crushing, possibly to 100 mesh, to liberate the mineral and I have at present no information as to how efficiently water or oil flotation will save it.

The question of tonnage is taken up in Mr. Turnbull's report, and since he paid more attention to that part of the examination, I will make no estimate, except to state generally that the showings and quality of the ore appear to justify the erection of a small mill of from 25 to 50 tons daily capacity. I can see no reason why the quantity of the ore and its quality should not be as good in depth as at the surface, but in underground mining much more work will be required to find the ore-shoots.

Mining is being done with air drills, 11 of all kinds from hand-pluggers to two-man machines. The aerial tramway appears to be well built and has auxiliary power at the upper terminal.

The mill contains a rock breaker of sufficient capacity, two pairs of rolls (a Nissen stamp is now being put in to follow the rolls), a slotted shaking-screen (which is unsuitable), and flotation units of the Callow and paddle-agitator types.

Transportation is by means of water carriage to Prince Rupert, costing under 50 cents per ton, thence by rail to points in Eastern Canada for approximately $16 per ton in carload lots. The ore body appears to merit the development so far accomplished. Thorough experimentation in a small mill, properly equipped, is necessary to determine the fineness to which the ore must be crushed and devise a method of concentration which will yield an efficient recovery of molybdenite.

The report furnished by Mr. Turnbull is as follows:

I attach hereto a sketch of the main workings of the Molybdenum Mining and Reduction Company's property at Alice arm, B.C., which consist chiefly of tunnelling at 1,200 feet above sea-level.

The ore occurrences vary in size and contents very rapidly in short distances, making accurate tonnage estimates impossible, and fairly reliable for short distances only.

Definite Ore.—This is chiefly confined to the east branch of the tunnel. Here there is a raise of 30 feet in ore, with a stope at the top which exposes good ore for a length of 20 feet or more, with a width of 4 to 6 feet (No. 1 on sketch plan). In the tunnel the ore is in two sections divided by a dyke. A cross-cut (No. 3 on sketch plan) opposite the raise, shows 10 feet of ore with a length of probably 25 feet, the inner end not being exposed. This might continue to cross-cut No. 6, say 125 feet. This ore is, however, quite lean and mostly doubtful. On the other side of the dyke 8 feet of good ore is reported in a small hole in the floor of the drift (No. 2 on sketch plan).

The management claims that the ore body exposed in these three showings will average 3 per cent. molybdenite, which seems high, but not very much too high.

Allowing a length of 40 feet, a depth of 40 feet including 10 feet below the drift, and an average width of 4 feet, would give approximately 500 tons of ore which may be considered definite as to tonnage, with good possibilities of extension, and of sufficient value to work. I consider 2 per cent of molybdenite fairly safe.

Probable Ore.—Along the surface, in the creek gulch, there are several outcrops, extending for a distance of 300 feet, but not continuous. Roughly these may be estimated as having a total outcrop length of 300 feet, and widths of 2 to 6 feet. Allowing 300 by 3 feet and a depth of 10 feet, gives approximately 700 tons of ore. These outcrops

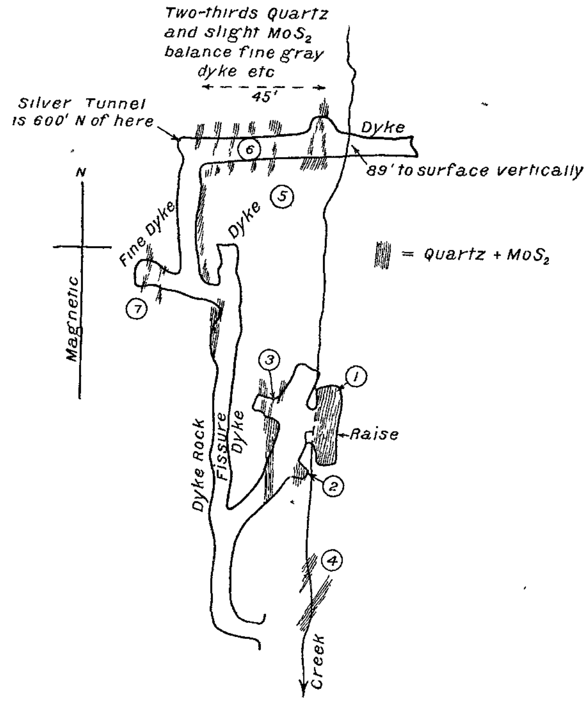


Fig. 2. Plan of lower tunnel, Molybdenum Mining and Reduction Co., Alice Arm, B.C.
Scale: 50 feet to 1 inch.

vary in quality, the average value not being known with any definiteness, but they probably contain considerably more than 1 per cent of molybdenite. Two of these outcrops are shown (No. 4 on sketch plan), the others extend up the creek toward the north.

Possibilities.—Eight hundred feet north of the tunnel mouth, and 250 feet higher in elevation, the apex of the vein enters another formation in which the mineralization changes to lead-silver-zinc. Above the tunnel level the unexplored vein area is roughly triangular with an area approximately 800 by 125 feet, less 25 per cent, say 75,000 square feet. To estimate this we have the above outcrops, and the showings in the tunnel which cover a length on the tunnel level of 200 feet. Unexplored area No. 5 may have a considerable width of quartz, as cross-cut No. 6 shows 45 feet width of quartz, with one-third barren rock included. Small stringers (No. 7) show that the full width of the ore zone has not been cross-cut. The values over these large widths, however, are very low. It may be possible to work small sections. Below the tunnel level the possibilities are unknown. Summing up the above, the present condition of the mine may be approximately represented as follows:

Definite Ore.—500 tons, containing 2 to 3 per cent of molybdenite which would correspond roughly to 20 or 30 tons of 65 per cent concentrate.

Probable Ore.—700 tons, containing 1 to 1½ per cent of molybdenite which would correspond roughly to 15 or 20 tons of 65 per cent concentrate.

Possibilities.—75,000 square feet area in the triangle above the tunnel, which would correspond to 6,000 tons per foot of width, which width, 1 foot, is about all that might be hoped for on the present indications, and is rather doubtful. There is a chance of considerable ore being found below the tunnel level.

The examination on which the above statement is based was made by me on September 1, 1916. No samples were taken, so that the values given are based on appearances, and information furnished by the management.

Index Mine, Lillooet, B.C.—This property, on the crest of a high mountain, at an altitude of 8,500 feet above sea-level, is situated between Texas and Cayuse creeks, 15 miles southwest of Lillooet, and became of some prominence in August, 1916. It is reached by a wagon road from Lillooet to Texas creek 12 miles, thence by a bad trail 15 miles long up Texas creek and the mountains to the north.

It was visited early in September by W. F. Robertson, Provincial Mineralogist of British Columbia, and a little later by Newton W. Emmens, M.E., who bonded it from the former owners, A. F. Hautier and J. B. Perkins. C. W. Drysdale of the Canadian Geological Survey also visited it about this time. My information is gathered from their accounts and from enquiry of a man named Bourgeois who did most of the work in taking out ore.

Under Emmens' management, a little more than 8 tons of 15·7 per cent ore were packed out by Indians and sent to the International Molybdenum Company at Renfrew, Ont. Then the mine shut down, as its position and preparation were unsuitable for winter work.

The ore body appears to be in the form of an impregnation of the granite along lines of weakness or shearing, but cannot be followed for any distance on the surface owing to the encumbrance of broken slide-rock. The principal work has been done on an ore body estimated to be from 18 to 24 inches wide containing high-grade ore such as was shipped. This ore body is not traced or developed beyond a few feet on the surface. Another attractive occurrence is a band of ore of lower grade containing 2 per cent molybdenite or better, which is said to have been traced several hundred feet.

Bourgeois, who is an old prospector and packer, thinks well of the property, and his impressions endorse the above statement of grade and extent. Probably the high-grade occurrences are in short patches or shoots as is usual with this mineral, and extensive prospecting is needed to prove the quantity of ore.

The Molly Mine, Lost Creek, B.C.—This property, some 8 miles by good wagon road southeast of Salmo, was the first shipper of molybdenite ore in British Columbia. In 1914-15, two carloads, said to contain about 52 tons of ore assaying from 12 to 15 per cent of molybdenite, were shipped to Denver, Colo. At a later date the mine was operated by the International Molybdenum Company of Renfrew, Ont., who first shipped 8 to 10 tons of 9 to 12 per cent ore and during the winter of 1916-17 made additional shipments of three carloads, containing from 3 to 7 per cent of molybdenite.

The ore body has been described by C. W. Drysdale in the Transactions of the Canadian Mining Institute for 1915. In September, 1916, when seen by the writer, the ore appeared to be in the form of a shoot 8 to 10 feet wide and 3 to 4 feet thick, dipping with the hillside, underneath a shell of granite. The granite over-mantle had been removed, resulting in an excavation 60 feet long. From the bottom of this open-cut the workings continued as a winze parallel to the surface of the hillside, the lower overlying mantle of granite being left in place. This winze was 20 feet deep and still in ore. About 70 feet below the winze a tunnel and cross-cut were being driven to intercept the ore body and to raise towards the winze; but ore had not, at the time of my visit, been found in these lower workings. However, I was informed later that ore had been found in the lower workings and 3 carloads of lower grade shipped. About February 15, 1917, the mine was shut down and future developments are unknown.

There are many occurrences of molybdenite in the vicinity of the workings and possibly other occurrences of high-grade shoots, but no large tonnage of milling ore was evident in September, 1916.

Grande Prairie Molybdenite.—This property is mentioned in reports by T. L. Walker (1) and W. M. Brewer.(2) The chief owner is C. A. Mackay, Adelphi P.O., Ducks, B.C.

The property is situated about one mile west of the Salmon river, on a ridge 750 feet above the river.

Hornblendic granites intruding a patch of the Câche Creek quartzites and limestone (Carboniferous), have sent out spurs causing intense metamorphism. Dykes of a more basic character are also present. The ore-bearing material is a narrow band of hard greenish silicious rock with much garnetite. This band, averaging 2 feet in width, strikes approximately north and south, and dips to the west at an angle between 30° and 45°. Câche Creek quartzites form the foot-wall, while crystalline limestone is in contact on the hanging-wall side. The band has been followed nearly continuously by open cuts for about 300 feet. There is one incline shaft 40 feet deep, said to be in barren rock at the bottom, and barren places also occur in the open-cut work. From these excavations, 50 to 75 tons of ore, carrying from 1 to 2 per cent of molybdenite, have been taken out. Representative specimens show the large flakes characteristic of this ore. There are many other excavations

(1) Report on the Molybdenum Ores of Canada, Mines Branch, Dept. of Mines, 1911, pp. 53-54.
(2) Annual Report, Minister of Mines, British Columbia, 1915, p. 216.

on this ridge showing some molybdenite, but the only promising concentration of values is in this 300 by 2½ feet of ore-bearing rock in contact with crystalline limestone. Some shipping-ore could be hand-picked, but the owners are unwilling to spoil the looks of the dumps, and prefer to sell, or to put in a small mill.

This property deserves some more development. It has so far proved neither rich nor extensive, but, as such properties go, is probably in the same class as the Molly, Lillooet, and Alice Arm mines, being of more importance than the many mere 'occurrences' which offer no promise. Moreover, this property can be developed as cheaply as any of them.

Golconda Mine, Olalla, B.C.—This property which lies one mile west of and 1,100 feet above the town of Olalla, is being worked by McEachern Bros. A mass of decayed pyroxenite or peridotite, with some silicification and showing the yellow oxide of molybdenum, forms the outcrop. This outcrop has been stripped for a length of about 15 or 20 feet. It is only a few feet wide and appears to strike in a northeasterly direction.

A shaft, 20 feet deep, shows the shoot of ore to be lying against a steep fault-plane or slip running southeasterly, or nearly at right angles to the surface outcrop. The ore forms a wedge-like body 3 feet thick near the collar of the shaft and tapers at the bottom to a few inches carrying slickensided molybdenite.

Two men have taken from this shaft about two tons of high-grade ore, which carried a little copper sulphide. The molybdenite is somewhat pulverulent, slickensided, and amorphous, but possesses a bright lustre. The ore may contain from 20 to 50 per cent. of molybdenite. The owners expect to take out 5 tons for shipment to Ottawa, and there is a good prospect of their being able to do so. There is a possibility of winning more ore from other chimneys or shoots, or even by following the one they now have.

This property deserves some attention, providing that the copper pyrites in the ore can be satisfactorily dealt with in the milling process.

PLATINUM

General

This metal is the most important of the platinum group which includes platinum, palladium, iridium, rhodium, osmium, and ruthenium. These metals, although constituting two transitional groups, are very closely related to each other. In nature they sometimes all occur associated together in what is commonly known as platinum ore, and are on this account usually spoken of as the platinum group of metals.

Platinum is a white lustrous metal possessing a very high melting-point and high specific gravity. It is exceedingly malleable and ductile and may be welded at a red heat.

Some years ago its principal uses were in the manufacture of jewelry, scientific laboratory utensils and apparatus, incandescent lamps, certain electrical devices such as spark-coils, magnetos, etc., and in dentistry. Since 1914, however, a very large quantity of platinum has been employed in the contact method of manufacturing sulphuric acid for war purposes, and as the metal is not used up or destroyed in this process a large portion will be available for other uses when the over-production stage has been reached. Considerable quantities are used in the ignition apparatus of all types of internal-combustion engines, so indispensable in war time, and although the termination of hostilities has somewhat lessened this demand, quantities of the metal will continue to be used for this purpose.

The unprecedented demand for the metal during the period of the war, with an equally abnormal increase in its market value, was the cause of some concern to all of the belligerents and naturally gave rise to the adoption of stringent regulations regarding its purchase and use in the fine arts. We are unaware of the precise nature of the difficulties experienced by the Central Powers through the scarcity of platinum, but no doubt the Imperial German Government had secured fresh supplies of the metal subsequent to the Russian debacle and therefore it is not improbable that they possessed a sufficient quantity of the metal to meet their actual war requirements. The Allied Governments and the United States were at the disadvantage of being unable to gain access to the platinum fields in the Russian Urals, and therefore were forced to look elsewhere for supplies. Up to the time that the United States declared war the Allied Powers prohibited the exportation of platinum to that country without special guarantees, fearing that it would come into the hands of the enemy, and therefore a large quantity was held in England, France, and Russia which the manufacturers of certain war-munitions in the United States were unable to obtain.

Prior to the war the world's supply of platinum was derived almost entirely from the Ural mountains, in Russia, and when hostilities commenced in the fall of 1914 the Russian production was reduced almost one-third, due principally to the conscription of miners for the Russian army. This curtailment of the normal supply was further aggravated by the fact that a very large quantity was required by the munition industries of England, France, and the United States in the manufacture of sulphuric acid, and also for the ignition apparatus of all types of internal-combustion engines.

Colombia, in South America, is second only to Russia as an important source of platinum. In 1913 its production was 15,000 ounces and that of Russia 250,000 ounces. In 1917 Colombia produced 32,000 ounces and the Russian output fell to about 50,000 ounces (estimated).

In 1906 the price of refined platinum varied from $20 to $38 per troy ounce, but by 1914 had increased to an average of $45 per ounce. At the end of 1915 the price advanced to $85, averaged $84 in 1916, and by December, 1917, had reached a figure of over $100 per ounce. In March, 1918, the United States Government made an official fixed price of $105 per ounce of refined platinum and adopted stringent regulations governing its purchase and exportation. In August, 1918, the British Government advised the Imperial Munitions Board at Ottawa that it was prepared to pay the official United States price for Canadian platinum.

Prof. J. L. Howe of Washington and Lee University, has recently thoroughly revised the figures regarding the total world production of platinum, and the following table, based on his figures, has been published by the United States Geological Survey:(1)

Estimated Total Production of Crude Platinum in the World to January, 1917, in troy ounces.

Country	Minimum	Maximum
Russia	7,115,482	10,128,308
Colombia	700,000	735,000
Borneo	175,000	200,000
New South Wales and Tasmania	9,000	10,000
Canada	9,000	10,000
United States	10,000	12,000
	8,018,482	11,095,308

From these figures it is estimated that the total supply of platinum metals in the world in 1917 was probably more than 10,000,000 ounces, of which about 1,000,000 ounces of platinum and 400,000 ounces of other metals of the platinum group were in the United States.

The world's production of crude platinum for the years 1913-1917 is estimated by the United States Geological Survey as follows:(2)

(1) Mineral Resources of the United States, 1917, Part I, p. 13.
(2) Ibid. p. 14.

Estimated World's Production of Crude Platinum, 1913-1917, in troy ounces.

Country	1913	1914	1915	1916	1917
Borneo and Sumatra	200	(a)	(a)	(a)	(a)
Canada	50	30	100	60	80
Colombia	15,000	17,500	18,000	25,000	32,000
New South Wales and Tasmania	1,500	1,248	303	222	(a)
Russia	250,000	241,200	124,000	63,900	50,000
United States	483	570	742	750	605
	267,233	260,548	143,145	89,932	82,685

Canada has up to the present been of very minor importance as a producer of this metal. From 1913 to 1918, inclusive, an average of about 1,800 ounces of metals of the platinum group is reported to have been recovered annually from the refining of Sudbury copper-nickel matte by the International Nickel Company in the United States, of which a little over one-third was platinum. Probably a somewhat larger quantity was recovered by the Mond Nickel Company at its refinery in England. In this connection it is interesting to note that the Mond Nickel Company is reported to be making a better recovery of platinum metals by its process of refining than the International Nickel Company has so far accomplished at its New Jersey works.

The report of the Royal Ontario Nickel Commission states that in 1916 the matte produced by the Canadian Copper Company was estimated to contain 5,640 ounces of platinum and 8,460 ounces of paladium, and that the recovery of these metals by the International Nickel Company in that year amounted to 1,093 ounces of platinum and palladium, together with 257 ounces of other metals of the platinum group. Recent research investigations conducted by the International Nickel Company have shown that it is possible to greatly improve its recovery of the platinum group metals and it is probable that these improved methods will be practised in the near future. The Mond Nickel Company did not furnish figures of platinum recoveries to the Royal Ontario Nickel Commission, but from assays made by that Commission it would appear that the Mond Nickel Company's matte contained more of the platinum-group metals than the matte of the Canadian Copper Company.

The British America Nickel Corporation, Limited, will employ the Hybinette process of electrolytic refining which is expected to make a more or less complete recovery of the precious metals in the matte.

Should the International Nickel Company succeed in recovering a high proportion of the precious metals, it is well within the range of possibility that the total production of platinum-group metals by the three companies will exceed 10,000 ounces annually.

Some years ago a considerable quantity of crude platinum was produced from the Tulameen district in British Columbia. There are no data for the quantity produced previous to 1885, but since that date the platinum recovered has been estimated by C. Camsell at from 10,000 to 20,000 ounces,[(1)] and at one time this district was the principal producer of platinum in North America.

In view of the apparent serious shortage in the world's supply of this metal and more especially because of its importance as a war mineral, the Secretary drew the attention of the Deputy Minister of Mines to the advisability of making a careful examination of certain Canadian localities, particularly the Tulameen district in British Columbia, known to contain the metal.

About the middle of March, 1918, the Secretary proposed to the Deputy Minister of Mines that the Department should organize a field-party to prospect the bench and river gravels in certain areas in British Columbia. This proposal was seconded by C. Camsell of the Geological Survey and also by Wm. Fleet Robertson, Provincial Mineralogist of British Columbia and member of the Minerals Advisory Board to this Commission. No action was taken by the Department of Mines, but the Deputy Minister promised the assistance of the Geological Survey if the Commission would undertake the work.

In May, William Douglas, barrister, of Toronto, informed the Secretary that in the fall of 1917 he had operated a bucket-dredge on the Saskatchewan river a few miles east of Edmonton, for the purpose of recovering black sands containing gold, platinum, and iridium. Mr. Douglas stated that in fifteen days operation in November, 1917, he had recovered 3,000 pounds of black sands which assayed 6 ounces of platinum and 14 ounces of gold per ton. Subsequently Mr. Douglas interviewed the Chairman of the Imperial Munitions Board, who then requested the Secretary of this Commission to undertake an examination of the Douglas property on the Saskatchewan river. This the Secretary assented to, and made immediate arrangements to have W. L. Uglow of the Commission staff proceed to Fort Saskatchewan, Alberta, where the Douglas property is situated. A preliminary report from Dr. Uglow contained the information that both platinum and gold were found to occur in the gravel bars, but that no reliable estimate could be made of the value of the property without careful examination by means of core-drills. Accordingly, a 4-inch Empire drill, the property of the Department of Mines, was shipped to Dr. Uglow early in July and he commenced operations about the 10th of that month.

While Dr. Uglow waited for the drill to come forward from Ottawa he received instructions from the Secretary to make a quick trip up the Peace river for the purpose of investigating certain alleged platinum discoveries near the junction of the Finlay and Parsnip rivers with the Peace river. His report on the possibilities of securing platinum in the Peace River district was not optimistic.

(1) Geol. Surv. Can., Memoir 26, 1913.

On June 28 the Secretary received the following letter from the Chairman of the Imperial Munitions Board:

> DEAR MR. MACKENZIE,
>
> The Ministry advise, confidentially, that they consider the development of the platinum resources in Canada of great importance, and ask us to take such steps as may be necessary under urgent pressure to develop existing plants or ascertain what can be done elsewhere.
>
> Under these circumstances can I ask you to arrange for increased activity in the investigations you are now carrying on in Saskatchewan? If it is possible for you to add two, or three, or four, additional parties with drills to your existing organization I will greatly appreciate the service being rendered.
>
> Yours truly,
>
> (*Sgd.*) J. W. FLAVELLE,
>
> *Chairman.*

After receiving the above letter, the Secretary had several consultations with the Chairman and his Assistant and was impressed with the necessity for vigorous action in the exploration of the platinum resources of Western Canada. The Assistant to the Chairman stated that the matter of expenditure was of secondary importance, and in view of the urgent request to develop latent possibilities the Commission should place several parties equipped with drilling apparatus in the field at once. Subsequently, the Deputy Minister of Mines, who had consulted the Imperial Munitions Board on the subject, received the same impression. However, after discussing this matter with the Deputy Minister, the Secretary decided hat the wisest course to pursue would be to thoroughly equip one party and to explore only those portions of the country which were known beyond doubt to have produced platinum in the past.

In order to personally superintend the field-work, the Secretary left Ottawa on July 6 and proceeded directly to Edmonton, thence to Fort Saskatchewan where Dr. Uglow was drilling with the 4-inch Empire equipment.

Two extra 6-inch Empire drills which had been ordered from New York were unfortunately delayed in reaching Fort Saskatchewan until about August 12; and as the Fort Saskatchewan work was completed on August 15 the 6-inch drills were not used for this particular job.

The Secretary remained with Dr. Uglow at Fort Saskatchewan until July 24 and then left for Vancouver to meet the Deputy Minister of Mines and C. Camsell, Resident Geologist for the Geological Survey in British Columbia, for consultation regarding other localities deserving of attention. Both of these gentlemen were of the decided opinion that the Tulameen river was the most likely source of platinum in British Columbia, and as this locality could be reached by the Kettle Valley railway, there would be no trouble experienced in moving the necessary working equipment.

Before proceeding to Tulameen, Mr. Camsell and the Secretary interviewed the Honourable William Sloan, Minister of Mines, and William Fleet Robertson, Provincial Mineralogist for British Columbia, who were much interested in the proposed work and promised every assistance. It was pointed out to the Minister that inasmuch as many of the old placer-mining leases on the Tulameen and Similkameen rivers were not in good standing, some provision might be desirable to hold ground for the Crown in the event of such ground being proved valuable. Mr. Sloan suggested that miners' leases could be taken out by agents of the Commission and any open ground, or ground not in good standing, could be staked for the Crown. This suggestion was forwarded to Ottawa for consideration but was not acted upon, supposedly for the reason that the Canadian Government did not wish to interfere with private interests.

Early in August, Mr. Camsell and the Secretary, accompanied by an expert panner, visited the Tulameen river for the purpose of making a preliminary survey of the possibilities of securing platinum. The result of a week devoted to a reconnaissance of the Tulameen and Similkameen rivers and Granite creek, a tributary of the Tulameen, was the decision that the Tulameen river between the town of Tulameen and the mouth of Slate creek, a distance of about 3 miles, should be carefully examined by means of placer drills. The following recommendation was telegraphed to the Imperial Munitions Board:

Tulameen, B.C., Aug. 10, 1918.

EDWARD FITZGERALD,
Imperial Munitions Board,
Ottawa, Ont.

Have examined Tulameen river and consider this stream most likely source of platinum, much better than Fort Saskatchewan.

Miners operating have small production this fall which am taking steps secure.

Larger production next year contingent upon dredge placed in commission, but thorough drilling should be completed preliminary to dredge installation.

Gravel to be examined approximately fourteen million cubic yards and drilling in approved manner will cost seven thousand dollars per month and require six months to complete.

Propose using five drills, three we have and secure two more on coast, also to continue drilling through winter if first two months results encouraging.

Provided that Government objects to expenditure will the Board finance and shall I proceed.

Answer at Tulameen until August fifteenth then Vancouver.

(*Sgd.*) GEO. C. MACKENZIE.

On August 14 the following telegram was sent to the Imperial Munitions Board:

Tulameen, B.C., Aug. 14, 1918.

EDWARD FITZGERALD,
Imperial Munitions Board,
Ottawa, Ont.

Result of drilling Fort Saskatchewan property unsatisfactory and have ordered all equipment moved to Tulameen, British Columbia.

(*Sgd.*) GEO. C. MACKENZIE.

On August 16 the Secretary received the following message from Mr. FitzGerald:

Ottawa, Aug. 15, 1918.

G. C. MACKENZIE,
Tulameen, B.C.,

Referring to your telegrams tenth and fifteenth.

We note you will now concentrate your work on Tulameen river.

Regarding specific question asked in last sentence your telegram tenth, we think we could not give expression of opinion in advance of Canadian Government deciding what action they shall take in the matter.

(*Sgd.*) FITZGERALD.

Notwithstanding the fact that the Imperial Munitions Board had pressed for prompt and energetic action in examination of platinum resources, the Secretary received no further communication from them until September 15, when the following message came to hand:

Ottawa, Sept. 14, 1918.

GEO. C. MACKENZIE,
510 Pacific Building,
Vancouver, B.C.

We cabled contents your telegram August tenth to Ministry regarding continuance of drilling operations at Tulameen river.

Ministry cabled today as follows: Ministry wish to know if you can estimate probable cost of platinum obtainable from this source and how interests of Government will be protected if capital expenditure suggested is authorized.

Please telegraph your views.

(*Sgd.*) FITZGERALD.

In answer to the above telegram the following message was despatched in code:

Tulameen, Sept. 16, 1918.

EDWARD FITZGERALD,
Imperial Munitions Board,
Ottawa, Ont.

Your wire September fourteenth.

Have made washing test on 90 cubic yards gravel and recovered $31.84 gold and platinum of which practically half by weight is platinum.

This is equivalent to 35 cents per cubic yard actually recovered.

Our methods crude and did not save more than 60 per cent total metals in gravel.

Assume dredge operating costs at 10 cents per cubic yard which is three times best California practice.

Assume fifteen million cubic yards available. Assume dredge will recover 25 cents or ·002 ounces each of gold and platinum per cubic yard which is conservative.

This totals 30,000 ounces gold and 30,000 ounces platinum recovered from fifteen million cubic yards gravel.

Assume dredge cost five hundred thousand dollars for capacity of five hundred thousand cubic yards monthly. Total cost including operating two million.

Total returns gold six hundred thousand dollars and platinum over three million dollars taking gold at twenty and platinum at one hundred and five per ounce.

There can be no protection for drilling expenditure unless Ministry intend to operate for recovery of metals.

British Columbia Minister of Mines assures that his Government will assist and protect to the limit of their jurisdiction.

Would suggest you ask Canadian Government to ascertain what protection could be secured through joint action Ottawa and Victoria.

We can stake and hold open ground for Crown as suggested my letter September third.

Ground now under lease can be secured by payment nominal royalty to owners who are willing to negotiate.

Bad weather is approaching and if work is to be undertaken I must make provision quickly. Therefore avoid delaying decision.

Platinum occurs here in commercial quantities present price and can be secured through expenditure of capital.

Will mail report next Saturday from Vancouver returning Tulameen twenty-fourth.

(*Sgd.*) GEO. C. MACKENZIE.

The Imperial Munitions Board acknowledged receipt of the above telegram and stated that they had forwarded a very large portion of the message to London, and had asked the British Ministry of Munitions for a reply.

On October 5, the following message was received from the Imperial Munitions Board:

Ottawa, Oct. 4, 1918.

GEO. C. MACKENZIE,
510 Pacific Building,
Vancouver, B.C.

We have cabled substance of your report to Ministry.

In reply they express great appreciation of your work and trouble in this matter and ask us to convey this appreciation to Mines Department.

They regret that they have to decide against proceeding with operations on lines you indicate.

The ground for this decision is that in view of the time required for exploration and for providing necessary equipment they do not anticipate that less than twelve months would elapse before appreciable quantity of platinum was secured.

This would not meet their purpose.

Apparently situation is purely an emergency one as they would like to hear if we find any source of quick supply.

(*Sgd.*) FITZGERALD.

On October 8, the Imperial Munitions Board furnished the Secretary with a copy of their cablegram B 8147, in which this proposition was laid before the British Ministry of Munitions. A copy of this cablegram follows hereunder:

Ottawa, Sept., 25, 1918.

REPRESENTATIVE,
Imperial Munitions Board,
London.

B 8147. M 5256 Regarding Platinum.

Expenditure of $7000 per month suggested by Mines Department is for drilling in district where indications are promising.

Mackenzie of Mines Department who is on the spot reports that ground is either open and can be staked for Crown under British Columbia mining laws or where not open can be secured by payment of nominal royalty.

His opinion is that platinum occurs in commercial quantities at present prices and can be secured by expenditure of capital.

If drilling results confirm his present opinion he suggests follow with dredging operations.

He estimates that on present indications recovery would be two ounces platinum and two ounces gold per thousand cubic yards.

He estimates cost of dredging ten cents per yard and initial expenditure five hundred thousand dollars.

He estimates fifteen million cubic yards available for dredging which could be treated at rate of five hundred thousand yards monthly producing one thousand ounces of platinum monthly on above estimate.

You will recognize that estimate is merely based on small washings and requires to be checked by regular drilling.

In any case dredging is an uncertain operation and commercially speaking is generally a gamble.

The immediate question is whether Ministry requires platinum in considerable quantities sufficiently urgently to justify them spending between $40,000 and $50,000 in drilling a promising prospect.

If so it would be determined after drilling whether results justified installation of dredging operations.

Drilling is an exploring operation and will not itself produce platinum in substantial quantities.

Can you get this question decided at once as Mackenzie reports that in view of seasonal conditions work must be begun at once if drilling is to be done this year.

We should be glad therefore if you would send immediate reply.

(*Sgd.*) IMPERIAL MUNITIONS BOARD.

It is to be noted that in the sixth paragraph from the bottom of the above cable the Imperial Munitions Board made the following statement:

In any case dredging is an uncertain operation and commercially speaking is generally a gamble.

The above statement is so inconsistent with the facts of dredging operations throughout the world, when these operations have been preceded by careful drilling, that the Secretary immediately sent the following telegram to the Imperial Munitions Board:

Vancouver, B.C., Oct. 8, 1918.

EDWARD FITZGERALD,
Imperial Munitions Board,
Ottawa, Ont.

Have received your telegram October fourth and regret decision of Ministry regarding Tulameen but will not stop operations until Canadian Government issue instructions.

Regarding your cable B-8147, September twenty-fifth, to Ministry, you state therein that *in any case dredging is an uncertain operation and commercially speaking is generally a gamble.*

This assertion is not true providing that dredging is preceded by careful drilling.

Camsell and myself consider your cable misleading in this particular and suggest you correct the erroneous impression which you have undoubtedly conveyed.

Ministry quite correct in estimating twelve months before any production secured, but they are in grave error in assuming that an emergency supply can be secured in this country.

(*Sgd.*) GEO. C. MACKENZIE.

To the above telegram the Imperial Munitions Board replied as follows:

Ottawa, Oct. 9, 1918.

GEO. C. MACKENZIE,
510 Pacific Building,
Vancouver, B. C.

Your telegram 8th received. We have transmitted same by cable to London today exactly as received.

(*Sgd.*) FITZGERALD.

No further communication was received from the Imperial Munitions Board regarding this subject and therefore it was taken for granted that either the British Ministry of Munitions was needlessly alarmed over the platinum situation, or else the officials who requested the exploration in June, 1918, did not realize the nature of the work involved by the request they made, and the impossibility of securing a quick supply of platinum as the result of this work.

Before leaving the subject of the correspondence on the platinum work, attention should be drawn to the following letter addressed to the Honourable Martin Burrell, Minister of Mines, and to Colonel Thomas Cantley, Chairman of the Munition Resources Commission, both letters being the same.

Ottawa, Oct. 22, 1918.

COLONEL THOMAS CANTLEY,
Chairman, Munition Resources Commission,
Ottawa, Ontario.

SIR,

In June last, in view of the serious situation with regard to the supply of platinum required for war purposes, arising out of the stoppage of platinum exports from Russia, this Board was requested by the Ministry of Munitions to ask the Canadian Government to investigate, as a matter of urgent importance, certain reports which had reached the Ministry of important platinum discoveries in British Columbia.

By the courtesy of the Mines Department and the Munition Resources Commission, Mr. Geo. C. Mackenzie, of the staff of the Department of Mines, and Secretary to the Munition Resources Commission, who had already lent most valuable assistance to this Board in several other matters, was allowed to undertake the investigation in question.

Following on this, Mr. Mackenzie and his assistants carried out a thorough investigation at various points in Alberta and British Columbia. As a result of these investigations Mr. Mackenzie reported that he had discovered a promising source of supply on the Tulameen river in British Columbia. Preliminary tests and washings which he made in this locality indicated that a considerable quantity of platinum might be obtained by dredging operations. A little later Mr. Mackenzie put forward a definite scheme for developing this supply—firstly, by means of drilling operations to test the ground, then, if drilling gave favourable results, by installing dredging operations.

Mr. Mackenzie estimated that there were on the Tulameen river fifteen million cubic yards of gravel with a platinum and gold content available for dredging, and that by dredging this gravel at the rate of five hundred thousand cubic yards monthly a recovery of 30,000 ounces of platinum would be made over the recovery period, besides 30,000 ounces of gold. He estimated the initial cost of the dredging operations at $500,000 and the operating costs over the period at not more than $1,500,000.

The substance of Mr. Mackenzie's report was communicated to the Ministry of Munitions who have now replied expressing their great appreciation of the work done by Mr. Mackenzie and of the assistance afforded by the Mines Department of the Dominion Government, but stating that as the proposed development would not be likely to produce any platinum earlier than twelve months from date, they are not able to authorize the Board to undertake it on behalf of the British Government.

It is understood from the various communications received from the Ministry that the position with regard to platinum has somewhat altered since last summer. The appeal made in Great Britain apparently resulted in an unexpected quantity of platinum being offered which was already available in that country in various forms. There is now a prospect of the Russian exportation being resumed. While the Ministry still require a further supply, they apparently require it immediately and in comparatively small quantity, and the prospect of a large supply which will not begin to be available till twelve months from date does not attract them.

In conveying the thanks of the Ministry of Munitions to the Mines Department and also to the Munition Resources Commission, the Board wishes to express its own sense of the zealous help given by Mr. Mackenzie in this as in other matters, and its regret that the investigations which he has so ably carried out cannot be made the ground for the development of further operations in Canada as far as the British Ministry of Munitions is concerned.

They trust, however, that these investigations may not be altogether fruitless but may form the ground for development either by the Dominion or Provincial Government, if the prospects of success and the commercial demand for platinum appear likely to justify such development.

A similar letter has been sent to the Minister of Mines.

Yours faithfully,

(*Sgd*) J. W. Flavelle.

The Chairman of this Commission, Colonel Thos. Cantley, replied to the above letter as follows:

New Glasgow, N.S., Oct. 26, 1918.

Sir Joseph Flavelle,
Chairman, Imperial Munitions Board,
Ottawa, Ontario.

Dear Sir,

I desire to acknowledge the receipt of your letter of October 22 last.

In view of Mr. Mackenzie's expression of confidence that the work so far done in the Tulameen district of British Columbia warrants further exploration with the possibilities of considerable quantities of platinum being secured, the necessary drilling should be undertaken with vigour at once. If this were done and such preliminary work results in proving platinum-bearing ground to the extent and value at present indicated, I can see no reason why dredging should not be put in operation by early spring, and a very considerable quantity of platinum won before midsummer next.

I regret that our efforts to aid the British Ministry in matters so far undertaken, have been rather disheartening. In the case of molybdenum, a great cry went up for an increase in production and conservation of this material, and an embargo was placed on the sale of it in Canada A good deal of prospecting and considerable development work was done, and the result so far as the purchase of this material by the authorities was concerned, was disappointing to practically all the operators who were induced to undertake the work.

In the case of platinum, it was understood some few months ago that the situation was serious, if indeed not desperate, and again serious efforts were made to meet the situation as then understood, by the Munition Resources Commission, as well as by others, and now when a reasonable prospect has resulted which we think would warrant further exploitation the Ministry advise that the matter is not of sufficient importance to warrant further exploration.

I have, however, much pleasure in thanking you for the kindly expressions of appreciation for the zealous assistance and painstaking work given Mr. Mackenzie, for this and the other matters in which the assistance of the Commission was enlisted. I desire to further add that if the Commsssion can now or at any time in the future be of assistance within their sphere of influence, they will be very pleased to co-operate in the heartiest manner possible.

Yours respectfully,
(*Sgd.*) THOMAS CANTLEY,
Chairman.

In a communication to the Secretary on October 23, Mr. Edward FitzGerald of the Imperial Munitions Board explained the general situation in terms similar to those in Sir Joseph Flavelle's letter to Colonel Cantley.

The following reply was addressed by the Secretary to Mr. FitzGerald, which apparently terminated the correspondence:

Tulameen, B.C., Oct. 30, 1918.

EDWARD FITZGERALD,
Imperial Munitions Board,
Ottawa, Ontario.

DEAR MR. FITZGERALD.

I have your letter of October 23 with enclosed copy of communication from Sir Joseph Flavelle addressed to Colonel Cantley and the Honourable Martin Burrell on the subject of platinum.

It is regrettable that the Imperial Ministry of Munitions did not make themselves perfectly clear when they introduced the subject in June last. If at that time we had been instructed to provide an emergency supply of only a few hundred ounces of platinum, we would have undoubtedly adopted somewhat different measures because there is every reason to believe that we could have accumulated the required amount through the purchase of scrap.

At the present time the fact that we have a small platinum refinery in Vancouver has attracted quite a lot of scrap, but I am confident that if this refinery was well advertised throughout the whole of Canada, the returns would be sufficient to meet present requirements. If this suggestion meets with the approval of the Board, the Minister of Mines should be asked to advertise the Vancouver refinery in the Canadian press and to continue advertising until the required amount of platinum is obtained.

I am not optimistic over the chance discovery of a rich deposit that will yield quickly an emergency supply. We are investigating a reported occurrence on Jervis inlet, because the samples brought in by the owners of the property were exceedingly rich in platinum, but how these samples were taken or what they represent is impossible to estimate without careful examination. We could very easily secure samples of Tulameen black sand that would assay many ounces of platinum, but they would not be accurate representations of the average value per cubic yard of gravel. The layman and the ordinary prospector have absolutely no sense of the mathematics of sampling, with the consequence that 'many are called, but few are chosen.'

Would you please convey my thanks to Sir Joseph Flavelle for his appreciation of our field-work? I feel confident that if the Canadian Government will continue the work, platinum in considerable amounts will be proved to exist in the Tulameen and adjacent streams.

Yours very truly,

(*Sgd.*) GEO. C. MACKENZIE.

Secretary.

Drilling operations were commenced with the 6-inch Empire equipment at Tulameen during the first week in September and were continued until December 2, when, owing to heavy snow storms, the work was stopped.

After the Imperial Munitions Board advised that the British Government was no longer interested in the drilling of the Tulameen river, the Secretary laid the whole matter before the Honourable Martin Burrell, who was then in Vancouver, and pointed out to him the desirability of continuing the attempt to prove the value of the ground, because all the equipment being on hand it would be unwise to stop operations until the Canadian Government had an opportunity of reaching some decision in the matter. Mr. Burrell agreed to this proposal and after returning to Ottawa instructed the Secretary to continue drilling operations until December 15, 1918.

In addition to the exploring of placer ground by means of core drills, the Commission engaged Mr. Wm. Thomlinson of New Denver, B.C., to examine, sample, and report upon certain occurrences of ores and minerals in British Columbia that were alleged to contain platinum. It was manifestly impossible to examine every occurrence brought to the attention of the Commission, as this would have entailed more work than time permitted and was beyond the capacity of the assay-laboratory facilities placed at the disposal of the Commission by the Department of Mines.

Mr. Thomlinson's instructions, therefore, were to confine his investigations to localities within easy reach of rail and steamboat transportation and exercise reasonable judgment in the sampling of occurrences, with regard to their possible commercial value in the immediate future. Mr. Thomlinson's work which is described in his reports entailed a great deal of travelling and required familiarity with the country. The fact that the Commission had undertaken this work of sampling and assaying absolutely free of charge, meant that Mr. Thomlinson's services were constantly in demand by prospectors and others who believed that they were in possession of claims which contained minerals carrying an appreciable quantity of platinum. It will, therefore, be recognized that in carrying out his instructions Mr. Thomlinson had to exercise some nicety of judgment in order to avoid useless work, and at the same time avoid overlapping the activities of others who have investigated some of these localities in the past. With due appreciation of these conditions, Mr. Thomlinson spent over three months in the field and completed his work with tact and resourcefulness in a manner highly appreciated by the Commission.

Many of the samples submitted by Mr. Thomlinson consisted of specimens of rock and ore in place, containing small proportions of platinum in a manner difficult of determination and in quantities rendering doubtful the commercial value of these deposits. For instance, the copper ores of the Franklin camp in the Grand Forks mining division were found to contain some platinum, apparently in association with chalcopyrite, possibly as sperrylite, the arsenide of platinum, and in order to recover this platinum, the copper ore would of necessity require to be smelted, bessemerized, and subsequently refined electrolytically. Therefore, it may be assumed that unless the Franklin Camp ores contain sufficient copper to warrant their exploitation for that metal alone, there is small likelihood of these ores being worked for platinum itself. On the other hand, black sands from placer operations and from the mechanical concentration of certain platinum-bearing rocks which contain the metal in the native state may possibly be treated by a special process of amalgamation, explained farther on in a report by Mr. W. B. Timm.

In order to provide facilities for the assaying of all field samples of platinum-bearing ores and sands collected by officials of the Commission, the Mines Branch, Department of Mines, undertook the equipment of a special laboratory at the Dominion Assay Office in Vancouver and transferred Mr. H. K. Anderson of the Mines Branch staff in Ottawa, to the Assay Office in Vancouver for the sole purpose of taking charge of this work. The securing of correct results in assays for platinum is not without certain difficulties and there are few chemists in this country who have had either the opportunity or training necessary for precision assaying of the platinum group metals. The Commission desires to make special acknowledgment of Mr. Anderson's services in this respect, knowing that his work was accomplished with great care and accuracy.

The Department of Mines established a small platinum refinery at the Dominion of Canada Assay Office, in September, 1918, which received up to the end of December 124·58 ounces of crude and scrap platinum, of which amount only 38·81 ounces were crude. The operation of this little refinery did, however, encourage prospectors to send their deposits to Vancouver, instead of, as formerly, to the Eastern United States. The Commission recommends that in order to encourage platinum production in British Columbia the operation of the Vancouver refinery be continued and arrangements be made to accept and valuate deposits for sale at the current market price.

Platinum Resources of the Tulameen District, British Columbia.

By GEO. C. MACKENZIE

The Tulameen district lies in the Similkameen mining division, in the southern part of the Province of British Columbia, and is reached from Vancouver via Ruby Creek Junction and the Kettle Valley railway. Leaving Vancouver in the morning at 8.30 it is possible to reach Tulameen the same day at 4.30 in the afternoon.

The Tulameen river is a small mountain tributary of the Similkameen river, and in the early days was worked energetically for placer gold. A considerable quantity of platinum has been secured from the Tulameen in the past, but as the price of this material at the time of these early mining operations was only from $5 to $10 per ounce not much attention was given to its recovery.

Placer sluicing with hand labour was the only method of mining in the early days, and while several attempts at drift tunnelling in the bench gravels were made, these ventures were on the whole unsuccessful, chiefly because of lack of equipment on the part of the operators.

Only the richest portion of the river that would pay to work by hand labour was attacked, and when the Cariboo gold rush came in the early sixties the Tulameen district was practically deserted for the more attractive fields in the north. However, small operators, both Chinamen and white miners, returned to the Tulameen from time to time and have always taken out more or less gold and platinum, making wages with every attempt.

All these operations were confined to the upper portions of the river where the gravels were not deep and to the deeper cañons where a plentiful supply of water under sufficient head gave opportunities for working the stream to bed-rock wherever pay gravel was found.

The ground in the Tulameen valley between the mouth of Slate creek, which enters the Tulameen 3 miles above the town of that name, and a point some twenty miles down-stream where the Tulameen joins the Similkameen river, has never been worked, owing to the fact that the gravels are heavy and very deep.

One or two attempts have been made to ascertain the depth and value of these gravels by boring with power-drilling outfits, but these attempts were not carried out systematically nor with persistence, and all that has been accomplished is two or three holes which are reported to have struck pay-gravel at various points on the Tulameen between the town of Princeton and Slate creek.

Both Camsell (1) and Kemp (2) have described exhaustively the occurrence of platinum in this district, and there is no need of further amplification. Both of these investigators determined the fact that platinum, associated with chromite and magnetite, originated with the pyroxenite rocks of the district. It is interesting to note in this connection that we were shown several small nuggets of platinum encrusted with chromite which the uninitiated might readily mistake for pure chromite or magnetite. When these small encrusted nuggets were immersed in dilute nitric acid for a short time the coating of chromite was dissolved away leaving the kernel of platinum.

During our investigation in the field there were no large nuggets of platinum discovered, but we were shown a very fine collection of nuggets,

(1) Geol. Surv. Can., Memoir 26, 1913.
(2) U. S. Geol. Surv., Bulletin 193, 1902.

Pot-hole mining, Tulameen river.

Tulameen river, opposite Slate creek.

Test wash of gravel, Tulameen river, B.C.

Valley of the Tulameen river above Otter creek, B.C., looking west.

the property of Mrs. Cook, of Coalmont. The largest of these nuggets was about the size of a large kernel of corn, and the smallest about the size of a grain of wheat. These nuggets have been on exhibition at various times and as they form a unique collection should be acquired for the museum of the Department of Mines in Ottawa.

The upper portion of the Tulameen river lying above the mouth of Slate creek has a more or less cañon-like character, the banks being very steep and precipitous, and this portion of the river is being worked at the present time by prospectors for the recovery of the precious metals. Some of these prospectors are working the high benches from 50 to 100 feet above the creek bottom, whilst others are attempting to recover the gold and platinum from pot-holes in the river-bed (Plate XXXVI); but the sum total of their operations is rather small, and the production of precious metals almost negligible, making little better than wages for the operators.

Below the mouth of Slate creek, and for 3 miles down-stream to the town of Tulameen, the character of the river is decidedly different. The river valley broadens to an average width of 900 feet, and the gravel lies in large bars and low-lying benches at depths that vary from 20 to over 100 feet. This is the area that should be prospected by means of core drills. The total quantity of gravel has been roughly estimated at 15,000,000 cubic yards, most of which consists of heavy coarse pebbles with many boulders the size of a football. Large boulders weighing many tons are occasionally encountered, but are by no means numerous and should not present any serious difficulties in dredging operations. (Plates XXXVI and XXXVII.)

The Kettle River railway touches the Tulameen river at the town of Tulameen, 3½ miles below Slate creek, and follows the river for a distance of approximately 20 miles to the town of Princeton. The question of transportation is therefore solved. The river valley between the town of Tulameen and Slate creek is not heavily timbered, although there is some quantity of poplar and jack pine with an occasional spruce of a good size and more rarely fir and red and white pine.

The river between Slate creek and the town of Tulameen drops 116 feet in a series of rapids interspaced with quiet stretches, and has an average rate of flow of about five miles per hour. The stream is not deep—probably the deepest holes directly below the numerous small rapids are not more than 15 feet. The average depth of the river at low water is about 1½ feet. Like all mountain streams, it is very turbulent in the spring of the year, but this condition should not seriously affect dredging operations if due precautions are taken.

In company with Mr. Charles Camsell of the Canadian Geological Survey, and an expert panner, the writer arrived at Tulameen during the first week in August and spent the following ten days in a preliminary examination of the gravels in the Tulameen and Similkameen rivers.

Samples taken during this preliminary work were sent to the Dominion

Assay Office in Vancouver, and the assay results are shown in the following table:

ASSAY RESULTS

Preliminary Investigation of Tulameen and Similkameen Rivers, Tulameen District, British Columbia

Sample No.	Location	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
1	Tulameen river, at mouth of Bear Creek.	Combined black sand from two pans of medium-size gravel.	67·36	50·56
2	Tulameen river, at mouth of Slate creek.	Combined black sand from five pans of medium-size gravel.	1·52	17·51
3	Same as No. 2.	Combined black sand from three pans of medium-size gravel.	29·27	38·40
4	Same as No. 2.	Pebbles of magnetite.	0·02	Trace
5	Same as No. 2.	Pebbles of chromite.	nil.	Trace
6	Similkameen river, two miles above Princeton on south bank of river.	Combined black sand from two pans of sandstone bed-rock.	5·91	5·86
7	Same as No. 6.	One pan of river gravel at edge of bed-rock.	15·84	6·98
8	Same as No. 6.	Combined black sand from two pans of sandstone bed-rock.	3·47	0·33
9	Same as No. 6.	Sandstone bed-rock, without panning.	0·02	Trace

Note: These assay results show the presence of gold and platinum, but do not indicate the value of the ground per cubic yard.

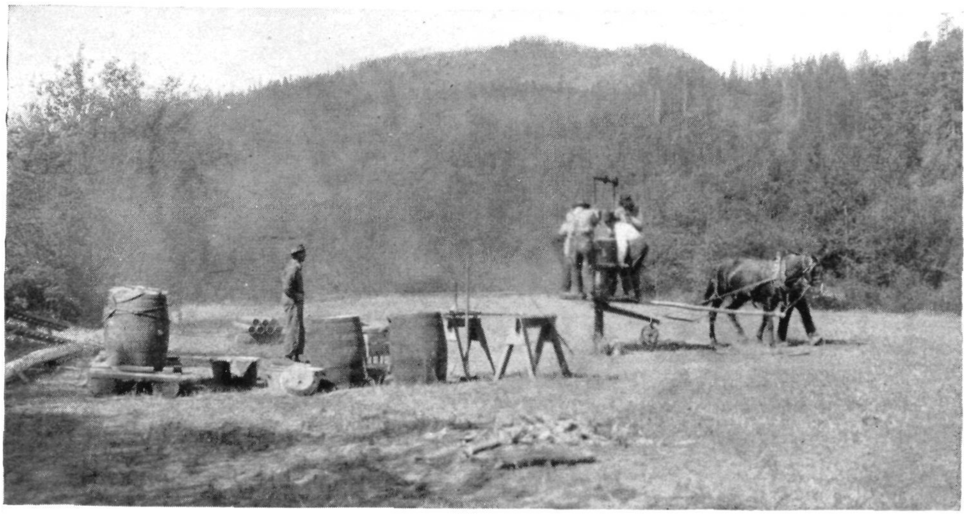
On August 9 the party motored from Tulameen to Princeton, and as the road follows the hillside immediately above the valley of the Tulameen river we had a good opportunity to inspect the character of this ground.

A considerable portion of the valley consists of low, flat, gravel bars containing a large quantity of gravel which, if it proved to be valuable, could be dredged.

At Princeton we called upon the managers of the Bank of Montreal and the Canadian Bank of Commerce, and secured from them statements, given below, of the deposits of platinum which they have received during the past few years. Both banks have, until quite recently, been in the habit of shipping their platinum to refineries in the Eastern United States. The managers promised to hold any that comes in and forward it to the Dominion Assay Office in Vancouver.

PLATE XXXVIII.

Keystone drill in operation, Tulameen river, B.C.



Empire drill in operation, Tulameen river, B.C.

Crude Platinum purchased by the Bank of Montreal, Princeton, B.C.

Date.	Depositor	Weight		Value
1916		Oz.	Dwt.	
Mar. 31	Thompson, C. W.	2	5	$ 135.38
April 18	Schubert, J. A.	3	4	166.17
May 26	Cook, F. P.	2	1	102.49
June 13	Schubert, J. A.	4	9	168.99
July 13	Schubert, J. A.	2	15	114.54
	Cantril, A. N.		11	21.22
Sept. 14	Schubert, J. A.	4	7	272.43
Oct. 30	Schubert, J. A.	2	9	152.51
Nov. 28	Thompson, Chas. W.		17	45.72
1917				
June 30	Wing Kong	1	15	123.85
July 9	Howse Co., A. E.	4	1	291.95
26	Schubert, J. A.		15	47.77
31	Schubert, J. A.	3	5	236.22
Aug. 18	Yin, c/o Wing Kong	4	8	318.31
Sept. 4	Wing Kong	8	2	566.84
5	Lung Kee	2	3	148.65
5	Schubert, J. A.	1	4	81.74
Oct. 10	McTavish, I.		4	13.10
15	Schubert, J. A.	3	7	224.01
23	Thompson, Chas. W.	1		66.77
Nov. 20	Thompson, Jos.	1	3	71.37
1918				
Feb. 20	Schubert, J. A.	2	10	160.11
Mar. 22	McTavish, I.	1		61.69
	Totals	57 oz	15 dwt	$ 3591.83

Crude Platinum purchased by the Canadian Bank of Commerce, Princeton, B.C

Year.	Oz.
1915	8·685
1916	2·365
1917	12·527
1918 (to Aug. 9)	5·250
	28·827

Returning to Tulameen, the party made camp at the mouth of Slate creek and decided to undertake sluicing on a small scale for the purpose of experimental tests.

Making use of an old ditch near the mouth of Slate creek, we coupled up some three hundred feet of sluice-boxes and washed 90 cubic yards of medium-size gravel (Plate XXXVII). Bed-rock was stripped and cleaned over an area of 20 square feet at the upper end of the sluice, but no bed-rock was reached at its lower end. The operations were carried out in two tests. In the first test 27 cubic yards of gravel was washed from the upper end of the sluice and the ground cleaned to bed-rock. In the second test 63 cubic yards of gravel was washed but bed-rock was not reached. The black sand caught in the sluice-boxes was cleaned by means of rockers and forwarded to the Dominion Assay Office at Vancouver for recovery of both gold and the platinum group of metals.

The results of these tests are given in the following tables and show the actual values of the precious metals recovered:

Result of Washing Test on Tulameen River opposite Slate Creek

TEST NO. 1. Washed 27 cubic yards of gravel.

	Weight	Value	Value per cu. yd.
	Oz.	$	c.
Gold recovered	0·078	1.56	5·8
Platinum recovered	0·061	6.40	23·7
	0·139	7.96	29·5

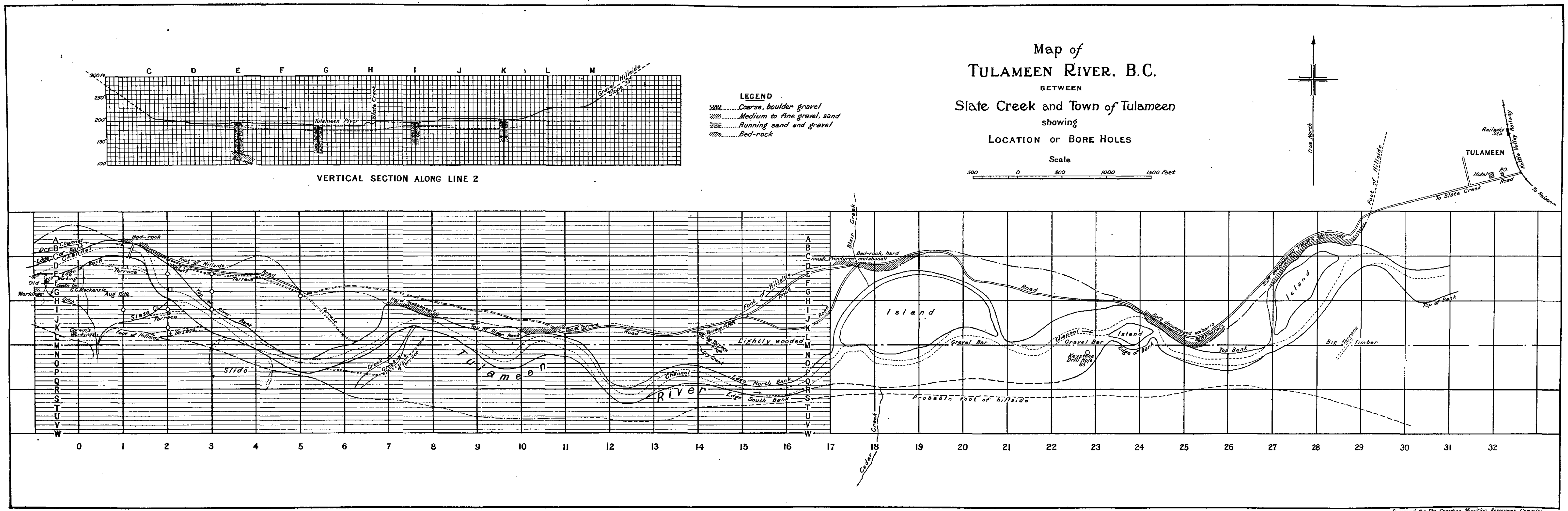
TEST NO. 2. Washed 63 cubic yards of gravel.

	Weight	Value	Value per cu. yd.
	Oz.	$	c.
Gold recovered	0·2224	4.45	7·06
Platinum recovered	0·1859	19.51	30·96
	0·4083	23.96	38·02

TOTAL RESULTS. From 90 cubic yards of gravel (Combined results of Tests Nos. 1 and 2).

	Weight	Value	Value per cu. yd.
	Oz.	$	c.
Gold recovered	0·3004	6 01	6·67
Platinum recovered	0·2469	25.91	28·78
	0·5473	31.92	35·45

It should be noted that our appliances and methods were necessarily crude, and it is doubtful if the saving of the precious metals exceeded 60 per cent of the original content of the gravel.



Map of
TULAMEEN RIVER, B.C.
BETWEEN
Slate Creek and Town of Tulameen
showing
LOCATION OF BORE HOLES
Scale
500 0 500 1000 1500 Feet
True North
LEGEND
Coarse, boulder gravel
Medium to fine gravel, sand
Running sand and gravel
Bed-rock
VERTICAL SECTION ALONG LINE 2
TULAMEEN
Railway Sta.
Hotel
P.O.
To Slate Creek
Road
To Nelson
Island
Gravel Bar
Channel
Keystone Drill Hole B5
Top Bank
Big Terrace
Timber
Probable Foot of hillside
Foot of Hillside
Blair Creek
Cedar Creek
Bed-rock, hard
much fractured metabasalt
Soft decomposed volcanic
Edge of Bank
Lightly wooded
Edge North Bank
Edge South Bank
Tulameen
River
Slide
Slate Creek
Terrace
Top of River Bank
Hard metabasalt
Dry Creek
Old Channel
Edge of Bank
Old Workings
G.C. Mackenzie Aug 1918
Corwin's Workings
Surveyed for The Canadian Munition Resources Commission by W.L. Uglow, 1918.

Both gold and platinum were found to be in small rounded and flat grains. Some of these when examined under a strong magnifying glass showed sharp edges, indicating that they had not travelled far from their source. None of them could be called nuggets as they usually weighed less than one milligram.

After completion of the washing tests described in the preceding paragraphs it was decided that the results obtained justified more extensive examination of the ground. Dr. Uglow was therefore instructed to commence a survey of the Tulameen river between Slate creek and the town of Tulameen. While this survey was in progress the Empire-drill equipment was in transit from Fort Saskatchewan, Alberta.

Drilling with the Empire hand-equipment was commenced in September, and after the completion of 3 holes, the deepest being 62 feet, it was decided to install a power-drill of the Keystone type, as the gravels were too heavy and tight to allow of much speed being made with the Empire equipment.

The chief advantage of the Empire hand-drill is its mobility. It will take down so that the largest piece to be transported does not weigh more than 250 lb., and, providing that the gravels to be examined are not heavy and do not contain too many boulders, considerable progress can be made with this equipment. The manufacturers claim that the essential feature of the Empire is the rotation of the casing during the entire drilling operation. A platform is mounted on the top of the casing upon which four labourers stand and alternately lift and drop the drill rods to which are attached the drilling tools. Providing the ground is not very tight and does not consist of heavy gravel, the rotation of the casing by means of horse-power together with the weight of the equipment and the men on the platform will sink the casing as drilling proceeds, and the core of sand and gravel accumulated in the inside of the casing is pumped out as fast as it forms. (Plate XXXVIII.)

A power-drill of the Keystone type works in a somewhat different manner. The casing is driven into the ground for every foot made and as a general rule progress is made by alternately driving for one or more feet and then pumping the core accumulated from the previous driving. When exceptionally large boulders are encountered, drilling below the casing is resorted to and is generally permissible. The Keystone casing is larger and heavier than the Empire, and is driven by means of two steel driving-blocks bolted to the drilling-stem, the total weight of which is approximately 800 lb. In driving, some fifty to sixty blows are struck per minute with a fall of approximately 14 inches, and it is an exceptionally large boulder that cannot be drilled through, broken up, or pushed to one side by this heavy and continuous pounding. (Plate XXXVIII.)

When starting with the Empire drill it was quickly demonstrated that the ordinary Empire method of working would not make progress in heavy gravel, and it was therefore decided to erect a tripod over the drill platform and with an ordinary pile-driver trip employ a 500-pound driving-block of fir in order to drive the casing in the same manner as a Keystone casing is driven. With this equipment, and using a horse to lift the driving-block, from two to four blows were struck per minute and considerably better progress was made than by allowing the casing to sink simply by rotation. Notwithstanding this additional equipment the Empire could not keep pace with the Keystone, and the power-drill was eventually used exclusively.

Drilling was continued until December 2, when a heavy fall of snow held up operations, and as no provision had been made to continue during the winter months, the work was stopped and the outfit stored in Vancouver.

From the comparatively small amount of work accomplished it is difficult to arrive at definite conclusions regarding the value of the Tulameen gravels, but it can be stated that results, incomplete as they are, warrant further investigation.

Eleven holes were put down, the deepest being 72½ feet and the shallowest 11 feet, with a total of 516 feet drilled. Six holes were put down to bed-rock, the others being stopped at depths at which the values did not warrant further drilling. Bed-rock was found to consist of a rather hard, green, quartz schist, which on panning yielded no black sand but abundance of fresh iron pyrites. Both gold and platinum were found to occur in small scales and pellets with an occasional gold 'colour' approximately ½ milligram in weight. Platinum in the ore samples could not be distinguished from drill-steel cuttings, and therefore no log could be made of its occurrence during drilling operations. Gold 'colours,' however, were logged in the customary manner.

Core samples, consisting of the total quantity of black sand from each hole, were forwarded to the Dominion Assay Office, Vancouver, and in every case the whole sample was melted down for assay. This entailed a great deal of work, but was considered necessary because of the difficulty in accurately cutting down to assay-ton samples. No attempt was made to amalgamate gold in the field because in the recovery of both gold and platinum by large-scale operations ordinary methods of amalgamation would not apply.

Complete data and results from the drilling operations are given in the accompanying table. If this table be studied in conjunction with the map of the Tulameen river prepared by Dr. Uglow (Plate XXXIX) it will be noted that only a very small portion of the ground has been covered. Consequently, nothing definite can be stated regarding the value of the ground for dredging operations on a large scale.

A definite conclusion can be reached only by completing the drilling of the ground. This, of course, would involve the expenditure of considerably more money, but all the necessary equipment is still on hand.

Acknowledgments are due to Dr. W. L. Uglow and Mr. Wm. Thomlinson, who superintended the camp and all drilling operations.

DETAILED RESULTS OF SAMPLING TULAMEEN GRAVELS BY CORE DRILLS*

(Gold valued at $22.67 and Platinum at $105 per troy ounce)

No. of hole	Drill used	Depth of gravel Ft.	Depth of gravel In.	Depth of sample in feet From	Depth of sample in feet To	Gold from assay of sample	Gold value per cu. yard of gravel represented by sample	Platinum from assay of sample	Platinum value per cubic yard of gravel represented by sample	Total gold and platinum value per cu. yd of gravel for each hole	Remarks
		Ft.	In.	From	To	Milligrams	Cents	Milligrams	Cents	Cents	
E 2	Keystone	70	5	0	50	5·37	7·13	8·35	5·62	5·50	Started in coarse sand and gravel. Drilled 7 inches into oxidized schist bed-rock.
				50	60	0·80	0·53	0·37	1·24		
				60	70·5	1·40	0·88	1·38	4·44		
E 3	Empire	14	6	0	18·5	3·80	1·80	8·58	21·10	22·90	Four feet of silt on top of gravel. Bed-rock struck at 18·5 feet similar to E 2.
G 2	Keystone	61		0	10	0·36	0·24	1·55	5·22	1·98	Started in coarse gravel. No bed-rock struck.
				10	20	1·41	0·93	0·85	2·86		
				20	30	0·36	0·24	0·18	0·60		
				30	40	0·32	0·21	0·18	0·60		
				40	50	trace	....	0·03	0·10		
				50	61	0·02	0·01	0·34	1·14		
G 3	Empire	23	6	0	26	3·02	1·00	3·30	5·80	6·80	Two and one-half feet of silt on top of gravel. Bed-rock struck at 26 feet similar to E 2.
H 5	Keystone	38		0	20	1·66	0·55	0·10	0·17	14·50	Seven feet of silt on top of gravel. Bed-rock struck at 45 feet same as E 2.
				20	30	94·58	62·84	0·04	0·13		
				30	40	1·52	1·01	0·28	0·94		
				40	45	0·08	0·11	trace	....		
I 1	Keystone	67		0	20	0·08	0·26	0·06	0·10	6·70	Five feet of silt on top of gravel. Bed-rock struck at 72 feet same as E 2.
				20	30	0·86	0·57	0·07	0·23		
				30	40	0·96	0·63	1·60	5·39		
				40	50	5·80	3·85	3·46	11·66		
				50	60	0·42	0·28	0·07	0·23		
				60	67	1·56	1·48	7·30	24·60		
I 2	Keystone	50		0	10	0·10	0·07	0·20	0·67	0·80	Started in coarse gravel. No bed-rock struck.
				10	20	0·12	0·08	0·28	0·94		
				20	30	0·16	0·11	0·14	0·47		
				30	40	0·04	0·03	0·16	0·53		
				40	50	0·06	0·04	0·36	1·21		
I 3	Empire	59		0	55·5	0·47	0·01	3·03	1·84	2·72	Three feet of silt on top of gravel. No bed-rock struck.
				55·5	59	1·36	3·49	0·02	0·26		
I 5	Keystone	48		0	20	0·96	0·318	0·94	1·58	1·47	Started in coarse gravel. Bed-rock struck at 48 feet same as E 2.
				20	30	0·72	0·47	0·17	0·57		
				30	40	0·12	0·08	0·04	0·13		
				40	48	0·20	1·66	0·60	0·25		
K 2	Keystone	46		0	20	19·25	6·39	1·22	2·05	3·44	Four feet of silt on top of gravel. Bed-rock not struck.
				20	30	0·16	0·11	0·06	0·20		
				30	46	0·06	0·24	trace	....		
L 5	Keystone	7		0	7	trace	....	0·10	0·48	0·30	Three feet of silt on top of gravel. No bed-rock struck. Work stopped on account of heavy snowfall.

* The assays were made at the Dominion Assay Office, Vancouver, B.C.

Amalgamation Tests by a New Method on Platinum-Gold Concentrates from the Bullion Mine, Cariboo District, British Columbia.

By W. B. TIMM

A sample of about six pounds of platinum-gold concentrates was received by the Ore Dressing and Metallurgical Laboratories, Department of Mines, Ottawa, from the Bullion mine, Cariboo district, British Columbia, through the Canadian Munition Resources Commission.

The sample was submitted for testing amalgamation of the platinum group of metals by a new method devised by V. J. Zachert,(1) which consists of sprinkling zinc-amalgam on the dressed plates, the pulp being fed over the plates in a weak solution of copper sulphate and sulphuric acid. An electro-chemical action takes place forming a permanent coating of copper on the platinum, which in passing over the plates is held by the mercury.

One-half of the sample received was taken and crushed to 150 mesh. A sample was cut out for assay. One pound of the material through 150 mesh was placed in a bottle with 200 c.c. of a 0·05 per cent copper sulphate and 0·05 per cent sulphuric acid solution. One-tenth of a pound of mercury to which had been added 1 gram of powdered zinc-amalgam was put in the bottle and the bottle gently rolled for 10 minutes. The contents of the bottle were then panned to recover the mercury, and the tailings sampled and assayed.

The results of this test were as follows:

	Gold. Oz.	Platinum. Oz.
Pulp before amalgamation.....	0·25	0·013
Pulp after amalgamation......	0·15	0·006
Retort sponge.................	0·14	0·004

Extraction: Gold, 40 per cent; platinum, 54 per cent.

Another pound sample was taken of the 150-mesh material and placed in the bottle with 200 c.c. of a 0·1 per cent copper sulphate and 0·1 per cent sulphuric acid solution. One-tenth of a pound of mercury, to which was added 1 gram of powdered zinc-amalgam, was put in the bottle and the bottle gently rolled for 10 minutes. The contents of the bottle were panned to recover the mercury and the tailings sampled and assayed.

The results were similar to those obtained from the preceding test.

The tailings from these two tests were then put into a pebble jar with 400 c.c. of a 0·1 per cent copper sulphate and 0·1 per cent sulphuric acid solution. One-fifth of a pound of mercury to which was added 2 grams of powdered zinc-amalgam was put in the jar and the whole revolved for one

(1) Process for recovering Platinum. V. J. Zachert. Mining and Scientific Press, Oct. 12, 1918.

hour. The contents were then panned to recover the mercury and the tailings sampled and assayed.

The results obtained were as follows:

	Gold. Oz.	Platinum. Oz.
Pulp before amalgamation.....	0·12	0·007
Pulp after amalgamation......	0·10	0·005

Extraction: Gold, 17 per cent; platinum, 30 per cent; or a further extraction of 8 per cent gold and 15 per cent platinum.

The remaining portion of the original concentrate was then ground to 200 mesh and sampled for assay. One side of a set of standard amalgamation plates was partitioned off and the plates dressed. The upper two plates were sprinkled with powdered zinc-amalgam. A quantity of 0·2 per cent copper sulphate and 0·2 per cent sulphuric acid solution was made up and fed with the pulp over the plates. The tailings were panned to remove any mercury which had been carried over and then sampled and assayed.

The results of the test were as follows:

	Gold. Oz.	Platinum. Oz.
Pulp before amalgamation......	0·10	0·003
Pulp after amalgamation.......	0·06	0·001

Extraction: Gold, 40 per cent; platinum, 66 per cent.

Summary and Conclusions.—Results of the last test performed in a commercial way were similar to the bottle tests. There is a large variation in the two head-samples of the same material, illustrating the difficulty in getting an accurate sample. The accuracy of the above tests is doubtful owing to the low platinum-gold content of the material on which the tests were conducted.

An Investigation of an Alleged Occurrence of Platinum on the Peace River, B.C.

By W. L. UGLOW

In accordance with instructions received from Mr. G. C. Mackenzie on June 2, 1918, I visited and examined the gold-platinum placer deposits of Messrs. Wadleigh and Sanders, on the Peace river, British Columbia.

These properties are located along the Peace river between the upper end of Rocky Mountain cañon and the junctions of the Finlay and Parsnip rivers with the Peace river. They may be reached during the summer season by steamer from Peace River Crossing to Hudson Hope, and from that point by 14 miles of wagon road over the Rocky Mountain portage.

The properties consist of: (a) Dredging lease on the Peace river from the upper end of Rocky Mountain cañon to the mouth of Wicked river, a distance of 75 miles (15 claims, each 5 miles long). (b) Ten bench claims (each 1,500 by 2,350 feet) on the alluvial flat at Twelve Mile point. (c) An interest in 8 bench claims (each 1,500 by 2,350 feet) on Braman's flats. (d) Fifteen bench claims just above Rocky Mountain cañon.

During the period of my examination in June, high-water conditions prevailed in the Peace river, and all the bars were submerged. The river was from 800 to 2,000 feet wide (between high-water marks) and was flowing at a rate of from 5 to 10 miles per hour. The level of the river during this period was about 19 feet above low-water level. Consequently, the only examination possible was confined to the benches and cut-banks along the edges of the river.

On May 28, 1918, the leaseholders commenced an investigation of their properties with a Union drill, the boring being under the direction of J. W. Neill, of Pasadena, California. One hole was bored on a bar in the river a short distance above the cañon, but the ensuing high-water relegated the rest of the boring operations entirely to the benches. The most promising ground in the bench leases was believed to be on Braman's flats, about 25 miles up the river above the cañon, and a wagon road was being cut along the north shore of the river for the purpose of moving the equipment up-stream to this objective. Holes were bored at intervals near the course of this road to test the ground as it was traversed. From the following information received from J. W. Neill, it will be seen that the bore-holes were practically blanks:

No. 1.—On a river bar just below Beattie's cabin, at upper end of portage.
Depth 0-27 feet; gravel
" 27-45 " ; quicksand.
Pannings from total hole gave 1·5 mg. of gold but no platinum.

No. 2.—On a bench just below Beattie's cabin, and 300 feet east of it.
Depth 0-12 feet; soil and silt.
" 12-25 " ; gravel.
No gold or platinum.

No. 3.—At the foot of a high bench, 2,300 feet east of Beattie's cabin.
Depth 0-23 feet; soil and silt.
" 23-25 " ; gravel.
No values in gold or platinum. Only a few very fine specks of gold.

No. 4.—On the top of a high bench, one-half mile east of Beattie's cabin.
Depth 0-5 feet; soil and silt
" 5-16 " ; gravel.
Pannings showed a few very fine specks of gold but no platinum.

No. 5.—On a bench under the influence of a creek delta, 5 to 6 miles west of Beattie's cabin.
Depth 0-13 feet; soil and silt.
" 13-24 " ; gravel (wash).
At depth 13 feet 5 inches, two small 'colours' were obtained which may have been platinum, and only traces of gold.

No. 6.—On a bench above the creek valley, near Eight Mile creek.

Depth 0–4 feet; soil and silt.
" 4–28 " ; gravel with intervening layers of silt.
No values of any kind.

On Wednesday, June 12, A. C. Galbraith, J. W. Neill, and myself made a 17-mile trip on foot with packhorses upstream to Braman's flats, which was believed to be one of the most promising pieces of ground on this part of the river. Platinum had been reported from this locality and one piece, valued at $1.00, was said to have been recovered about a year previously.

The area is comparatively level, sparsely timbered, and is at an elevation of from 4 to 15 feet above the high-water level of the river. A pronounced terrace, 10 to 15 feet in height, crosses the flat through station WS10, running about N. 20° W. (mag.). Fine sand and silt, varying from 3 to 10 feet in depth, cover the gravel of the flat.

The ground was sampled at the points marked WS 1 to WS 14 on the sketch.(1) Some of these samples were taken from cuts made into the gravel of the river bank, a few were taken from the gravel and silt in the walls of old pits and small shafts, while others were taken from old dumps of gravel from caved pits. On account of the high water the bars were flooded, and no samples could be obtained from them.

At each point selected for testing, a panful of the gravel or the silt was taken, representing a weight of from 23 to 28 pounds. This material was panned by J. W. Neill, and the number and character of 'colours' obtained was recorded. If the pannings gave any suggestion of the possibility of pay material, another panful of the dirt was taken, screened dry into a small sack, and boxed for shipment to the Dominion Assay Office, at Vancouver, B.C. If the pannings were negative in character no sample was taken.

The following table gives the results of the panning tests and also of the assays of these samples made at the Dominion Assay Office:

Sample WS 1.—From a trench cut into the river bank.

Depth 0–9 feet; silt.
" 9– " ; gravel.

One panful of gravel from the top 18 inches showed 8 to 10 fine gold 'colours' but no platinum. One panful of silt from the bottom of the silt showed 1 'colour' of platinum and 30 'colours' of gold.

One panful of gravel from 3½ feet below top of gravel showed 6 'colours' of gold.

The sample represents the fines through a $\frac{3}{16}$-mesh sieve from one panful of gravel taken from a vertical cut 3½ to 4 feet below top of gravel. Assay results were nil.

Sample WS 2.—From a cut made into the river bank.

Depth 0–4 feet; silt.
" 4– " ; gravel.

(1) Sketch has not been reproduced for this report.

One panful of fine silt and gravel from the upper part of cut showed 1 'colour' of gold. One panful of gravel representing a vertical cut $4\frac{1}{2}$ feet below top of gravel, showed 15 'colours' of fine gold.

The sample represents the fines through a $\frac{3}{16}$-mesh sieve from along this same vertical cut. Assay results were nil.

Sample WS 3.—From an old pit 10 feet deep.

Depth 0–8 feet; silt.
" 8–10 " ; gravel.

One panful of fine sand on top of gravel showed 3 'colours' of platinum and 5 to 10 'colours' of gold. One panful of fine gravel from just below fine sand showed 4 'colours' of platinum and 30 to 40 fair-sized 'colours' of gold.

The sample represents fines from 1 panful of this fine gravel. Assay results gave traces of both platinum and gold.

Sample WS 4.—Sample represents one panful of fine sand overlying WS 3. Assay results gave traces of both platinum and gold.

Sample WS 5.—From a cut into the river bank.

Depth 0–4 feet; silt.
" 4– " ; gravel.

Two panfuls of gravel, one from the upper 1 foot and the other from a depth of 3 feet, yielded nothing but black sand. One panful of gravel from a depth of 4 feet in the same cut showed nothing.

No sample was taken for assay.

Sample WS 6.—From a cut into the river bank.

Depth 0–3 feet; silt.
" 3– " ; gravel.

Two panfuls of gravel taken, one from a vertical cut 5 to 7 feet, and the other from 7 to 8 feet below top of gravel, showed no values.

No sample was taken for assay.

Sample WS 7.—From an old dump.

One panful of gravel from the dump showed 10 to 12 fine 'colours' of gold but no platinum. Two panfuls of silt from same dump each showed 1 small speck of gold. No sample was taken for assay.

Sample WS 8.—From an old pit.

Depth 0–10 feet; silt. No gravel exposed.

One panful of silt from cut in side of pit showed about 100 very fine specks of gold but no platinum.

This sample represents a vertical cut of $1\frac{1}{2}$ feet on the side of the pit. Assay results gave traces of both gold and platinum.

Sample WS 9.—From an old pit.

Depth 0–3 feet; silt. No gravel exposed.

One panful of silt taken from a depth of 3 feet in the side of the pit showed about 15 specks of gold but no platinum. No sample was taken for assay.

Sample WS 10.—From an old shaft 10 feet deep.

Depth 0–6 feet; silt.
" 6–10 " ; gravel.

One panful of this gravel (at depth of 6 to 9 feet) showed 1 small speck of gold but no platinum. No sample was taken for assay.

Sample WS 11.—From an old pit.

Depth 0–6 feet; silt.
" 6– " ; gravel.

One panful of gravel taken from the dumps showed about 25 'colours' of gold (one fair-sized scale) but no platinum. No sample was taken for assay.

Sample WS 12.—From an old pit.

Depth 0–7 feet; silt. No gravel exposed.

One panful of silt taken from 4 to 5½ feet vertically on the wall of the pit showed absolutely no values.

Sample WS 13.—From an old pit.

Depth 0–8 feet; silt. No gravel exposed.

One panful of gravel taken from dump showed no values.

Sample WS 14.—From a gravel bar near high water.

One panful of gravel taken from a hole to water-level showed 10 to 15 'colours' of very fine gold but no platinum. No sample was taken for assay.

From this brief preliminary examination which I was permitted to make of the large placer-holdings of Messrs. Wadleigh and Sanders, I would draw the following conclusions:

The values in gold and platinum are usually in the form of very fine scales and specks, which are beyond any ordinary methods of recovery. In places, however, scales of gold were found, which were of such a size that 1 'colour' per pan would represent about 1 cent per cubic yard. The best panning represented 26 cents per cubic yard ('colours' weighed). Out of a total of 22 localities tested by J. W. Neill with the Union drill, and by myself, only 3 showed any platinum at all.

The whole flat had been tested by pits and worked in a desultory fashion, both by Chinese, and by some white placer-miners about a year ago. Their chief work appears to have been confined to the point of the flat near WS 3 and WS 4, and this is the locality from which the platinum previously found is reported to have come. During my investigation, I found that whatever values there were, were very largely confined to this small area.

From all the information that was available, it seems that the values are confined more or less to the very points of the flats, and to the gravel spits, and that the values are of the nature of surface enrichments.

The possibility of obtaining platinum from dredging operations could not be investigated on account of the high-water; but the swift current of the river, the high floods, and the shortness of the working season would render dredging operations difficult and expensive.

As a result of my examination, both A. C. Galbraith and J. W. Neill were satisfied of the futility of further explorations and immediately closed down and moved all the equipment out of the district.

In no respect are these properties as worthy of exploration by the Munition Resources Commission as the Douglas property on the North Saskatchewan river.

The Sampling of some Platinum-bearing Lodes and Placers in British Columbia*

By WM. THOMLINSON

I left Vancouver, B.C., on August 2, 1918, and proceeded to Grand Forks in the Boundary district, for the purpose of taking ore samples at the Maple Leaf lode mine in the Franklin camp, Grand Forks mining division.

Franklin Camp, Grand Forks Mining Division.

I arrived at Franklin on August 5, and arranged with Mr. Louis Johnson, manager of the Union mine, for accommodation during my stay in the camp.

Union.—On August 6, as Mr. H. W. Young, manager of the Maple Leaf mine, had not yet arrived in camp, I looked over the Union mine with Mr. Johnson, and took several samples which were later assayed by the Dominion Assay Office, Vancouver, B.C., for gold and platinum with the following results:

Sample No.	Claim	Description	Gold per ton	Silver per ton	Platinum per ton
			Oz.	Oz.	Oz.
T 1	Union	Oxidized material from outcrop of vein	trace	...	trace
T 2A	"	Pannings from oxidized material from outcrop of vein..	7·20	40·36	trace
T 2B	"	Ore-pulp, representing six cars of ore shipped. Supplied by Mr. L. Johnson....	0·38	...	trace

The following day Mr. H. W. Young arrived and showed me over the various workings on the claims of the Maple Leaf group.

Maple Leaf Group.—On the 7th, 8th, and 9th of August, I took seven general samples and one special from the workings on the Maple Leaf group of claims, after which I personally broke down, quartered, and prepared them for shipment to the Dominion Assay Office, Vancouver, B.C.

The only samples from the Maple Leaf group found to be of importance as to platinum content were those taken from a large open-cut on the upper portion of the Maple Leaf claim.

Two cars of ore had been shipped previously from this open-cut, the copper contents of which were said to have been 5·6 and 9·6 per cent, respectively; and according to Mr. Young, each ton of ore shipped contained nearly one-quarter of an ounce of platinum, for which the owners were not paid.

**Editor's note:* Assays from panning samples show the presence or absence of platinum and gold, but are no guide to the value of the original gravel or other material from which the samples were panned.

The main copper-bearing mineral seen in this open-cut is chalcopyrite, occurring in bunches, veinlets, and as disseminated particles in the lode-gangue which consists of pyroxenite and augite syenite.

The lode occurs at a contact or zone of magmatic segregation, the pyroxenite being under the augite syenite and probably a basic segregation from the same magma.

At the lower workings on the Beaver claim, the lode material is quite different from that in the open-cut just described, and the copper minerals are mainly of a secondary character.

The platinum contents of the samples taken here were traces only. Results of assays by the Dominion Assay Office, Vancouver, B.C., are as follows:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 3	Maple Leaf	From small vein at north end of claim........	trace	trace
T 4	"	From small vein, 175 ft. from centre post, north end....	trace	trace
T 5	"	From 12-inch streak of altered rock crossing short drift near shaft at upper workings......	trace	trace
T 6A	"	From main open-cut at upper workings. A large general sample of all ore-minerals in sight in the cut. Taken by hand-cobbing ore similar to that in two carloads previously shipped by owners........................	0·04	0·15
T 6B	"	From same open-cut as T 6A. Taken as check sample, in same manner.............	0·04	0·17
T 7	Beaver	General sample from an 85-ft. drift at lower main workings............................	trace	trace
T 8	"	General sample of apparently the best ore in lower workings............................	0·03	trace
T 9	"	Special sample of material indicated by Mr. Young, who stated it gave a malleable bead of white metal on fusion with soda...........	trace	trace

The above assay returns and my own observations when taking samples, led me to conclude that in the ores from the Maple Leaf claim the platinum content was roughly proportionate to the primary sulphides in the ores, especially to the contained chalcopyrite.

Some time after my samples were taken, Mr. J. J. O'Neill of the Geological Survey of Canada, met me in Grand Forks, and being much interested in the mode of occurrence of the platinum in the ores from the Maple Leaf mine, visited the mine with me and personally took a special sample for assay.

Mr. O'Neill took his sample from the main open-cut on the Maple Leaf claim (where I took samples T 6A and T 6B), but his sample was taken from a mass of almost pure chalcopyrite occurring in the pyroxenite, near the margin of the augite syenite, on the hanging-wall side of the lode.

This sample showed a content of 0·38 ounces of platinum per ton, which appears to confirm the view that the contained platinum in the ore is closely associated with the primary sulphides found in the pyroxenite-syenite zone, known locally as the 'Black Lead.'

A detailed description of the geology of the Franklin camp, with maps showing the Maple Leaf and other mining claims, will be found in a memoir of the Geological Survey of Canada by C. W. Drysdale.(1)

The presence of platinum does not appear to have been known when the memoir was written. A detailed description is given of the 'Black Lead' or pyroxenite zone.

The encouraging results from assays of samples previously taken at the Maple Leaf mine, and the fact that the pyroxenite zone or dyke on which the Maple Leaf mine is situated outcrops on at least a dozen other mining properties in the camp, led me to obtain permission for my return to the camp to sample some of them.

After finishing my work along the Lardeau river, West Kootenay, British Columbia, I returned to Grand Forks and reached Franklin camp on September 17, 1918.

As the few men then in Franklin camp were practically all employed on road-building, I had some difficulty in securing a suitable guide and helper for the work of finding and sampling the various properties. However, Mr. Louis Johnson of the Union mine, was good enough to undertake the work and proved to be a reliable and agreeable assistant.

The Lucky Jack claim, situated about 4,000 feet northeasterly from the Maple Leaf mine, was the first property sampled, and the following results were obtained by the Dominion Assay Office, Vancouver, B.C.:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 41	Lucky Jack	From dump of pyroxenite at mouth of short drift near west end-line. Sample taken from selected pieces of dark-coloured close-grained rock, showing fine particles of chalcopyrite, some pyrite, and small crystals of a whitish metallic mineral..........................	trace	0·08
T 42A	"	From small shaft about 200 ft. easterly from above-mentioned drift. Taken from lens of dark, close-grained rock at southeast corner of shaft, near the bottom. Rock contained fine particles of chalcopyrite, some pyrite, and specks of a darker mineral....................	0·04	0·04
T 42B	"	From open-cut near east end-line. Taken from selected pieces of medium-grained pyroxenite containing particles of chalcopyrite, some pyrite, and stained by copper carbonates.....	0·04	0·06

(1) Geol. Surv. Can., Memoir 56, 1915.

Mountain Lion.—The workings on this claim are at a contact between pyroxenite and a greenstone, where there is a large exposure of sulphides and oxides of iron showing very slight indications of the presence of copper-bearing minerals. Samples taken, and assay results obtained by the Dominion Assay Office, Vancouver, B.C., were as follows:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 43	Mountain Lion	From small shaft and large open-cut on the ridge about 1,000 ft. west of shaft on the Gloucester claim. Mostly oxidized pyroxenite and iron sulphide.	trace	0·09
T 44	"	General sample from small shaft and large open-cut. Mainly decomposed pyroxenite and reddish-brown oxides of iron....	0·02	0·02

Golden Age.—The claim is situated about 2,000 feet southeasterly from the Mountain Lion claim and is reached by a trail along the ridge running in that direction. On this property the contact zone appears to be split up and less regular than at other points along the so-called 'Black Lead.' This is shown by the scattered positions of the various small shafts and open-cuts on the property. A sample was taken, and the following assay obtained by the Dominion Assay Office, Vancouver, B.C.:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 45	Golden Age.	From small shaft near southwest end of claim. Mainly oxidized pyroxenite showing sulphides and oxides of iron with fine particles of chalcopyrite and stains of copper carbonates.. .	trace	0·06

Averill Group.—This property is situated on Franklin creek, about three miles up the creek and one-half mile north of it. It is reached by trail from the main road at the mouth of the creek. The pyroxenite here is very coarse in texture and occurs as a large lenticular mass entirely within the area of augite syenite. Two samples were taken, and the following are the assay results obtained by the Dominion Assay Office, Vancouver, B.C.:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 46	Averill group	From dump at lower drift near the cabin. Broken from selected pieces of coarse-grained pyroxenite associated with fine-grained syenite, showing specks and small masses of chalcopyrite with a few fine particles of bornite...........	trace	0·09
T 47	"	From dump at upper shaft. Selected pieces of coarse-textured pyroxenite containing some chalcopyrite and a few particles of bornite....	trace	0·09

The largest and most continuous outcrop of the pyroxenite-zone or 'Black Lead' is found northeast of Franklin creek in the northwest corner of the camp.

Mr. B. J. Averill of Grand Forks, kindly gave permission to use his cabin on the Averill group of claims as headquarters during the sampling in this section of the camp.

During recent years practically no work has been done on the properties on Franklin creek, west of the Averill group, consequently the trails are in bad condition, and sometimes almost impassable on account of fallen trees.

The workings on several of the claims were hard to find owing to fallen timber and second-growth brush.

Buffalo Group.—During the evening of September 23, I made a preliminary visit to the Buffalo group, succeeded in finding all the main workings, and took several hand-specimens of the mineral-bearing pyroxenite, which I sent to Mr. C. Camsell, British Columbia Branch Office, Geological Survey, at Vancouver, B.C.

The pyroxenite on the dump from which the sample T 48 was taken has decomposed to a large extent as the result of exposure for over six years and now forms granular masses from which the contained sulphides are gradually being liberated.

The samples taken from the Buffalo group and the assay results obtained by the Dominion Assay Office, Vancouver, B.C., are as follows:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 48	Buffalo	From dump at old shaft below and near trail at southwest end of claim. Pyroxenite, containing small masses and particles of chalcopyrite, some pyrite, and a few stains of copper carbonates.	trace	0·19
T 49	"	From several open-cuts in dry ravine below trail near southeast corner. Selected pieces of chalcopyrite with some pyrite.	trace	0·08
T 50	Ottawa	From large open-cut on side-hill north of and near trail and cabin. Selected pieces of pyroxenite containing magnetite, pyrite, and specks of chalcopyrite...	trace	0·06
T 51	Columbia	From dumps of two drifts on side-hill north of cabin on north bank of Franklin creek, Selected pyroxenite containing some pyrite and chalcopyrite.	none	0·04

On the claims to the northwest of the Buffalo group copper-bearing minerals appear to become scarcer, and magnetite and other minerals more plentiful; but this may be more apparent than real, as the pyroxenite out crop here is very large and very little development has been accomplished.

Careful and systematic investigation of the pyroxenite is necessary to show where the segregations of the economic minerals are most frequent, the average value of such segregated zones or masses, and also to decide the best method of separating the useful minerals from the worthless gangue.

Most of the minerals noted in the pyroxenite appear to be sulphides and oxides, and therefore are likely to be amenable to concentration by means of tables or vanners, supplemented by the flotation process. The mode of occurrence of the platinum has not yet been determined, but I think that it may occur mainly in the form of sperrylite, the arsenide of platinum, and closely associated with the sulphides.

Castle Mountain, near Cascade, Grand Forks Mining Division.

Having heard that samples of chromite from near the town of Cascade had been found to contain platinum, I left Grand Forks on August 12, and went to Cascade to examine the chromite-bearing rocks on Castle mountain.

The following samples were taken, and assayed by the Dominion Assay Office, Vancouver, B.C.:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 10	Cerargyrite	Fine green serpentine with some oxides of iron and altered rock, from the face of an open-cut near the bottom and from upper side of a lens of chromite	none	none
T 11	"	From same cut as T 10. General sample of chromite on dump and in the lens. *Note:* Mr. Phillips stated that rock from cut had assayed 0·56 per cent nickel, and the chromite over $9 per ton in platinum	trace	trace
T 12	Midnight	From open-cut toward north end of claim. Banded chromite enclosed in fine green serpentine. *Note:* Mr. Phillips stated that a sample of the clean chromite gave $3.60 per ton in platinum	trace	0·015
T 13	Blacktail Fraction	From the main workings, open-cuts on the north lens of ore. Soft reddish-brown oxidized material from streaks in the serpentine and from near the lenses of chromite	trace	trace
T 14	Blacktail	From the main workings, open-cuts on the north lens of ore. General sample of chromite being taken out for shipment	0·02	0·02
T 15	Mastodon	From line of open-cuts where chromite was being mined for shipment. Soft altered rock with some firm serpentine containing grains of chromite. Taken at request of Supt. T. C. Eastman who wished material tested for platinum	0·05	trace
T 16	"	From all the main workings, open-cuts. General sample of the chromite being mined for shipment	0·01	trace
T 20	Blacktail	From open-cuts on north lens of ore. Special sample of granular chromite enclosed in amethyst-coloured spar	0·06	none

With Mr. W. S. Phillips of Cascade, B.C., as guide, I examined all the properties from which chromite was then being shipped and also looked over a number of partly-developed claims on which small bodies of chromite were exposed in open-cuts and trenches.

The following casual samples were received from the several persons named, and assayed for gold and platinum by the Dominion Assay Office, Vancouver, B.C.:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 17	Fife mines, about 3 miles northeasterly from Cascade, B.C.	Copper-gold ore. Received from W. S. Phillips, Cascade, B.C. ...	0·12	trace
T 18	Sophie creek, near Rossland, B.C.	Chromite-bearing rock. Received from Angus Cameron, Cascade, B.C....	none	none
T 19A	About 11 miles southeast of Cascade, B.C., near monument No. 172 on International Boundary line.	From small area of peridotite (var. harzburgite). Received from Angus Cameron, Cascade, B.C....	0·01	none
T 19B	Same as T 19A	Same as T 19....	trace	trace
T 52	Near mouth of Franklin creek, North fork of Kettle river, Grand Forks mining division B.C.	Black sand pannings. Received from B. J. Averill, Grand Forks, B.C....	0·32	0·03
T 53	McDonald creek, a branch of Franklin creek.	Black sand pannings. Received from B. J. Averill, Grand Forks, B.C....	none	0·09
T 54	Said to be from points on West branch of North fork of Kettle river, B.C.	Black sand, said to be pannings. Received from J. Donaldson, Grand Forks, B.C....	trace	0·06

McDonald creek crosses the outcrop of the 'Black Lead' in the Franklin camp, and the presence of platinum in placer sample T 53 would appear to confirm the presence of platinum-bearing material in the large pyroxenite mass on the Blue Jay and Buffalo claims at the head of the creek to the north.

The presence of platinum in sample T 54 appears to indicate, if the data furnished are correct, that platinum-bearing rocks occur at points to the west and southwest of Franklin camp. The Boundary camps may, therefore, be found to contain many areas of serpentinized peridotites and pyroxenites, all or any of which may prove to be platinum-bearing and would be worthy of careful exploration.

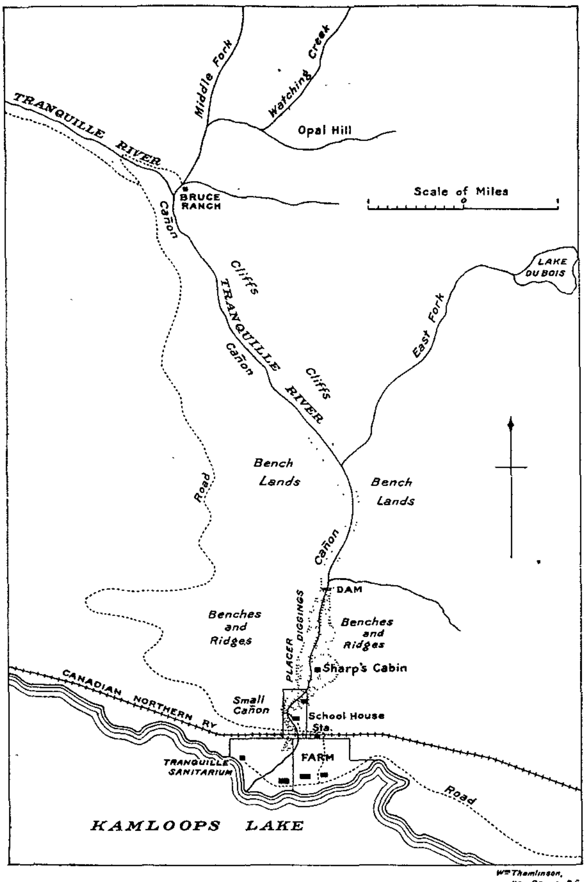
Rock Creek, Greenwood Mining Division.

In accordance with your instructions I moved from Grand Forks to Rock creek, in the Greenwood Mining division, to take samples of 'black sand' from the creek in the vicinity of the old placer workings there. It has been persistently reported for many years that platinum had been found in the placers at Rock creek, but on making careful enquiries in the district I could find no one who had ever panned out or seen any platinum from the local diggings. However, I examined most of the old placer workings on the creek and panned out 'black sand' at numerous points along the channel of the main creek and on the south fork. Hank Wilmott, James Copland, and others are still doing a little placer mining here.

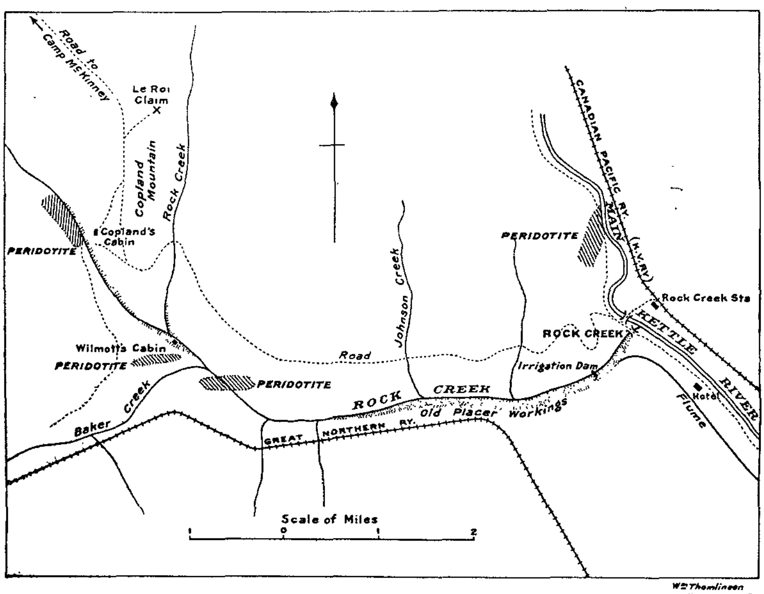
I examined a small area of peridotite found about 1¼ miles north of Rock Creek townsite on the west side of the Kettle River valley, where chromite 'float' had been found a few days before my arrival and a number of lode claims staked.

The main road from Rock creek to Beaverdell crosses the area, and masses of serpentine and talcose material are exposed in several of the grade-cuts along the road. Some exploratory work was being done to ascertain if chromite occurs in place, but so far I have not heard of any important find. The samples taken were assayed by the Dominion Assay Office, Vancouver, B.C., with the following results:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 21	Brookside lode claim, west side of south fork Rock creek, near James Copland's placer workings.	From peridotite dike.	none	none
T 22	James Copland's placer claims, south fork of Rock creek.	'Black sand' pannings..	0·30	none
T 23	Bench on same claims as T 22.	'Black sand' pannings.	0·05	none
T 24	Le Roi lode claim, Copland mountain, between north and south forks of Rock creek.	Pannings from large mass of oxidized material from the outcrop	0·16	none
T 25	Along Rock creek, for about 1 mile above irrigation dam.	Pannings from gravel bars.. . . .	0·11	none
T 26	Along main channel Rock creek, below irrigation dam about 500 feet from mouth of creek.	'Black sand' pannings..	0·03	none



Sketch map of portion of Tranquille river, Kamloops mining division, B.C.



Sketch map of Rock creek, Greenwood mining division, B.C.

Judging from the extensive old placer workings along Rock creek above the irrigation dam, this portion of the creek must have been the main gold-producing area when placer operations were being carried on some thirty years ago. (Plate XL.)

Vicinity of Kaslo, Ainsworth Mining Division.

Instructions to investigate a reported find, by Mr. A. J. Curle, of platinum-bearing material near Kaslo were complied with when on my way to the Lardeau River placers, in the Trout Lake mining division.

I arrived at Kaslo on the evening of August 28, and met Mr. Curle the following day. Arrangements were made to visit the place where the material previously sent in by Mr. Curle had been obtained. We left Kaslo by train at 6.30 a.m., and after arrival at the mouth of the south fork of Kaslo creek, walked about 9 miles up the South Fork wagon road to the Index mine. After lunch we returned down the wagon road about 1 mile to a point where a rock-slide from a mountain lying to the south reaches the road.

The rock fragments forming this slide consist of various phases of the local granodiorite, and range from those containing mainly blackish-green ferro-magnesian silicates to angular feldspathic fragments of a white to pinkish colour and a dense structure resembling quartzite.

Mr. Curle informed me that the last-mentioned type of rock was the material he had sent to be assayed and which was reported to contain a trace of platinum. On examining the rock I found, as Mr. Curle had stated, that it contained specks and small masses of a hard dark-coloured mineral which appeared to be almost free from weathering effects, more so than the rock itself. Two general samples of the light-coloured rock containing the dark mineral were taken. Sample T 27 was taken by me and T 28 by Mr. Curle. We returned to Kaslo the same evening. Assays made by Mr. J. T. King of the University of Toronto, gave the following results:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 27	South fork of Kaslo creek, near Index mine.	Dense, feldspathic, white to pinkish granodiorite, containing a dark-coloured mineral...............	0·04	0·08
T 28	Same as T 27	Same as above.................	0·06	0·05

During my stay in Kaslo I met Mr. Peter Kelley, an old-time miner and prospector of the district, who informed me that some twenty years ago a sample of gold quartz from the Cable claim on Woodbury creek, Ainsworth camp, had been assayed and found to contain platinum amounting to over $30 per ton, the price of platinum then being $15 per ounce.

Mr. Kelley procured a sample of ore from the Cable claim which I sent in to be tested for gold and platinum. An assay by the Dominion Assay Office, Vancouver, B.C., gave the following result:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 40	Cable claim, Woodbury creek, Ainsworth camp.	Quartz, received from P. Kelly..	trace	0·07

The ore evidently does contain platinum, but, according to the results from the above sample, in less quantity than was stated to have been found twenty years ago. However, Mr. Kelley stated that the sample given to me was perhaps a low-grade specimen, as he had no means of distinguishing the low-grade from the high-grade material. A further investigation of this occurrence of platinum appears to be advisable.

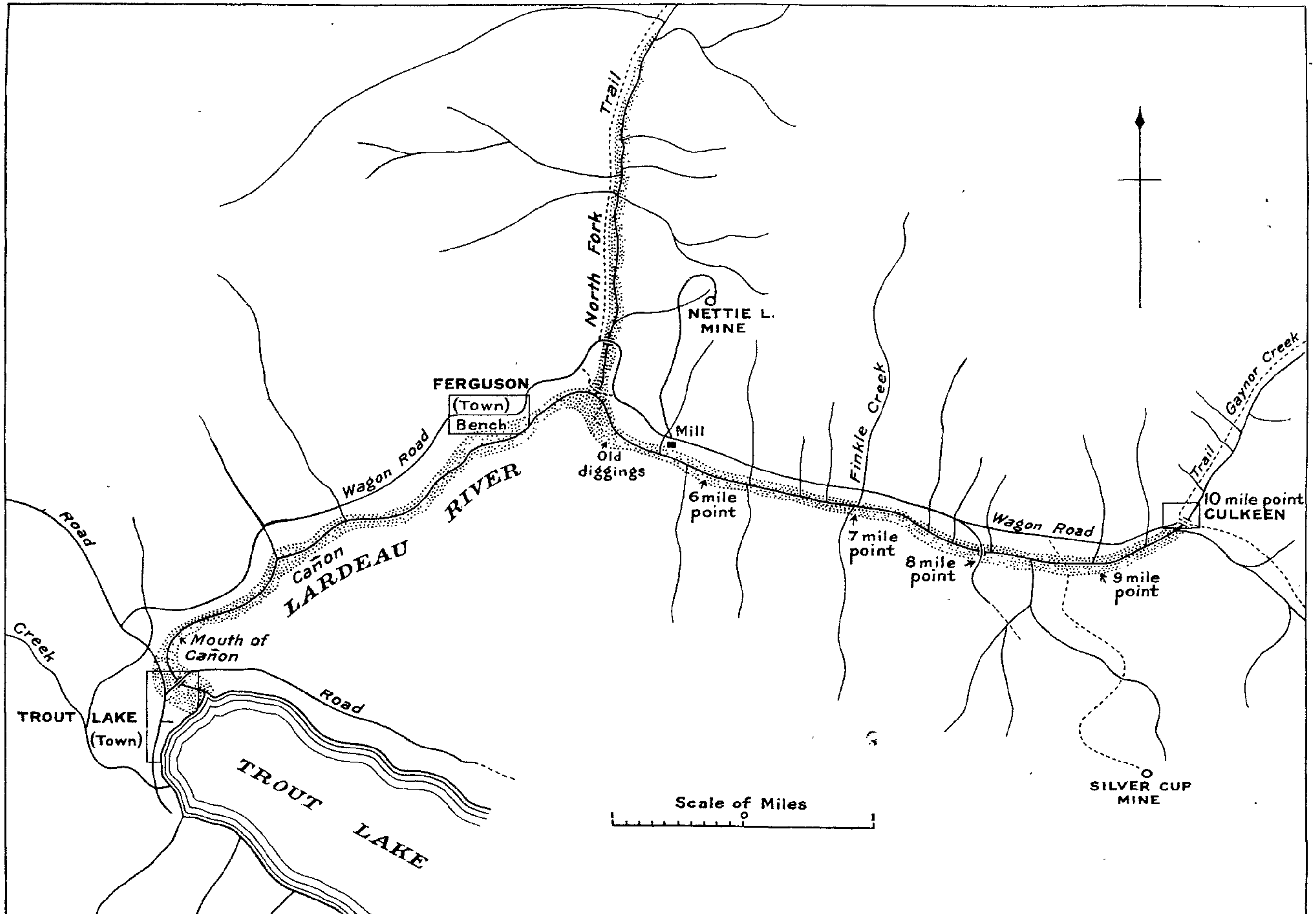
Lardeau River, Ainsworth and Trout Lake Mining Divisions.

On August 31, I left Kaslo for the town of Ferguson, in the Trout Lake mining division, to take samples from the old placer workings along the Lardeau river (Plate XLI). At Gerrard, at the southeast end of Trout lake, I met Mr. A. G. Langley, Resident District Engineer for the Provincial Government.

On September 3, in the morning, I walked from Gerrard to Ferguson so that I could examine the remarkable cañon which runs almost continuously between the two towns and from which considerable placer gold has been taken in bygone years. During the afternoon, accompanied by a guide, I examined about 3 miles of the North fork of the Lardeau river, and took samples T 34B and T 34C, described later.

Starting early next morning, I rode along the main stream to Ten-mile point at the mouth of Gaynor creek where I met and engaged Mr. Peter Culkeen, an old and experienced placer miner of the camp, as my helper for that day.

Mr. Culkeen and I panned out the following samples from fresh gravel bars or old diggings, down-stream towards Ferguson, at intervals of about 1 mile. Considerable placer work had been done where sample T 29 was taken, and Mr. Culkeen informed me that the diggings here had produced a lot of gold. Samples taken, and the assay results obtained by Mr. J. T. King of the University of Toronto, are as follows:



Sketch map of Lardeau river, B.C., Trout Lake–Ferguson–Culkeen section.

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 29	Lardeau river. Bar just below small cañon at bridge on road to Triune mine.	Material from panning..........	0·33	0·04
T 30	Lardeau river. Nine-mile point, near an old cabin above the falls.	Material from panning..........	0·43	0·01
T 31	Lardeau river. Bar at Eight-mile point just above the bridge on road to Silver Cup mine.	Material from panning..........	0·44	0·16
T 32	Lardeau river. Bars at mouth of Finkle creek which enters river from north at Seven-mile point, near Livingstone's camp.	Material from panning..........	0·24	0·12
T 33	Lardeau river. Bars 300 to 500 yards above old power-house of Silver Cup mill, about 6 miles from Ferguson.	Material from panning..........	0·35	0·12
T 34A	Near old cabin at placer workings one-half mile from Ferguson, and above mouth of North fork.	Discarded 'black sand,' found lying near cabin................	1·23	0·02
T 34B	North fork of Lardeau river. Mainly from bars below small cañon about 2½ miles from Ferguson.	Material from panning..........	0·36	0·11
T 34C	North fork of Lardeau river. Small bars in cañon below wagon-road bridge, about one-half mile from Ferguson.	Material from panning.........	2·80	0·03
T 34D	Lardeau river. Bench placer on main river near Ferguson townsite.	'White iron' (marcasite?), from panning. Special sample received from Peter Cameron, hotel-keeper, Ferguson......................	0·10	0·01

On September 4, I returned by automobile stage to the town of Trout Lake and engaged Mr. John Aitkinson as my helper. I panned a sample from the gravel bars at the mouth of the main cañon north of the town and near where placer operations had evidently been carried on some years previously.

Mr. O. Jacobson, Mining Recorder, gave me a sample of black sand which he stated came from small bars in the centre of the main cañon about half-way between Trout Lake and Ferguson.

The results of assays of these samples by Mr. J. T. King of the University of Toronto, are:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 35A	Said to be from small bars in centre of main cañon of the Lardeau river, half-way between Trout Lake and Ferguson.	Black sand, received from Mr. O. Jacobson, Mining Recorder, Trout Lake mining division	3·93	0·22
T 35B	Bars near mouth of cañon, Lardeau river, about one-half mile north of town of Trout Lake.	Material from panning.	0·29	0·17

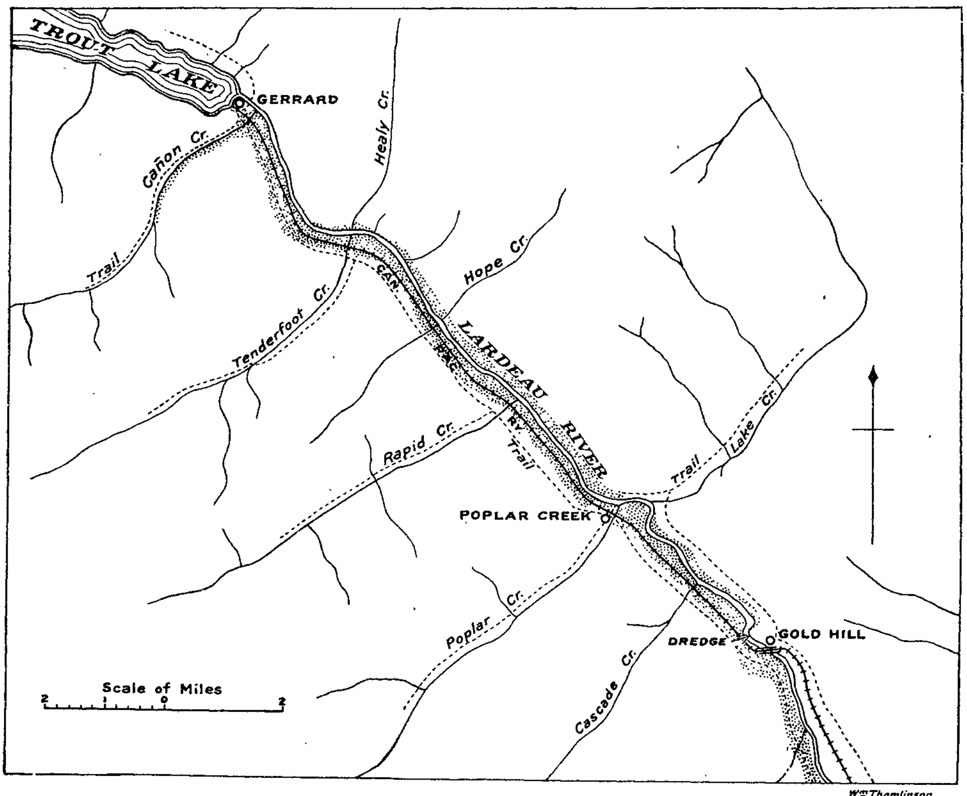
On September 5, Trout lake was traversed by row-boat from Trout Lake to Gerrard at the southeast end of the lake. At Five-mile creek on the south side of the lake I panned a sample from gravel bars below a cañon about one-half mile up the creek. An assay by Mr. J. T. King of the University of Toronto, gave the following result:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 36	Five-mile creek, south side of Trout lake.	Material from panning.	0·15	0·09

In the forenoon of September 6, I walked up Cañon creek, south of Gerrard, for about 2 miles, and, returning, panned out a sample from bars along the cañon to a point where it enters the Lardeau valley. The following results were obtained by Mr. J. T. King of the University of Toronto:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 37	Cañon creek, near Gerrard.	Material from pannings.	·16	0·02

In the afternoon of the same day I moved down the Lardeau valley to Poplar creek and Gold Hill (Plate XLII) by means of a gasoline speeder.



Sketch map of Lardeau river, B.C., Gerrard–Poplar Creek–Gold Hill section.

At the town of Poplar Creek, in the Ainsworth mining division, I met Mr. A. G. Johnson, postmaster and storekeeper, who gave me a sample of pannings said to have been taken from the Lardeau river, near the mouth of Cascade creek, southeasterly from the town.

Mr. Johnson informed me that the sample had been treated with mercury to extract the gold, but that any platinum originally in the sample would probably still be present. I arranged with Mr. Johnson for the collection of several more local placer-samples, but at time of writing have not been notified that these have been forwarded. An assay of the sample, made by Mr. J. T. King of the University of Toronto, gave the following result:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 38	Said to be from Lardeau river, near the mouth of Cascade creek.	Material from pannings. Received from A. G. Johnson, Poplar, B.C.	1·90*	0·04

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

From Poplar I went to Gold Hill, some distance farther down the Lardeau river, where an old placer dredge is moored to the south bank. I found black sand in unusual quantity on a bar immediately below the railroad bridge which crosses the river about one-quarter mile below the dredge (see sample T 39B).

The river bars in the vicinity of Gold Hill are said to contain gold in profitable quantities and platinum is reported to have been found with it.

The attempt to dredge the river at this point was, from the evidence available, either a 'promoter's scheme' or had been made by operators entirely ignorant of such work. I took two general samples along this portion of the river, which were assayed by Mr. J. T. King of the University of Toronto, and gave the following results:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 39A	Bars near old dredge at Gold Hill, Lardeau river; also from points on south side of channel for about 1 mile up-stream from dredge	Material from pannings.........	0·27	0·04
T 39B	Bars near old dredge and along south side of channel, for about one-half mile downstream from dredge.	Material from pannings.........	0·08*	0·02

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

Isaac Creek, Columbia River, Revelstoke Mining Division.

After finishing the work in the Boundary district I proceeded north to the main line of the Canadian Pacific railway to sample old placers at Tranquille river, Kamloops mining division, and at Scottie creek, in the Clinton mining division.

On my way I spent two days at Arrowhead in looking over and taking samples from the recently discovered placer deposits on Isaac creek (Plate XLIII), about 12 miles northerly from Arrowhead, in the Revelstoke mining division.

At Arrowhead I met several of the principal claim owners including Mr. Ralph Simpson, Mr. Harry Johnston, and Mr. J. B. McGaghran, who gave me information and also provided transportation from Arrowhead to Wigwam Landing, about 12 miles up the Columbia river.

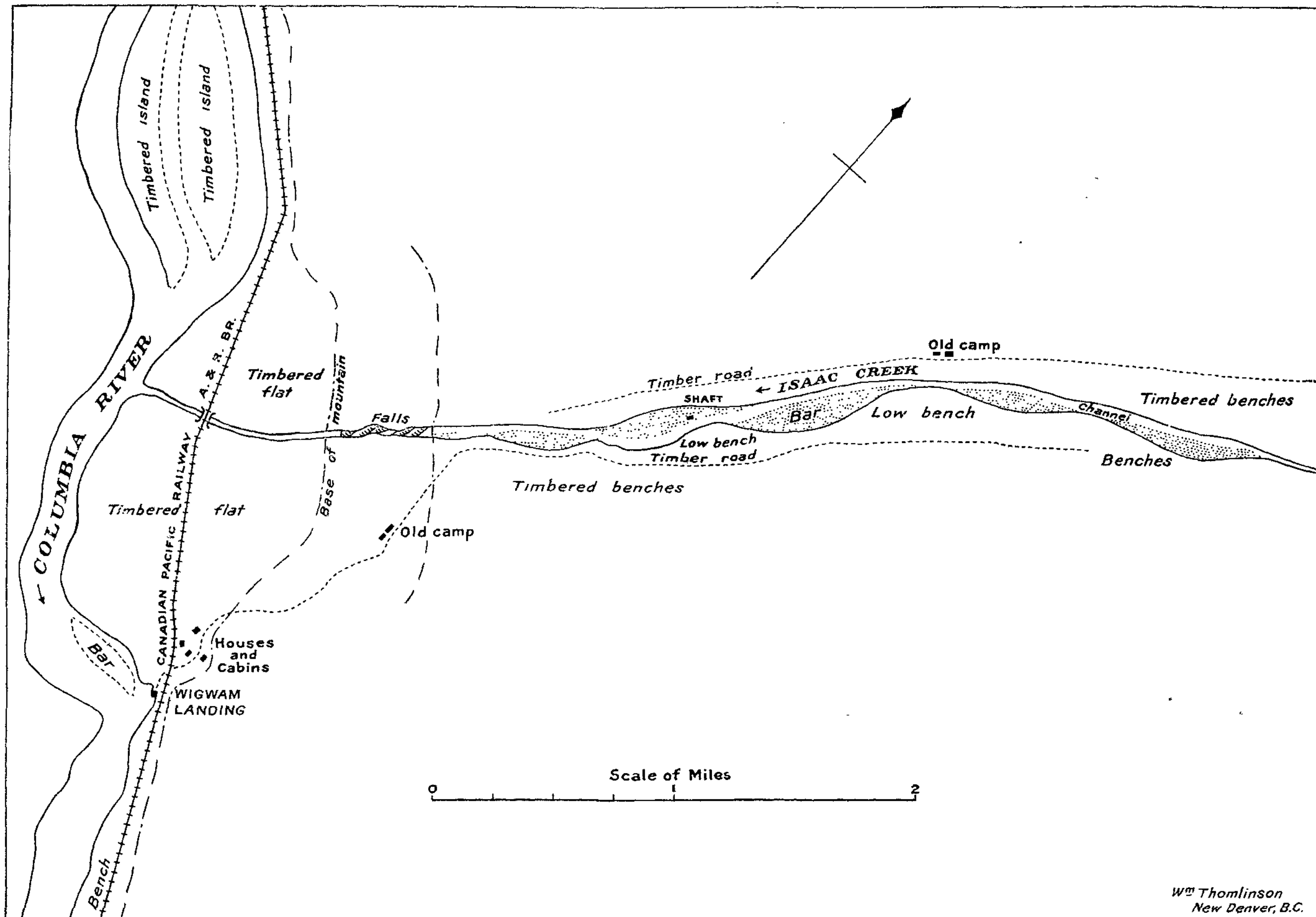
With Mr. Simpson as guide, and Mr. McGaghran in charge of his own launch, we left Arrowhead early on the morning of October 4, and arrived at Wigwam Landing in good time. From the Landing we travelled over an old timber-road for about 1 mile, passing an old logging-camp on the way, and after ascending to an elevation of several hundred feet above the valley of the Columbia river, turned easterly and entered the elevated valley of Isaac creek. Shortly after entering the valley we arrived at the creek at a point where it passes over a series of falls in its descent to the valley of the Columbia river. From the head of the falls the valley of Isaac creek runs easterly into a range of mountains which parallel the north and south course of the Columbia river.

The rocks seen in place were gneiss, limestones, and schists of the Shuswap series, one of the oldest geological formations found in the Province, and generally considered by British Columbian prospectors to be a 'hungry' or unlikely formation for valuable minerals.

In this elevated valley the benches are still heavily timbered although considerable logging has taken place there during past years. Timber-roads parallel both sides of the creek for several miles, and I saw the buildings of an old camp fully two miles above the falls. Although there is much gravel along the channel of the creek, most of the valley consists of benches from a few feet to 20 feet above the level of the stream. As far as seen, the creek has a good flow of water above the falls, where the placer claims are located, on a grade of about three per cent. The gravel is of fine to medium size, and large boulders are almost entirely absent from the creek bars and channel, although they are found on the adjoining benches. With the exception of a small shaft on one of the bars, I saw no evidence of development work or placer operations anywhere along the creek.

At the time of my visit little more had been accomplished than the panning-out of a number of samples for assay purposes, some of the assay returns being quite encouraging.

I was shown more than a half-dozen assay certificates signed by Provincial and other assayers, stating that samples of this black sand had contained from 0·08 ounces to more than 4·0 ounces of gold per ton.



Sketch map of Isaac creek, Revelstoke mining division, B.C.

On one of these certificates the assayer had stated: 'From the sample of sand assayed by me for platinum, I got perceptible traces of platinum, but not sufficient to record the weight. I also found traces of iridium in the sand.'

The following samples were panned out by myself from the bars along about 2 miles of the creek channel and assayed by Mr. J. T. King of the University of Toronto:

Sample No.	Locality	Description	Gold per cent	Platinum per cent
			Oz.	Oz.
T 55	Bars along south bank of Isaac creek, for three-quarters of a mile up-stream from a point one-half mile above falls.	Material from pannings.........	0·79	0·04
T 56	Bars along Isaac creek for three-quarters of a mile up-stream from a point 1¼ miles above falls.	Material from pannings........	0·47	0·02
T 57	Bars along Isaac creek for one-half mile up-stream from a point 2 miles above falls.	Material from pannings.........	0·20*	none

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

The bulk of the gravel consisted of schistose rocks and did not appear likely to contain platinum, but it is probable that some of the bars may contain gold in profitable quantities as several of my pannings showed gold 'colours' quite plainly, especially on bars where small rounded garnets were plentiful.

The property appears to me to be worthy of investigation by those searching for placer ground suitable for hydraulic or dredging operations, as the natural conditions for operating are quite favourable. The deposits are close to a railroad; there is a road already built to the area; most of the gravel can be readily handled, being free from large rocks or boulders; and a splendid dump can be secured by cutting away the rim of bed-rock at the head of the falls.

Sampling of the ground on a large and systematic plan should be carried out before any heavy operations are commenced, as it is not likely that the samples taken by the owners or by me represent the average gold or other contents of the deposits.

Tranquille River, Kamloops Mining Division.

On October 8, I left Kamloops and proceeded to the mouth of the Tranquille river, about 10 miles to the west of the city of Kamloops, on the north side of Kamloops lake (Plate XL). Mr. Strachan, superintendent of the Tranquille Sanitarium farm kindly provided me with accommodations during my visit.

Quite a large area of diggings is found along the lower part of the river, starting from near the bridge on the Canadian Northern railway and continuing up-stream to the irrigation dam in the main cañon, a distance of about 1½ miles. The workings appear to be quite old and I could not secure any information as to the character or quantity of gold obtained, nor any confirmation of reports that platinum was found with it. Near the tracks of the Canadian Northern railway the remains of an old placer dredge were seen, but I doubt that it was ever operated on the Tranquille river. About 1 mile farther up the river an old pipe-line and hydraulic monitor were seen. The monitor had been used to some extent, but the gravel banks had evidently been found too lean or unsuitable for working by the hydraulic method. Judging from the nature of the gravel and the scarcity of 'black sand', I doubt if the diggings were ever very remunerative.

I took two general samples from that portion of the river where placer operations had been most actively conducted. The assay results obtained by Mr. J. T. King of the University of Toronto, are as follows:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 58	Points along Tranquille river, from near school-house upstream to Sharp's cabin, a distance of about one-half mile.	Material from pannings........	0·14	none
T 59	Points along Tranquille river, from Sharp's cabin upstream to a point in main cañon below irrigation dam, a distance of about 1 mile.	Material from pannings.........	0·21	0·02

As black sand is so thinly distributed in the gravels, considerable panning was necessary to secure the general samples required. No platinum was visible in the samples but gold 'colours' were seen in several pans, especially in those from a bar in the small gorge about half-way between the schoolhouse and Sharp's cabin.

On October 10, without a guide, I examined the river for a distance of about 8½ miles, to beyond Bruce's ranch near the mouth of the second east fork of the river. Above the main cañon I found few evidences of placer work along the channel or adjoining benches and therefore concluded that the best diggings had been along the portion of the river sampled the previous day. Owing to the absence of old workings and the difficulty of finding black sand, I took no samples from the river above the main cañon, although I tested several bars along the channel.

The rocks in this vicinity are mostly of volcanic origin, showing a great variety of structure, physical condition, and colour; and minerals of economic value other than placer gold may possibly occur in them.

Were this Interior Plateau country to be systematically examined by trained prospectors, I feel assured that economic minerals would be found in both the igneous rocks and the folded, fractured, and altered sedimentary ones.

Scottie Creek, Clinton Mining Division.

On October 14, I left Ashcroft for Scottie creek in the Clinton mining division to look over the area of chromite-bearing rocks in that locality and to obtain samples of chromite and placer sands to be assayed for gold and platinum. (Plate XLIV.)

Scottie creek enters the Bonaparte river near the 19-mile post on the Ashcroft-Cariboo stage road. Through the kindness of Mr. A. Hunter, I lived at his ranch at the mouth of the creek during the time I was sampling.

The day after my arrival I made a preliminary trip up the creek valley to Mr. Peter Gagne's cabin, which stands in a basin just above the main cañon about 2½ miles from the Hunter ranch, but did not find him at home.

Next day, starting from Hunter's ranch, I panned gravel from bars along the channel of the creek up-stream for about one-half mile to a dam and some old placer diggings said to have been worked by Chinamen many years ago. Several pans of gravel were taken from these old workings, but the quantity of black sand obtained was very small with only one or two small gold 'colours.' Samples taken, and assay results obtained by Mr. J. T. King of the University of Toronto, are:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 60	Scottie creek. Bars and old workings between Hunter ranch and dam at Chinese diggings.	General sample. Material from pannings	0·12	0·01
T 61	Scottie creek. Bars along creek from dam at old diggings to a point below cañon.	General sample. Material from pannings	0·08*	none

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

With P. Gagne's partner as helper, I took two general samples from bars and old diggings on Scottie creek from above the cañon to the mouth of Chrome creek, a northeasterly branch of Scottie creek, a distance of about 1 mile. Assay results obtained by Mr. J. T. King of the University of Toronto, are given below:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 62	Scottie creek. From cabin on Gagne's claims to old shaft on low bench near the creek, a distance of about one-third mile.	Material from pannings. Considerable gold in sample, especially in gravel from near the old shaft.	3·02	0·14
T 63	Bars along Scottie creek from near old shaft on Gagne's claims to mouth of Chrome creek, a distance of about two-thirds of a mile.	Material from pannings. Several gold 'colours' observed in the sample........................	1·95*	0·04

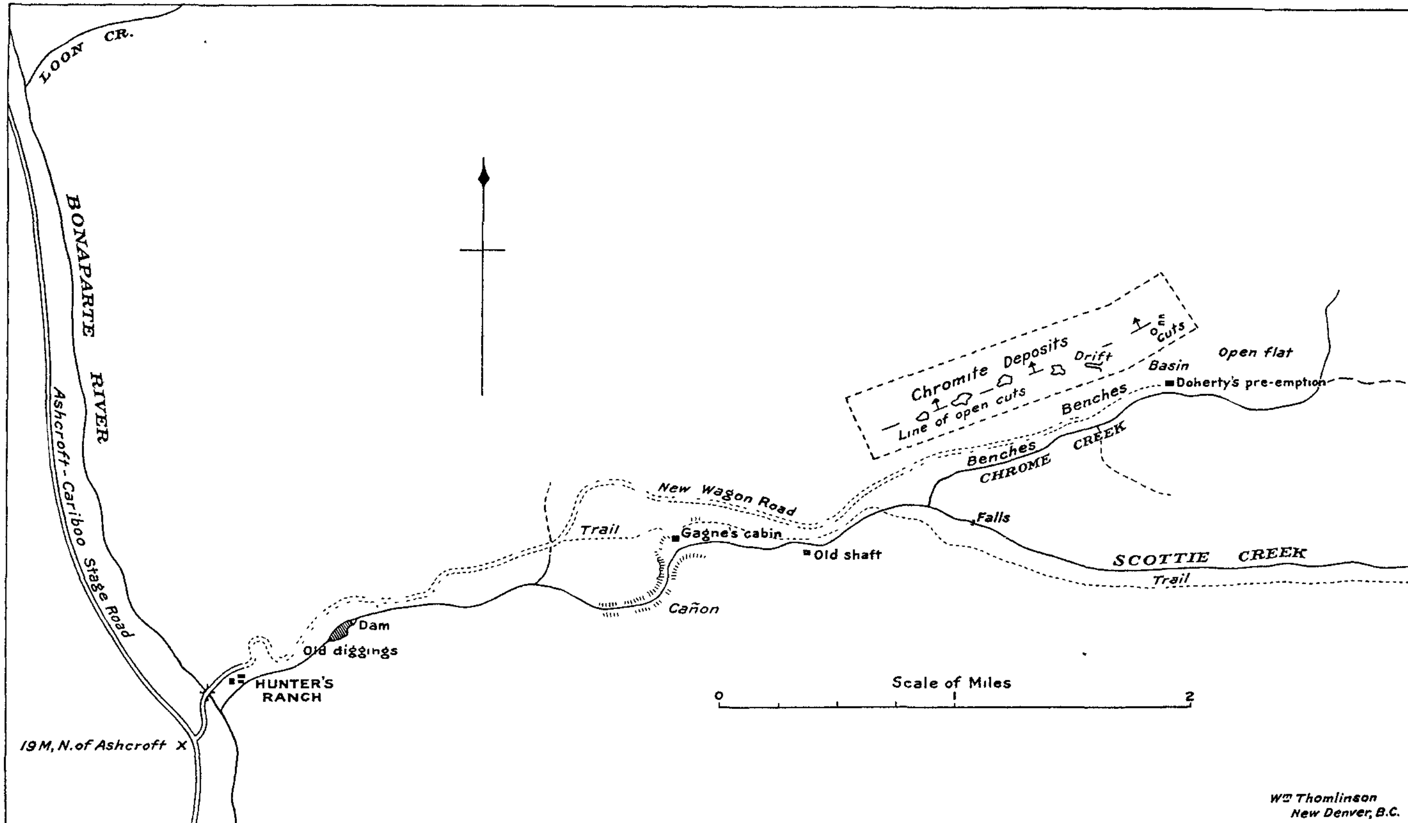
*Gold residue may contain iridium, osmium, ruthenium, rhodium.

Having reached the mouth of Chrome creek the previous day, I took two general samples on this branch of Scottie creek from near the mouth up-stream to a point near and below the chromite deposits which are on the north side of the creek about one-half mile from its junction with Scottie creek. The bed of Chrome creek which is a very small stream, is composed mainly of mud, soil, and fine sand, and it was difficult to obtain samples, much panning being required to secure a sufficient quantity of black sand. The following are the samples taken, and the assay results obtained by Mr. J. T. King of the University of Toronto:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 64	Chrome creek, from its mouth up-stream for about one-quarter mile.	Material from pannings.........	0·18	0·06
T 65	Chrome creek, from about one-quarter mile from its mouth to a point opposite the chromite claims, a distance of about one-half mile.	Materials from pannings........	0·82*	0·06

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

Having reached the chromite deposits I discontinued taking placer samples and began an examination of the lode claims in the vicinity. Mr. Gagne pointed out the various chromite workings. The following are



Sketch map of portion of Scottie creek, Clinton mining division, B.C.

the samples taken, with assay results obtained by Mr. J. T. King of the University of Toronto:

Sample No.	Locality	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
T 66	Chromite deposits on Chrome creek. Drift at north end of property in bluff of dark-coloured hard serpentine rock containing lenses of chromite.	General sample of chromite ore from dumps near the mouth of drift..........................	0·42*	0·10
T 67	Chromite deposits on Chrome creek.	General sample of chromite ore piled near various large open-cuts along the outcrop, mainly at the centre and south end of property.	0·06*	0·02

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

No platinum was seen in any of the placer samples taken, but Mr. Gagne informed me that small pieces of a pale-gray metal had been occasionally observed by men panning or sluicing for gold some years previously.

Most of the local rocks are clearly of volcanic origin, but on the north side of Scottie creek, near Hunter's ranch, a belt of dark, calcareous shale was seen. Farther up the creek, below the main cañon, several narrow belts of altered basic rocks were noted.

Above the cañon on Scottie creek, and also on Chrome creek, only igneous rocks were seen. These showed but few signs of alteration or decomposition until the area of peridotite and serpentine on Chrome creek was reached. Here the basic olivine-rocks have been extensively altered to serpentine and phases between serpentine and the original rocks. The lenticular masses of chromite found here are closely associated with a hard, dark form of the serpentine rock and resemble ore found at the bluff near the north end of the property. (Sample T 66.)

A notable feature of the deposits is the abundant chromite in masses of rock which have not been altered to serpentine. This chromite instead of occurring in lens-like masses is disseminated throughout the matrix, giving the rock, where weathered, a speckled appearance. There is a large quantity of this material, mostly of a friable nature, which should furnish an ample supply of good milling-ore.

So far as I can establish at present, this is the best chromite property found in British Columbia, because of the substantial tonnage of milling ore in addition to the lenses of almost pure chromite.

At the time of my visit, the development work consisted of a number of large open-cuts at various pionts along the line of outcrop, and one tunnel driven in one of the larger bluffs.

No buildings were seen, the two men working on the claims living in a tent. A wagon road about 4 miles long was under construction from Hunter's ranch to the property, about 12 men and several teams being employed.

The owners are mainly local men who had given a bond or option to the Stewart-Calvert Company, Inc., of Oroville, Wash., U.S.A.

Potato Creek, Jervis Inlet, Vancoueer Mining Division

In accordance with instructions to examine and report upon the placer claims situated on Potato creek, near the head of Jervis inlet, in the Vancouver mining division of British Columbia, I left Vancouver on the morning of October 26, and arrived at Pender harbour, at the entrance of Jervis inlet, on the same date.

On October 27, our party left Pender harbour in a chartered gasoline launch and reached the camp-site at the mouth of Potato creek about 7 p.m. the same day. (Plate XLV.)

Mr. James Malcolm and Mr. J. Rolph, of Vancouver, B.C., who were both interested financially in the Potato Creek placer properties, accompanied us and remained a day to look over the camp buildings, mining equipment, and the nearest placer workings.

My assistants in the work of examining and sampling the placer claims were, William Seavey as panner and William Stanfield as cook and general helper.

Potato creek, apparently not shown on any published map, is situated on the east side of Jervis inlet, about 2½ miles southeasterly from the entrance to Princess Louise arm and about 10 miles from the head of the inlet. At the mouth of the creek there is an excellent camp-site on a flat or delta upon which the Indians are said to have grown potatoes some years ago, hence the name Potato creek.

The placer deposits are at some distance from the shore of the inlet in an elevated U-shaped valley which runs northerly into the rugged mountains to the northeast of the camp. The first deposit starts at the lip of this valley about 2,000 feet northerly from the camp-site, at an elevation of about 550 feet above the shore of the inlet, and continues for about 2,200 feet up the creek to an elevation of 675 feet at the south end of the cañon. This cañon is nearly 1,500 feet in length, and at its north end, at an elevation of 800 feet, the second and larger deposit of placer ground begins and continues on a course of N.15° E. (magnetic) for a considerable distance up the valley. (Plates XLV and XLVI.)

The locators of these placer claims or leases state that the valley of Potato creek is more than four miles in length, and that, with the exception of 2,000 feet at the mouth of the creek, 1,500 feet at the cañon, and a small lake farther up the creek, the whole valley contains bars and benches of gravel suitable for placer operations.

Valley of Potato creek from Jervis inlet, B.C.
Camp-site in foreground.

Partly cleared portion of lower gravel deposit, Potato creek.

Looking down Potato creek on lower gravel deposit (Section 'K' on map).

Main sluice-box, Potato Creek placers.

The sketch-map shows the extent of the ground which was actually seen by the writer, and gives, as closely as practicable under the circumstances and with the time available, the main features of the deposits (Plate XLVII).

On the lower flat a magnetic base-line was cleared and measured, pickets being placed every 100 feet from station marked 'Zero' to station marked 'V', a distance of 2,200 feet; and from this line off-sets were cleared and measured to the edge of the creek channel, wherever thought necessary. The surveying was done with a Brunton pocket-transit; and, except the base-line and off-sets mentioned, nearly all distances were estimated by pacing.

Mr. Charles Camsell of the Canadian Geological Survey staff, visited the camp while work was in progress and took barometric readings at certain points in the valley. He also determined the grade of the creek, the nature of the gravels, and the local rock formations.

The material forming the alluvial deposits, consisting of loose rocks, boulders, gravel, and sand, appear to be derived from the fracturing, erosion, and decomposition of large masses of the local biotite granite or granodiorite. On some gravel bars pieces of black slate, sericitic schist, and a light-coloured feldspathic rock were noted; also a few of a basic igneous rock, but no serpentine or olivine-bearing rocks were seen in the gravels. It is possible, however, that pyroxenite rocks or even peridotite rocks may occur farther up the valley. At many points along the creek 'black sand,' mainly magnetite, could be panned out quite freely, and this sand, with any associated gold or platinum which may be found in it, has apparently been set free by the erosion and decomposition of the local biotite-bearing igneous rocks.

The depth of gravel to the bed-rock could not be determined, but there is enough drop or fall below the deposits to allow of proper sluices or bed-rock flumes being made by open-cut rock work, should the contents of the deposits justify large operations. However, as the grade of the creek along the gravel-bearing flats is from 3 to upwards of 5 per cent, much of the surface material could be handled by the cheaper ordinary placer-mining methods, although it is hardly probable that bed-rock could be reached by such operations.

During my preliminary exploration of the ground Wm. Seavey re-opened an old sluice at the lower end of the first flat and washed a considerable amount of gravel through it (Plate XLVI). Later the ditch was closed and five general samples of the 'black sand' were taken from the sluice. Two of these samples from the head of the sluice were carefully panned, but the other three samples from the head, centre, and tail portions of the sluice-box were taken without panning.

After finishing the surveying, in which Mr. Stanfield carefully aided me in clearing and measuring lines, Wm. Seavey and myself panned out the remainder of the samples taken along the creek. These samples were chiefly from the gravel bars along the main channel, but several special samples were taken from pits on benches or in old channels, at points indicated previously by Mr. James Malcolm.

For the location of these bars and pits tested by panning, the attached sketch-map should be studied (Plate XLVII).

The samples were dried and carefully placed in sample bottles and containers, each sample being sealed and labelled.

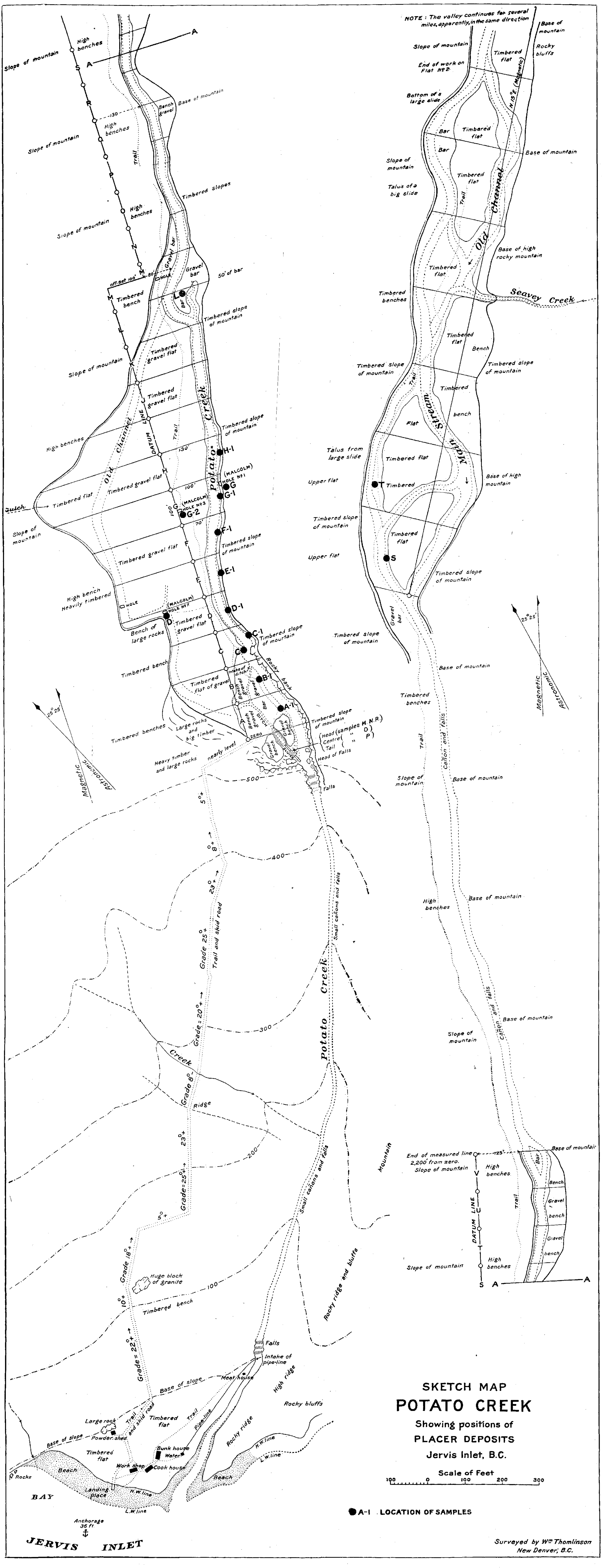
The assays were made at the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, Ottawa.

The following table shows the samples taken, their location, and assay results obtained:

Sample No.	Location	Gold per ton	Platinum per ton
		Oz.	Oz.
A1	Bar along main channel. Section A on map.	0·02	none
B1	Bars along main channel. Section B on map	0·008	trace
C	A pit indicated by Mr. Malcolm. See map..............	trace	none
C1	Bars along main channel. Section C on map.............	trace	trace
D	Pit marked '(Malcolm) Hole No. 7' on map.	trace	none
D1	Bars along main channel. Section D on map..	trace	trace
E1	Bar on main channel. Section E on map	0·01	none
F1	Bars on main channel. Section F on map........ . .	none	0·02
G	Pit marked '(Malcolm) Hole No. 1' on map	0·08	none
G1	Bars on main channel. Section G on map....	trace	none
G2	Pit marked '(Malcolm) Hole No. 3' on map	0·03	none
H1	Bars on main channel. Section H on map...............	none	none
L	50 feet of a bar indicated by Mr Malcolm. See map.... .	0·02	none
M	Panned sample from head of sluice-box............ ...	0·22	0·17
N	Panned sample from head of sluice-box................	0·03	none
P	Crude sample from tail or lower end of sluice-box.........	0·04	none
Q	Crude sample from centre portion of sluice-box...........	0·08	0·04
R	Crude sample from head or upper portion of sluice-box....	0·10	0·03
S	Special sample from upper flat of gravel, 300 feet above the cañon.	* none	none
T	Special sample from upper flat of gravel, 500 feet above the cañon.	0·03	none

* *Editor's Note:* Assays from panning samples show that the gravel does or does not contain platinum or gold but are no guide to the value of the original gravel or other material from which these samples were panned.

Before a complete examination of the valley can be made a good horse-trail should be constructed from the north end of the present skid-road to the first flat, to or near the glacial cirque at the head of the valley. The present trail is little more than a blazed line through the timber along the flats and benches near the creek, and even this slight aid to travel appears to end a short distance beyond the upper end of the cañon.


SKETCH MAP
POTATO CREEK
Showing positions of
PLACER DEPOSITS
Jervis Inlet, B.C.
Scale of Feet
100 0 100 200 300
A-1 LOCATION OF SAMPLES
Surveyed by Wm. Thomlinson
New Denver, B.C.
NOTE: The valley continues for several miles, apparently, in the same direction
JERVIS INLET
BAY
Anchorage 36 ft
Beach
Landing place
H.W. line
L.W. line
Work shop
Cook house
Bunk house
Water
Powder shed
Large rock
Timbered flat
Base of slope
Trail and skid road
Pipe-line
Rocky ridge
Rocky bluffs
High ridge
Meat house
Intake of pipe-line
Falls
Huge block of granite
Timbered bench
Rocky ridge and bluffs
Small cañons and falls
Potato Creek
Creek
Ridge
Mountain
Grade 25°
Grade 20°
Grade 22°
Grade 18°
Grade 8°
Old Channel
Main Stream
Seavey Creek
Datum Line
Slope of mountain
High benches
Timbered benches
Timbered gravel flat
Timbered slope of mountain
Base of mountain
Gravel bar
Bench
Upper flat
Talus from large slide
Talus of a big slide
Bottom of a large slide
End of work on Flat No. 2
End of measured line 2,200' from zero.
Head (samples M.N.R.)
Centre (" O)
Tail (" P)
Head of Falls
Heavy timber and large rocks
nearly level
Large rocks and big timber
Bench of large rocks
Rocky bank
Rocky bluffs
Base of high rocky mountain
Magnetic
Astronomic
(MALCOLM) HOLE No. 1
(MALCOLM) HOLE No. 3
(MALCOLM) HOLE No. 7
Gulch

Platinum at Mt. Ida, near Salmon Arm, Kamloops Mining Division, British Columbia.

By W. F. FERRIER

On my return to Kamloops from the Clear mountains at the end of August, 1918, I received a letter from Mr. John Thornton of Salmon Arm, B.C., stating that he had detected by qualitative chemical analysis what he called 'palladium', in ore from some claims on Mt. Ida in which he was interested.

He forwarded samples of the ore containing a mineral with which, according to his statements, the 'palladium' was associated. This mineral was identified as a somewhat peculiar variety of sphalerite (zinc blende) by Mr. R. P. D. Graham and myself.

A small sample of the ore was sent to the Dominion Assay Office at Vancouver to be assayed for platinum and gold, and proved to contain platinum in the proportion of 0·08 oz. to the ton, and no gold. Another sample was then sent on for assay and yielded 0·22 oz. of platinum to the ton, but no palladium or gold.

After receiving these results I made a trip to the locality on October 13 and 14, in company with Mr. R. W. Thomson, Resident Engineer of Mineral Survey District No. 3, and Mr. Thornton, and sampled a few of the veins.

Some of the claims where samples were taken lie on the north slope of Mt. Ida, about 3 miles in an air-line southeasterly from the town of Salmon Arm on Shuswap lake; others are on the northeast slope of the mountain, and about 4 miles from Salmon Arm.

The elevation of the highest point of Mt. Ida is 5,200 feet, or about 4,000 feet above the level of Shuswap lake, and the claims lie at elevations of from 2,800 to 3,400 feet. They are reached by good wagon roads leading from Salmon Arm to the base of the mountain, and thence by trails.

Mr. W. M. Brewer visited the 'Mt. Ida' group of claims in 1913 and has described the ore-bodies and the general geology of the region.(1)

The first claim sampled was the White Cliff on the northeast slope of Mt. Ida, at an elevation of about 3,150 feet. Two tunnels have been driven. The upper one is a cross-cut 122 feet in length which has just reached the foot-wall of a vein at the face. About 100 feet below this another tunnel, 24 feet in length, follows a vein the dimensions of which were not satisfactorily determined. The strike is apparently northeast with a dip to the southeast. A cut was taken along the western wall of the tunnel to determine if platinum is present.

Sulphides, chiefly sphalerite, with some pyrite and galena, occur somewhat sparingly in the quartz. A second sample, consisting principally of these

(1) Annual Report of Minister of Mines, British Columbia, 1913, pp. 198-199.

sulphides, was chipped at random from both walls of the tunnel to ascertain if the platinum was closely associated with the sulphides.

The Mountain View claim was next visited and a sample taken in an open-cut near the eastern boundary of the claim, across the full width of the vein. The strike here is about east and west, with a dip of 60° to the south, but Mr. Thornton stated that the vein had been traced through the White Cliff, running across four claims. The general character of the vein material resembles that seen at the White Cliff. As before, a second sample was taken here by cutting across the centre of the vein, which appeared to be the more highly mineralized portion.

All samples were assayed by Mr. J. T. King of the University of Toronto, and gave the following results:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
1	White Cliff	Lower tunnel. 10 ft. cut along western wall.................. ..	0·38*	0·03
2	White Cliff	Lower tunnel. Sample of sulphides, taken at random along both walls.	0·10	none
3	Mountain View	Open-cut. 8·5 ft. cut across full width of vein.....	0·35*	0·20
4	Mountain View	Open-cut. 2·5 ft. cut across centre of vein..........	0·08*	0·02

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

The following day we went to a claim on the north slope of Mt. Ida which Mr. Thornton stated to be the Everglade claim described in Mr. Brewster's report, but which has, I believe, been re-located. A drift, known as the 'Miller tunnel' has been driven for 273 feet on a shear zone full of quartz stringers in a granitic rock. This zone is about 16 feet wide at the portal of the drift and strikes northeast.

The face of the drift, which does not expose any walls, was sampled across its full width. Another sample was taken from a small highly mineralized streak in the face.

Sulphides, consisting of sphalerite, galena, chalcopyrite, and pyrite, appear to be more abundant in the quartz here than in that at the claims visited on the previous day.

There are some other workings on the claim which, for lack of time, we were unable to examine.

The samples taken were assayed by Mr. J. T. King with the following results:

Sample No.	Claim	Description	Gold per ton	Platinum per ton
			Oz.	Oz.
5	Everglade?	Miller tunnel. 4·75 ft. cut across full width of face, low down........	0·24*	0·02
6	Everglade?	Miller tunnel. Mineralized streak, 1·5 in. wide, in the face	0·14*	0·03

*Gold residue may contain iridium, osmium, ruthenium, rhodium.

The results obtained from the sampling of these claims on Mt. Ida show that platinum is present, but apparently in small quantity and irregularly distributed. Contrary to expectations, the samples taken of the sulphides yielded very little platinum (in one instance none), and were also low in gold.

On account of the associated gold the area is worthy of a more detailed study.

No work was being carried on at any of the claims at the time of my visit.

Douglas Gold-Platinum Gravels, North Saskatchewan River, Alberta.

By W. L. UGLOW

Location.—This property is located on the southeastern shore of the North Saskatchewan river, 4½ miles southwest of Fort Saskatchewan, and 15 miles northeast of the city of Edmonton, Alberta. It is in concession 54, range XXIII, west of the fifth meridian.

Accessibility.—The most accessible facilities are at Fort Saskatchewan, on the main line of the Canadian Northern railway. Fort Saskatchewan is reached by a good wagon road which has direct connection with the property.

Ownership and Extent of Property.—The ground examined is the property of William Douglas, barrister, Confederation Life Building, Toronto. It consists of 344 acres of unbroken farm land, situated entirely on one of the many alluvial flats of the river (Plate XLVIII); and a number of bench leases, located side by side along the waterfront, covering the ground between high-water and low-water levels. The owner of the property has, in addition, a dredging lease of the river along his entire frontage.

Topography, Character of Ground, etc.—The farm consists partly of open ground, covered with low underbrush, and partly of ground thickly timbered with light poplar and willow. There is a general slope toward the river of about 30 to 40 feet per 1000. This slope is not gradual, but is broken by a series of river terraces, as shown on Plates L and LI. The farm is bordered, during the periods of low-water, by an extensive bar, 1¼ miles in length, and from 50 to 300 feet in width. The bar consists of medium to fine gravel with a covering of sand in places, while the farm itself is underlain by 10 to 25 feet of silt, on top of which is a light covering of soil.

River Conditions.—The North Saskatchewan river in this vicinity flows through a pronounced valley, 80 to 125 feet deep and from one-half to one mile wide. The sides of the main valley may be readily traced by marked rock escarpments having a dip slope of 45° to 50° (Plate XLVIII). In the bottom of this main valley the river winds a serpentine course through its old flood-plain, having thus produced a series of alluvial flats and islands (Plate XLIX). At low-water, the river is from 600 to 800 feet in width and ten to twenty feet in depth. It runs with a current varying from two to four miles per hour, and in places is so shallow that slight rapids are the result. The spring freshet ordinarily raises the water-level five or six feet, but a few years ago an abnormal freshet caused a raise of about 20 feet which resulted in the submergence of many of the alluvial flats.

Previous Work.—Previous to 1918 no work in the way of exploration of the property had been undertaken. A few holes were put down with a post-hole auger about a year before, but they did not succeed in getting samples from more than the upper two feet of the silt-covered gravels.

In 1917 a concentrating plant was constructed by the owner of the property for the purpose of recovering precious-metal values from the bar gravels. This plant was built on the immediate bank of the river, and was so arranged that it could be moved from place to place along a set of steel rails (Plate XLIX). Information regarding the exact method of concentration and recovery of the values was not available at the time of the examination.

General Method of Examination.—On May 10, 1918, the writer received instructions from the Munition Resources Commission to proceed to Fort Saskatchewan, Alberta, to make a preliminary examination and sampling of the Douglas property, with the idea of ascertaining whether the platinum content of the gravels was sufficient to warrant systematic exploration with an Empire drill.

Preliminary Examination of the Bar Gravels

Work was commenced on this examination on May 17 and completed on May 31, 1918.

The method of procedure was divided into three parts, as follows:

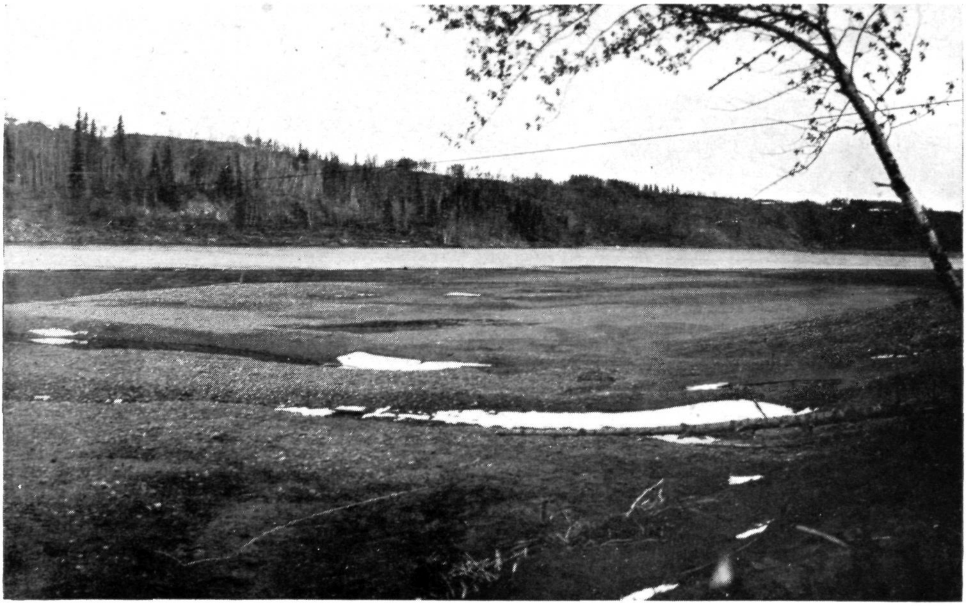
(a) A rapid instrumental survey of the bar and benches for the purpose of outlining the area and for equably distributing the location of the samples.

(b) Sampling of the bar gravels.

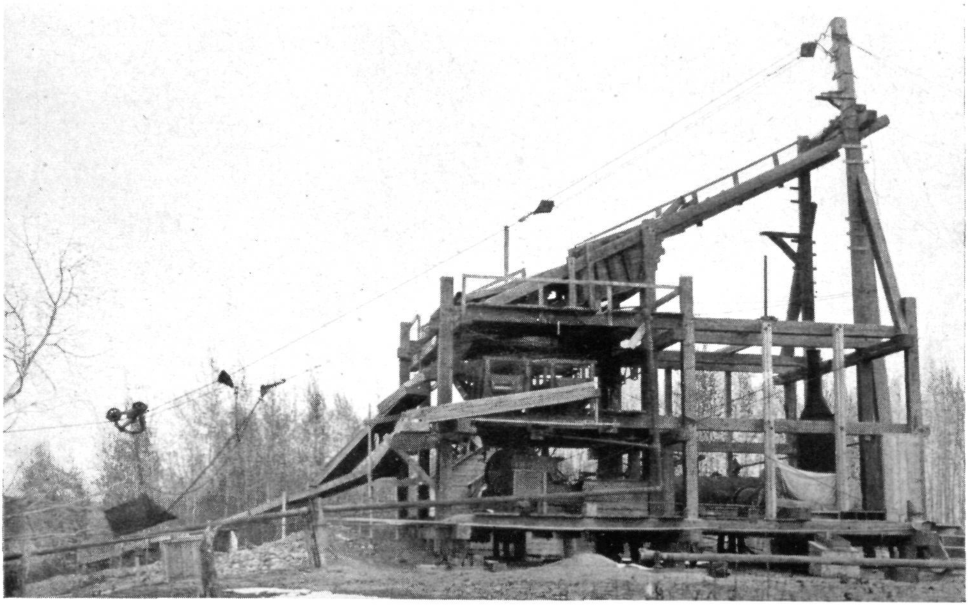
(c) Attempt to sample the bench gravels.

Alluvial flat, Douglas property, near Fort Saskatchewan, Alberta.

Cut-bank on North Saskatchewan river, near Fort Saskatchewan, Alberta.



North Saskatchewan river at low-water, near Fort Saskatchewan, Alberta.



Movable concentrating plant.
Douglas property, near Fort Saskatchewan, Alberta.

(a) Instrumental Survey.

This was done chiefly by means of the transit and stadia methods, as shown on Plate L. The survey consisted in locating the boundary lines of the farm, the present edge (May 17-31) of the bar gravels, the edge of the silt-covered gravels and alluvial plain, the crests of the main terraces, the edge of the rock escarpment where the gravels end, the ditch and buildings, and the exact positions of the samples to be taken.

(b) Sampling of the Bar Gravels.

The bar was divided into 300-foot lengths, and through each one of the divisional points a line was drawn perpendicular to the shore-line. One sample was taken at some point along each of these lines, but Mr. William Douglas, or his representative, was allowed to choose the exact position on these lines of the points at which he wished samples to be taken. These locations are shown on Plate L, numbering from DP 2 to DP 26. With some small scoops made from galvanized iron, a hole with a diameter of from five to six inches was excavated to water-level at each point so selected. In certain parts of the bar where the gravel was fine and inclined to cave the difficulty was overcome by sinking an 18-inch length of stovepipe as a casing, and the enclosed material was scooped out as the sample.

In each case the total material excavated was weighed. This material was then mixed in a large dish-pan and a portion selected for further treatment. This portion was weighed, then washed through three screens of $2\frac{1}{2}$, 4, and 8 mesh. The screened pebbles were weighed and the water and light slime decanted from the resulting sand. The net weight of the sand was thus obtained by difference, and all of this sand was washed into sample cans and sent to the Ore Dressing and Metallurgical Laboratories, Mines Branch, Department of Mines, Ottawa, for assay.

(c) Sampling of the Bench Gravels.

Owing to the considerable thickness of fine sand and silt which overlie the gravels on the alluvial plain and the benches, it was impossible with the appliances at hand to obtain anything like fair samples from these gravels.

Sample No. DP 1 was obtained during the course of cleaning out the well. It represents a thickness of about $1\frac{1}{2}$ feet of gravel from the bottom of the well, which was overlain by about 16 feet of sand and silt.

Holes Nos. DP 27 and DP 28 were bored with a post-hole auger from the bottom of the ditch, as shown on Plate L. Both holes encountered water as soon as the gravel was struck, and the water rose about one foot in the holes. From No. DP 27 a sample of wet muddy gravel was obtained, representing a depth of one foot. At that depth a large cobblestone was encountered, which prevented the downward passage of the auger. In hole No. DP 28 the same conditions prevailed, except that no gravel at all could be brought up.

Holes Nos. DP 29 and DP 30 were bored with a post-hole auger at points on the crests of two terraces, but could only be bored to depths of 20 inches into the gravel.

These samples were treated similarly to the samples from the bar gravels, and were sent to Ottawa for assay.

Final Systematic Exploration of the Douglas Property with Empire Drill

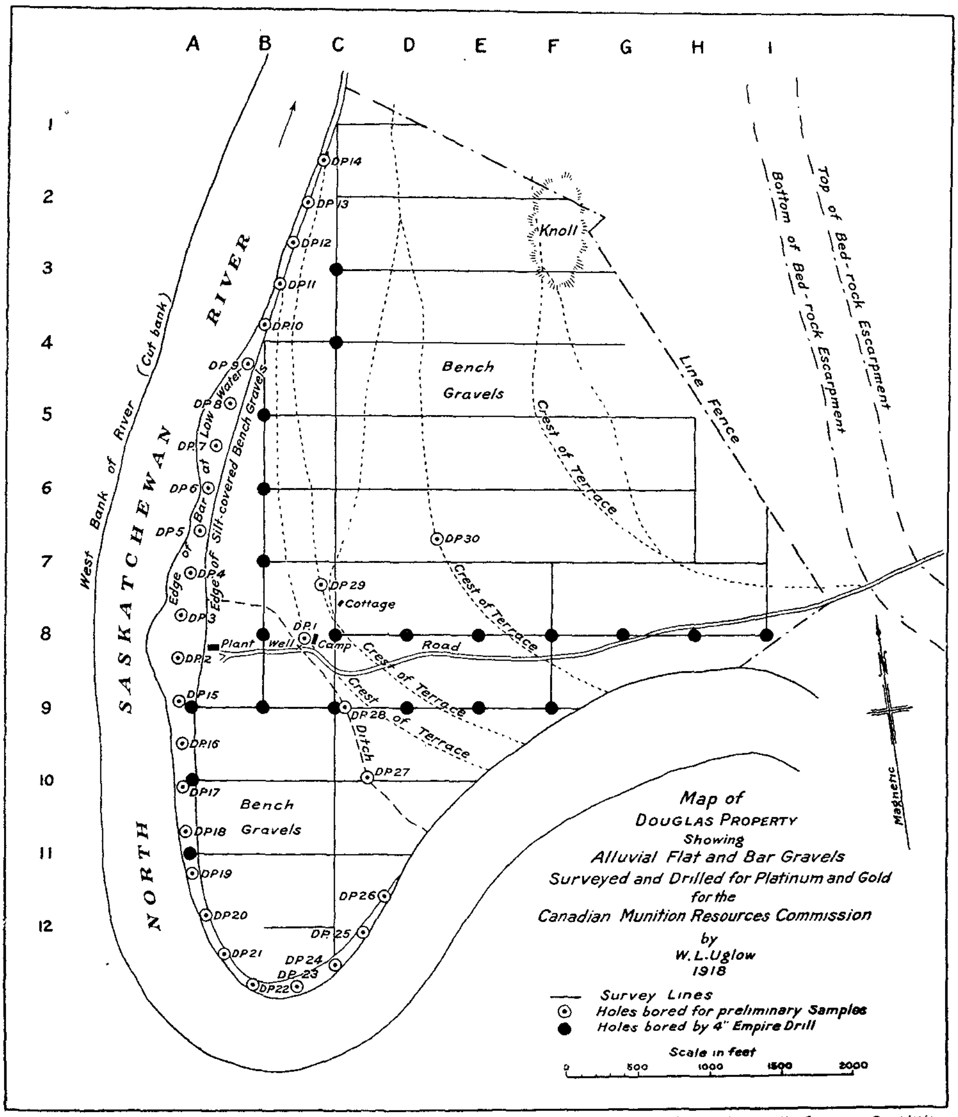
As a result of the assays on the 29 samples submitted during the course of the preliminary investigation, instructions were received from the Munition Resources Commission to proceed with a systematic boring of the Douglas property by means of a 4-inch Empire drill. This work was undertaken on July 6, and completed on August 16. (Plate LII.)

The work consisted of—(a) A complete survey of the entire property and the blocking-out of the ground along two sets of co-ordinates into squares, 500 feet to a side. The co-ordinates were so chosen that the northerly-southerly set coincided approximately with the direction of the main extent of the bar. This was done so that a line of drill-holes could be bored at 500-foot intervals along the bar. (b) The boring of holes at certain corners of the squares, as shown on Plate L. These holes were bored with a 4-inch Empire drill, and with two exceptions were sunk to bed-rock. The material passed through was accurately logged, both in respect to its character and to the number of gold 'colours' which were obtained with the sludge. The cuttings from each foot of gravel were pumped separately and panned by expert panners, and the number of gold 'colours' noted. The pannings from each foot were emptied into a second, or clean-up, pan and kept there until the completion of the hole. When each hole was finished, therefore, the clean-up pan contained the black sand and the gold and platinum values from the column of material excavated from the hole.

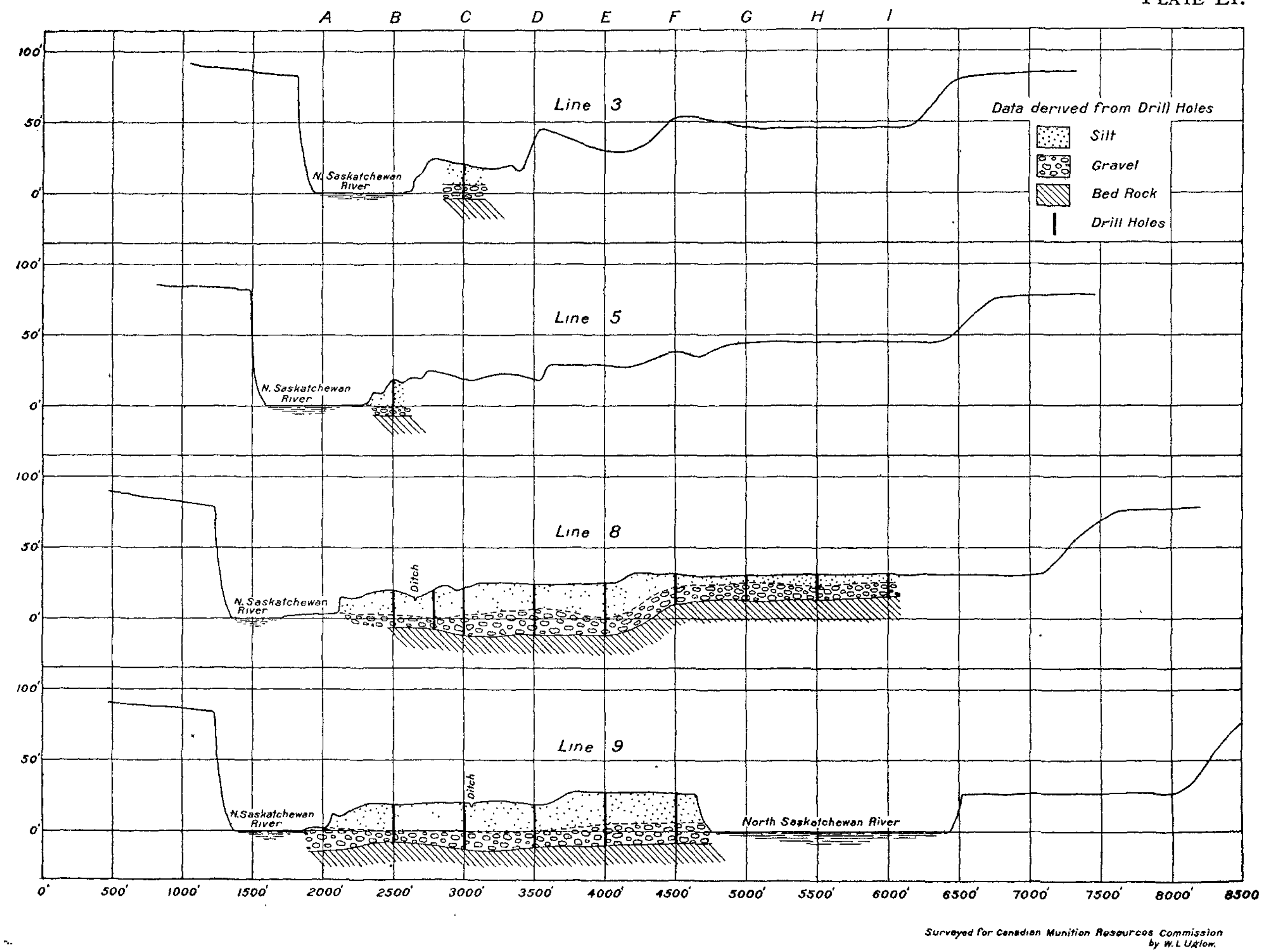
To this black-sand concentrate a small globule of mercury was then added, and thoroughly circulated amongst it until all the visible gold was amalgamated. The mercury globule was then washed into a small bottle and taken to the cleaning-up department for determination of its gold content. This determination was made by the writer in the field.

The black sand remaining in the pan after the amalgamation of the gold, was dried and screened through a 30-mesh screen, which eliminated the coarser fragments of rock and steel contained in the sludge. The screened portion was then bottled, sealed, and labelled, and sent by registered mail to the Dominion Assay Office, Vancouver, for the determination of its platinum and gold contents.

Results of the Preliminary Examination of the Bar Gravels.—As explained in a previous section, the samples submitted to the Assay Office at Ottawa were not the black sand concentrate obtained from each hole, but merely a portion of the actual material taken from the hole, screened through 8 mesh. This material was measured in terms of weight rather



Map of Douglas gold-platinum gravels, North Saskatchewan river, Alberta.



Douglas gold-platinum gravels. Vertical sections across North Saskatchewan River valley, Alberta.

than volume, on account of the difficulty of accurately determining the volume of the holes which were excavated. The assay returns, therefore, as reported in table No. 1,[1] were reduced in accordance with the ratio of the weights of the sample before screening to the sample after screening. That is to say, the weights of the precious metals in the screened samples were changed in accordance with the above ratio so as to represent the weights that would be found in the unscreened or original samples.

Platinum was valued at $105 and gold at $20 per troy ounce. These figures, therefore, gave values for the gravel on a tonnage basis. To transform these values to terms of yardage, the figure 3,375 was used as the weight of the gravel in pounds per cubic yard.

The first 14 samples in table No. 1, Nos. 2 to 15, inclusive, show values in combined metals of more than 10 cents per cubic yard, and are, therefore, the only ones included in the following calculations.

The average depth of these 14 samples was found to be 19·3 inches, or 1·61 feet.

In order to arrive at the average value of the material represented by these 14 samples, the figure representing the depth was multiplied by the figure representing the total cents per cubic yard for each sample; and the sum of these 14 products was divided by the figure for the total depth of all the holes. The quotient, which is 26·6, represents the average value in cents per cubic yard of all the material included in these 14 samples.

Each sample is considered as representative of that portion of the bar extending 150 feet on either side of it in the direction of the adjacent samples. Therefore, the total length of bar included in this estimate is 4,200 feet ($=300\times14$) and extends from 150 feet northeast of No. DP 14 to 150 feet south of No. DP 15 (Plate L).

The average width of the bar included within these end lines is obtained by adding together the figures for the widths at the locations of the 14 samples and dividing this sum by the number of samples. This quotient, which is 148·5, is the figure taken for the average width of the bar in feet.

Total Yardage of Material included in Estimate

Length	4,200	feet.
Average width	148·5	"
Average depth	1·61	"

Volume of material =

$$\frac{4{,}200\times148\cdot5\times1\cdot61}{27}=37{,}210 \text{ cu. yd.}$$

Gross Value of Material included in Estimate

$$37{,}210\times0\cdot266=\$\ 9{,}900$$

Results of Final Exploration with Empire Drill.—Work was commenced on July 10, 1918, at hole No. A 9, located on the bar. Nos. A 10 and A 11, the only remaining locations on the bar which were not at that

(1) See p. 194.

time under water, were then drilled in turn. Following the completion of A 11, it was decided to drill all the locations on line 9, beginning at B 9 and running inland from the bar. Line 8 was next drilled, commencing at I 8 at the inner edge of the farm, and proceeding toward the shore, as shown on Plate L. On account of the good value of the material of sample DP 1, obtained at the time of the preliminary examination, during the course of cleaning out the well, a check hole, No. W, was drilled as close to the well as the Empire equipment would allow. When this was completed, a line of holes was drilled in a northerly direction along lines B and C. By this method, two lines of holes (lines 8 and 9) gave two transverse sections across the whole property, which were intended to locate any paystreaks that might run in a northerly-southerly direction through the property. The holes on lines A, B, C, furnish a longitudinal section of the ground, and were drilled for the purpose of picking up any paystreaks that might run in an easterly-westerly direction.

Work was abandoned on instructions from the Munition Resources Commission during the course of the boring of hole No. C 2 on August 16.

Character and Depths of Formations Drilled

The material containing the values is a fine to medium gravel, consisting of fine sand and pebbles usually not more than four or five inches in diameter. In general, the weight of pebbles that will not pass 8 mesh is from two to three times the weight of the sand which passes the same screen. There is a predominance of sandstone and quartzite in the gravel, while the sand consists largely of the same constituents with minor amounts of garnet, chromite, and magnetite. It is with these heavy portions of the sand that the values are found.

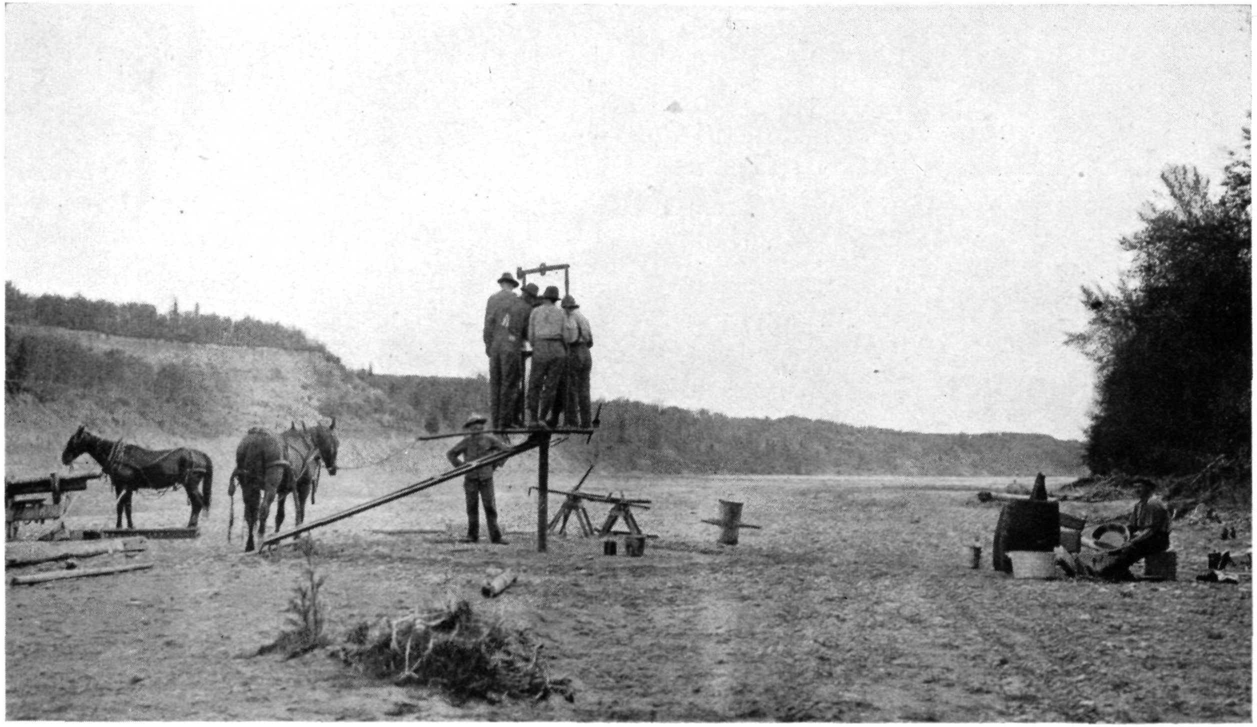
Results of the drilling and careful panning of a great deal of gravel and sludge show that the black sand occurs in the gravel in the proportion of from 1 to 3 pounds of black sand per cubic yard of gravel. Estimating a cubic yard of gravel at 3,375 pounds, this would give as the ratio of black sand to gravel from 1 to 3 pounds of sand to 3,375 of gravel.

In 20 holes which were bored to bed-rock (excluding Nos. A 10 and C 9, which did not reach bottom), the average depth of the gravel passed through was 11 feet.

In 19 holes which were bored on the alluvial flat through the bench gravels, the average depth of soil, fine sand, and silt passed through was 16 feet 8 inches. This material was found to be almost entirely barren of values.

The bed-rock was found to be of the character of a clay shale, rather hard and quite dry. In order to test its thickness one hole was bored with an auger-drill spoon to a depth of 4 feet 4 inches, without encountering any change of material.

In places immediately on top of this bed-rock, a layer from 6 inches to 3½ feet thick of soft blue clay was struck.



Drilling with the Empire drill, Douglas property, near Fort Saskatchewan, Alberta.

Character and Distribution of the Precious Metals

Both the platinum and the gold occur in minute scales and flakes; and only occasionally was a scale encountered with a diameter as large as one-fiftieth inch, during the course of the panning. Innumerable very fine specks of gold and smaller amounts of platinum were seen in several panfuls of gravel. None of the grains examined were found to have any appreciable thickness, the flakelike form being the characteristic one.

The distribution of the gold through the silt and gravel is shown graphically in Plate LIII. Except for a slight concentration on top of the clay seam in hole No. A 9, the greater portion of the gold is found in the upper five feet of the gravel. Owing to the difficulty of distinguishing the platinum in a pan of drill-cuttings on account of the presence of fragments of steel, this feature of location could not be determined for it. General conditions, however, indicate that the platinum occurs with the gold in the same parts of the gravel.

Values obtained from Empire-drill Holes

In table No. 2 are given the field data regarding each drill-hole, the assay returns from the Dominion Assay Office, Vancouver, and the consequent value of the ground passed through per cubic yard.

The procedure used to arrive at the valuations was as follows:

(a) After the amalgamation, in the field, of the gold in the concentrate from each hole, the globule of mercury was dissolved in hot dilute nitric acid, and the remaining gold dried and weighed. With a valuation of $20 per troy ounce, this weight of gold was converted into terms of cents per total volume of the hole. Using the figure 240 as the number of linear feet of 4-inch Empire-drill hole equivalent to one cubic yard of ground, the value of the hole was expressed in terms of cents per cubic yard. These values are given in table No. 2.[1]

(b) Portions of the fine gold did not readily amalgamate in many cases, and remained in the black sand along with the platinum. This was determined at the Dominion Assay Office, Vancouver, and reported as ounces per ton of black sand concentrate. The weight of the sample of black sand concentrate submitted to the Assay Office was reported in grams. From these data the total weight of the gold contained in the black sand was computed and expressed, as in (a) above, in terms of cents per cubic yard.

(c) The platinum content of the black sand concentrate was reported from the Dominion Assay Office in terms of troy ounces per ton of concentrate. Using a valuation of $105 per troy ounce for platinum, these figures were converted into figures for cents per cubic yard.

(d) Each sample represents a depth beginning at the surface regardless of whether the overburden is barren or pay ground.

(1) See p. 195.

Summary and Conclusions.—The investigation of the Douglas property, including a preliminary shallow sampling of the bar gravels and a systematic boring of certain sections of the alluvial flat, has led to the following conclusions:

(1) The gravel which carries the precious metals has an average thickness of about 11 feet.

(2) Covering a very large proportion of the ground, and lying immediately on top of the gravel, is a mantle of fine sand and silt with an average thickness of about 16 feet 8 inches.

(3) The gold and platinum occur in the form of very small flat flakes or scales, rarely larger than one-fiftieth inch in their greatest dimension. On this account a high recovery in dredging operations would be very difficult, if not impracticable.

(4) The values were found to be chiefly in the upper four or five feet of the gravel. Consequently, in order to recover them the entire thickness of the mantle of silt, itself almost barren, would require to be dredged.

(5) With the exception of the three drill-holes located on the bar (Nos. A 9, A 10, A 11), the value of the combined metals for the ground drilled was less than 5½ cents per cubic yard. Eliminating sample No. B 9 from the consideration of the holes on the alluvial flat, none of the samples returned higher than 1·77 cents per cubic yard. None of these locations gave samples indicating commercial ground. Consequently, no estimates of yardage were made.

(6) The samples from holes Nos. A 9, A 10, A 11 gave values of 8·63, 8·33, and 11·64 cents per cubic yard, respectively. These values represent depths of gravel from 11 to 16 feet. The samples taken on the bar during the course of the preliminary investigation, numbering from DP 2 to DP 15 (both inclusive) gave values varying from 11·9 to 58·5 cents per cubic yard. These samples represent an average depth of only 19·3 inches.

These two sets of results taken together would indicate that there is a volume of ground located on the bar which might be worked in a small way at a profit. In order to determine this definitely, a larger number of samples would have to be taken along this stretch of the bar, and they would require to be taken down to bed-rock.

(7) The results of the preliminary investigation show that this extent of bar has an area of about 70,000 square yards. With the same value per cubic yard found for the depth of 19·3 inches, every yard of depth would give a gross value in gold and platinum of about $18,600. The drill-holes, however, show that the higher values are near the surface of the gravel, and do not extend to bed-rock.

(8) The whole investigation has shown that although topographically the ground would be ideal for dredging, there is no part of it large enough, and

with sufficiently high values, to warrant the working of the ground on anything like the magnitude required by dredging operations.

TABLE NO. 1

*Results of Preliminary Sampling**

No. of sample	Depth of sample	Weight of sample before screening	Weight of sample after screening	Assay of sample submitted, gold and platinum per ton		Value per cubic yard		
				Au.	Pt.	Au.	Pt.	Total
	In.	Lb.	Lb.	Oz.	Oz.	Cents	Cents	Cents
DP 2	30	23·5	6·0	0·02	0·0025	17·2	11·3	28·5
" 3	25	20·5	8·25	0·01	0·005	13·5	35·6	49·1
" 4	21	12·0	6·25	trace	0·0025	trace	23.1	23·1
" 5	18	16·5	14·5	trace	none	trace	none	trace
" 6	10	14·5	5·0	0·04	none	46·5	none	46·5
" 7	19	8·5	6·5	0·006	none	15·5	none	15·5
" 8	23	15·0	5·5	0·04	trace	49·5	trace	49·5
" 9	29	20·5	5·5	0·03	trace	27·2	trace	27·2
" 10	18	21·5	6·75	0·025	none	26·5	none	26·5
" 11	13	37·5	8·5	0·03	trace	23·0	trace	23·0
" 12	13	11·25	8·75	0·005	trace	12·6	trace	12·6
" 13	13	9·0	6·5	0·005	trace	12·2	trace	12·2
" 14	8	15·0	6·5	0·04	trace	58·5	trace	58·5
" 15	30	20·5	7·25	0·01	trace	11·9	trace	11·9
" 16	32	19·25	6·25	0·005	trace	5·5	trace	5·5
" 17	37	20·0	7·5	0·005	trace	6·3	trace	6·3
" 18	41	22·0	7·5	0·005	trace	5·7	trace	5·7
" 19	31	65·5	12·5	trace	trace	....	....	....
" 20	39	19·75	9·25	0·005	trace	7·9	trace	7·9
" 21	46	15·5	8·0	trace	trace	....	....	....
" 22	50	22·75	4·5	trace	trace	....	....	....
" 23	44	24·5	4·5	trace	trace	....	....	....
" 24	29	21·5	5·0	trace	trace	....	....	....
" 25	28	24·75	4·75	trace	trace	....	....	....
" 26	26	14·5	7·5	trace	none	....	....	....
" 27	12	Overlain by 21′ 6″ silt		trace	trace	....	....	....
" 29	20	Overlain by 14′ 9″ silt		0·005	trace	13·5	trace	13·5
" 30	20	Overlain by 10′ 5″ silt		trace	trace	....	....	....
" 1	18	Overlain by 16′ silt		0·06	0·0075	81·0	53·0	134·0

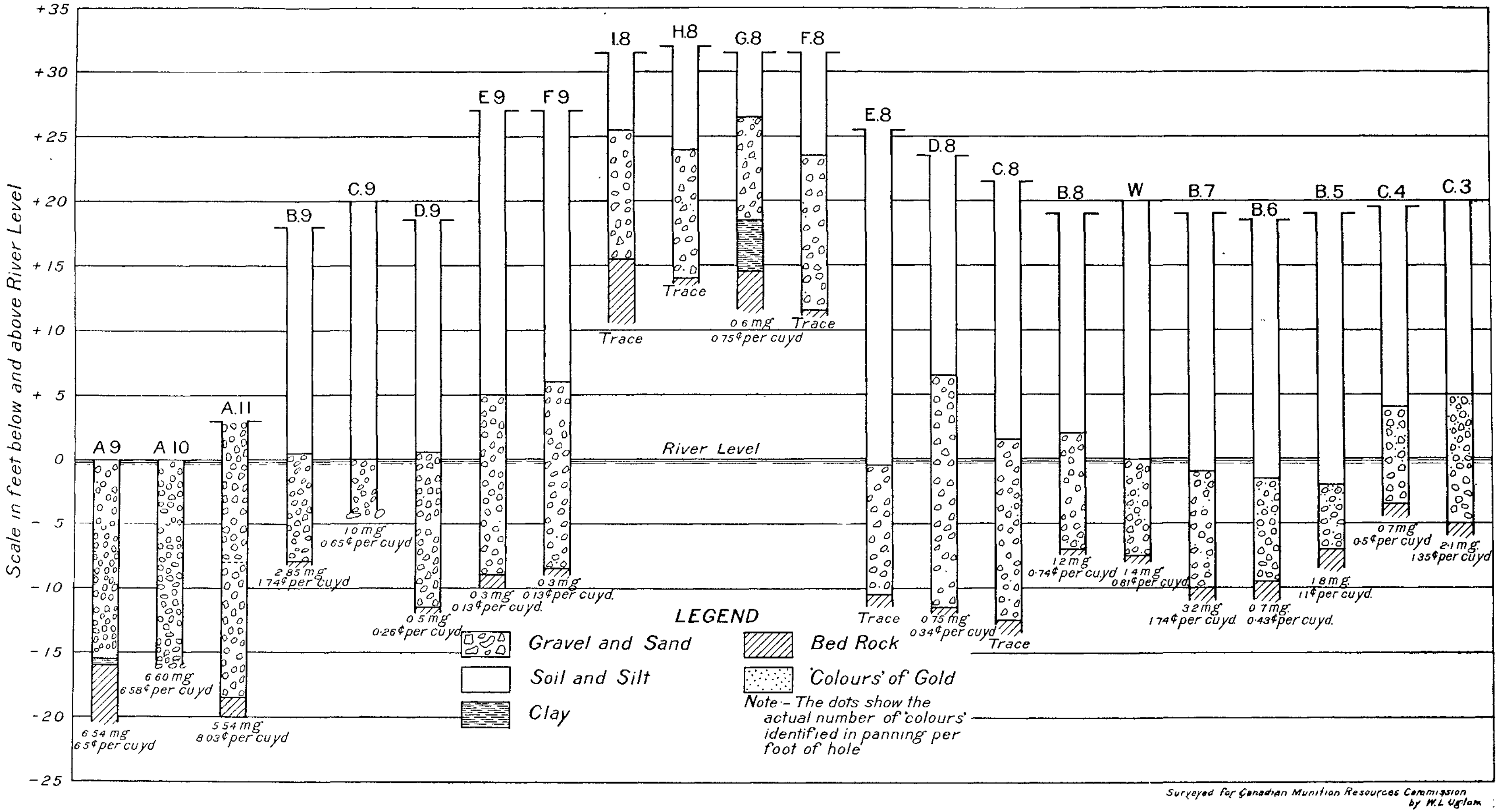
* Assays made by the Ore Dressing and Metallurgical Laboratories, Mines Branch, Department of Mines, Ottawa.

TABLE NO. 2

*Results of Sampling with Empire Drill**

No. of hole	Depth of silt	Depth of gravel	Depth of sample	Value of gold amalgamated per cu. yd.	Weight of black sand concentrate	Gold per ton of black sand concentrate	Platinum per ton of black sand concentrate	Gold per cubic yard of gravel	Platinum per cubic yard of gravel	Total value per cu. yd. of gravel
	Ft.	Ft.	Ft.	Cents.	Grams.	Oz.	Oz.	Cents	Cents	Cents
A 9	0·0	15·4	16·0	6·50	61·20	trace	0·20	trace	2·13	8·63
A 10	0·0	16·0	16·0	6·58	50·50	none	0·20	none	1·75	8·33
A 11	0·0	21·5	11·0	8·30	132·40	none	0·10	none	3·34	11·64
B 9	17·5	8·5	26·0	5·34	59·40	none	trace	none	trace	5·34
C 9	20·0	4·25	24·25	0·65	35·30	none	none	none	none	0·65
D 9	18·0	12·0	30·0	0·26	66·90	none	trace	none	trace	0·26
E 9	22·0	14·0	36·0	0·13	42·40	none	trace	none	trace	0·13
F 9	21·0	15·0	36·0	0·13	159·60	0·02	trace	0·05	trace	0·18
I 8	6·0	10·0	16·0	trace	7·60	0·08	0·02	0·20	0·03	0·23
H 8	8·0	10·0	18·0	trace	57·00	0·02	0·01	0·34	0·09	0·43
G 8	5·0	8·0	13·0	0·75	46·70	0·02	0·02	0·04	0·20	0·99
F 8	8·0	12·0	20·0	trace	81·90	0·02	0·01	0·04	0·11	0·15
E 8	26·0	10·0	36·0	trace	138·60	trace	0·01	trace	0·11	0·11
D 8	17·0	18·0	35·0	0·34	172·50	trace	0·02	trace	0·27	0·61
C 8	20·0	14·0	34·0	trace	50·40	0·82	0·06	0·64	0·25	0·89
B 8	17·0	9·0	26·0	0·74	117·10	0·05	trace	0·12	trace	0·86
W	20·0	7·5	27·5	0·81	76·70	0·03	0·01	0·12	0·08	1·01
B 7	20·0	9·0	29·0	1·74	37·56	0·04	trace	0·03	trace	1·77
B 6	20·0	8·0	28·0	0·43	104·24	0·06	trace	0·12	trace	0·55
B 5	21·0	5·0	26·0	1·10	21·45	trace	trace	trace	trace	1·10
C 4	15·5	7·5	23·0	0·50	23·46	0·32	trace	0·17	trace	0·67
C 3	15·0	10·0	25·0	1·35	45·90	0·01	trace	0·01	trace	1·36

* Assays made by the Dominion Assay Office, Vancouver, B.C.



Graphical representation of Empire-drill holes, Douglas property, near Fort Saskatchewan, Alberta.

TUNGSTEN

General

The metal tungsten is of primary importance because of certain valuable qualities it imparts to steel when alloyed with it. Its principal use during the period of the war was in the manufacture of high-speed tool steels so essential for the rapid production of all forms of projectiles, ordnance, and similar munitions.

Tungsten has, so far, distanced its rival molybdenum in this particular field because supplies of its crude ores were more readily obtainable; but the known tungsten resources of the world are limited, and molybdenum production has increased several hundred per cent during the past two years, so that the relative importance of the two metals may eventually be reversed.

Tungsten enters into the manufacture of armour plate, armour-piercing projectiles, gun liners, and aeroplane engines. It is also used in filaments for electric-light bulbs. Alloyed with aluminum it is employed in automobile construction, and with aluminum and copper in propeller blades. It is an important constituent of a new tool alloy called 'stellite.' With molybdenum it forms an alloy used in dentistry as a substitute for platinum.

In 1915 the British Government commandeered all supplies of tungsten ore concentrates within the Empire at a fixed price of 55 shillings ($13.50) per unit (1 per cent of a long ton) of contained tungstic acid. In the United States the open market quotations have fluctuated considerably during the past five years. Before the war the highest price was $15 per unit (1 per cent of a short ton), but in the spring of 1916 the price rose above $90 per unit. At the close of April, however, the price dropped considerably, and by the early part of 1917 had reached $17.50 per unit for concentrates carrying 60 per cent tungstic acid. Toward the end of 1917 the market tightened again, and tungsten concentrates were selling for approximately $24 per unit.

During 1918 tungsten prices at New York fluctuated between $24 and $26 per unit for the first nine months of the year, but after the signing of the armistice in November the market was very uncertain and at the close of the year business had come to a complete stop, with concentrates offering at $10 per unit.

Tungsten in British Columbia and the Yukon

There have been no important developments since Dr. T. L. Walker's 'Report on the Tungsten Ores of Canada' was published by the Mines Branch in 1909.

The occurrences there described in the Kootenay Belle (tungstite, wolframite, scheelite), Granite-Poorman (scheelite), and Meteor mines (scheelite), West Kootenay district, and that on St. Mary river (wolframite), East Kootenay district, were enquired into, and no developments of commercial value seem likely.

There has been no production from the deposit (chiefly scheelite) on Hardscrabble creek in the Cariboo district, but the property has been further developed and kept open.

The occurrence of scheelite and wolframite in the Yukon has been noted and described by the late Dr. Cairnes,(1) and during 1917 and 1918 several small lots of placer sands from the Yukon were received at the Ore Dressing and Metallurgical Laboratories of the Mines Branch, Department of Mines, for concentration. No production of any importance has so far been made.

Tungsten in Manitoba

The occurrence of scheelite in the Province of Manitoba has been noted and described by Mr. J. S. DeLury of the University of Manitoba, Winnipeg, in a memorandum submitted to the Secretary in May, 1918. This memorandum is not included in the present report, as an account of Mr. DeLury's field-work has already been published.(2)

Burnt Hill Tungsten Mine, York County, New Brunswick.

By J. C. GWILLIM

This property is situated in York county, New Brunswick, on the south side of the Main Southwest Miramichi river, nearly opposite the mouth of Burnt Hill brook. The mine may be reached from three different points on the Canadian Government railway, namely:—1. From Maple Grove station northward to the Miramichi river by 18 miles of bad bush-road. 2. From Boiestown, by poling or towing 30 miles up the Miramichi river. 3. From Half Moon bridge, where the railroad crosses the Miramichi, by poling down-stream a distance of 19 miles. Heavy supplies are best taken in by flat-boat or scow, during high water, from Boiestown, or by sleigh on winter road from Maple Grove.

This tungsten deposit was discovered by H. D. Freeze; the mineral rights being acquired by Matthew Lodge of Moncton, N.B. During the winter of 1915–1916, Messrs. A. A. Holland and J. W. Johnston undertook to develop the property, and in February, 1916, made a trial shipment of 2,193 lb. of wolframite ore to Queens University, Kingston, Ont. According to Holland's report this material averaged 8·6 per cent of tungstic acid, and a high saving was made by concentration with Harz jig and Wilfley table.

(1) Summary Report, Geol. Surv. Can., 1916, pp. 12-19.

(2) The Tungsten Deposits near Falcon Lake, Manitoba. J. S. DeLury. Canadian Mining Journal, June, 1918. pp. 186-188.

During the following summer the mine was opened up to a depth of 50 feet by a shaft, and the surface stripped for 130 feet along the outcrop. The outcrop was also traced by float for about 1,500 feet along the hillside. Machinery for a small mill and for hoisting was brought in by scows up the river from Boiestown.

In October, 1916, the vein had a width of from 1 to 3 feet in the workings, and was estimated to contain an average of 2½ per cent of tungstic acid. The total ore was estimated at 1,350 tons, which was expected to produce 52 tons of concentrate containing 65 per cent of tungstic acid.

The work had thus far been accomplished at a great disadvantage, owing to the isolated position of the mine, which necessitated costly and troublesome transportation. The property, after considerable pioneer work at heavy cost, was taken over by Messrs. L. H. and N. A. Timmins of Montreal, Que., who appear to have assumed Holland's obligations in the matter of a contract made to deliver 36 tons of tungsten concentrate to the Imperial Munitions Board.

The new management has continued the shaft from the 50-foot to the 150-foot level; driven a 50 ft. cross-cut to reach the vein on its northerly dip at the lower level; and an adit to tap the upper or 50-foot level. They have also continued the drifts on the 50-foot level to a length of about 300 feet, and have done some stoping above that level.

At the present time, August, 1917, the mill is treating about 15 tons of ore per day, of 1 per cent, or less, tungstic acid content. Mine labour is hard to secure and keep, and the property is under some disadvantage owing to the timber rights of the Miramichi Lumber Company in this district.

The mine has been visited, on behalf of the Imperial Munitions Board, by Chas. Camsell in June and October, 1916; by D. D. Cairnes in November, 1916; by Lieut. G. M. Ponton and by Dr. G. A. Young in July, 1917; and by me in August, 1917. The results of these inspections appear to show that the tungsten-bearing quartz has originated from the intrusion of banded argillites or slates by a mass of granite. These slates are fissured across their bedding in a northwest-southeast direction, and the principal ore deposit is a vein from 1 to 3 feet wide. A subsidiary zone of fracturing also carries some wolframite, to the extent of possibly one-half of one per cent of tungstic acid.

There is some evidence that this tungsten-bearing zone extends obliquely up the hillside for a distance of one-half mile, but the ore in place has been exposed at only two points, about 600 feet apart, and development work has been confined almost entirely to a length of 300 feet on the 50-foot level of the shaft workings.

The vein, or its continuation as a set of quartz stringers, has been cross-cut on the 150-foot level, but no drifting has been done at that depth. On the 50-foot level, going southeast, there is a fault plane in the drift, dipping to the northwest, which the workings have followed to the right or southwest for about 75 feet without picking up the continuation of the main vein on the other side of the fault. There are quartz veinlets in the fault plane, running parallel to it, and this ground is said to carry one-half of one per cent of tungstic acid.

It is probable that the faulted continuation of the main vein in the southeasterly direction is not much displaced, since the float on the hillside above continues in the general direction of the strike of the vein. The fault is probably a normal one and, if so, the chances are that the vein will not be found to the southwest—the direction in which it has been sought for—but to the left or northeast.

The mine workings are 165 feet above the level of the river, and about 1,500 feet from the mill which is beside the river and connected with the mine by a wooden-rail tramway.

This property may become a producer of tungsten ore, but a very considerable amount of development work will be required. So far, the workings have not shown an average tungstic acid content of 1 per cent over a stoping width of approximately 4 feet.

There are possibilities of richer and larger ore bodies to the southeast and northwest, along the direction of the ore bearing zone. As conditions stand at this date, there is an ore body from 1 to 3 feet wide, with an occasional extension of the mineralization into the walls, containing not over 1 per cent of tungstic acid. Considering the conditions under which the mine is worked, tungsten ore of this grade does not offer very profitable returns at the present official price of 55 shillings per unit of tungstic acid. Also, a large tonnage of even such a grade of ore is not yet assured. However, should the price of tungsten ore increase, which is not likely, the property would merit development.

Moose River Tungsten District, Nova Scotia

By J. C. GWILLIM

This tungsten-bearing area in Halifax county, Nova Scotia, lies 12 miles a little south of east from Middle Musquodoboit on a wooded plateau or range of from 250 to 300 feet greater elevation. There is a good road, with easy grades, from the Canadian Government railway to the mines, a distance of 16 miles.

The district has been described by Dr. T. L. Walker in his 'Report on the Tungsten Ores of Canada,' published in 1909 by the Mines Branch, Department of Mines, Ottawa.

The Moose River mines have been operated for gold to a shallow depth, usually under 300 feet, for about 50 years. Little or no mining is now going on.

The Touquoy gold mine, said to carry some tungsten ore (scheelite), was operated by a man of that name from 1881 to 1900. He is reported to have taken out from $200,000 to $250,000 in gold. In 1900, Robert Kaulbach and associates took over the property and are said to have taken out another $200,000 in gold. In 1908–1909, Mr. M. J. O'Brien tried to operate the property for gold but did not complete his option. Since then the mine has filled with water to the upper or 80-foot workings. The property comprises 50 acres which carry the mining rights for gold, silver, and coal. There are 8 shafts, varying in depth from 40 to 185 feet, more or less connected by an irregular system of drifting. The tungsten rights are held by Alfred Dickie, who optioned them to Robert Kaulbach until October 16, 1916.

The occurrence of tungsten ore (scheelite) is at about 140 feet below the surface, and 80 to 100 feet south of the vertical shaft. This part of the mine was flooded in August, 1916, and could not be pumped out in less than two weeks. Hence, I can only quote the statements of those who saw it several years ago.

Robert Kaulbach, part owner and manager of this mine for 16 years, states that the tungsten ore occurs as a band from 20 to 30 inches wide in the central portion of an 'embedded' quartz vein or lens from 3½ to 4 feet wide. It was cross-cut by a working from the No. 3 inclined shaft, and is now connected with the 175-foot level of the vertical shaft. At the time this 'embedded' vein was driven through, the value of tungsten (scheelite) ore was not known, and, being barren of gold, the vein was not further developed.

Harvey Higgins, foreman of the old Touquoy mine, corroborates the above statements of Robert Kaulbach.

John A. Reynolds, at present superintendent of the Scheelite Mines, Limited, property, in searching old dumps for evidence of tungsten ores, after such were known to be valuable, found 'angular pieces of ore as large as half a pail' in the Touquoy dumps, and on enquiry found that these came from the 'Robinson' cross-cut in the lower workings of No. 3 inclined shaft. A few small pieces of scheelite were seen by myself on the dump at this place.

The Moose River scheelite mine (Scheelite Mines, Limited), owned by various Nova Scotia interests, was for a time abandoned, but in August, 1916, was being unwatered, and I was able to examine some of the upper and southern workings. The appearance of these made a favourable impression, and I believe that if the present indications continue, as they probably will, this property may produce several tons of scheelite concentrate per day. The mill is a substantial building and can quite readily be modified to do good work. At the surface there is a pile of from 25 to 30 tons of picked ore which may contain 25 per cent of scheelite.

On the occasion of my second visit to this property, in August, 1917, I found that very little had been accomplished since my visit in August, 1916. The mine had been kept unwatered and a few men employed on development work, but no ore was milled nor shipments made during the past year. There are about 100 tons of ore, containing possibly 5 to 10 per cent of scheelite, on the dumps. Underground, there are many occurrences of ore in kidneys and small streaks. The best ore appears to follow the more acute folds, both anticlines and synclines, as they pitch westward at an angle of about 10°. If this holds true, the mining can be so laid out as to avoid the large amount of development and dead-work done in the past on barren portions of the veins. A few tons of scheelite could be obtained in a short time by milling the ore already on the dumps and ready for stoping in the mine.

MEMORANDUM AND RECOMMENDATIONS FOR INCREASED EXPLOITATION OF CANADIAN MINERAL RESOURCES

The Commission having undertaken a review of the mineral production of Canada as affecting the manufacture of munitions, submitted, in November, 1917, the following memorandum and recommendations for the consideration of the Government:

The Canadian munition industry is based upon the production of a variety of minerals that are essential for the manufacture of war munitions, and while it is undesirable from the point of brevity to list and describe all of these requirements, a few of the outstanding and more important minerals are enumerated and commented upon.

Iron.—Canada continues to be an unimportant factor in the production of iron ores, notwithstanding the fact that prices for ores of iron have increased considerably during the past two years. Some little activity is evident in the Ottawa Valley district and several dumps from old workings have been gone over and the better part of the ore removed, but beyond this no actual re-working of abandoned mines has been attempted.

The total production of Canadian ores for 1917 was 215,000 tons, practically all of which was derived from the Helen and Magpie mines of the Algoma Steel Corporation, in the Michipicoten district, Ontario.

The people of British Columbia have been making an effort to awaken interest in the establishment of an iron industry in that province, and while it can be shown that ores of merchantable quality exist, and that there is a supply of both fuel and limestone for smelting purposes, there is a notable hesitancy on the part of capital to launch such an undertaking. This condition is perhaps due to the fact that British Columbia does not at present possess a sufficient market to absorb the products of such an industry, and the success of the venture would perhaps rest with the ability of the operators to market their product in the neighbouring states of Washington, Oregon, and California.

Copper.—The total production of copper in 1917 is estimated to be 56,500 short tons, contained in ores, blister copper, or matte.

The installation of the copper-nickel refineries now under construction in Ontario for the International Nickel Company at Port Colborne and the British America Nickel Corporation at Deschênes, is not yet completed, but it is expected that some production of these refined metals will be forthcoming during the next year.

Nickel.—The production of Canadian nickel, all in the form of matte, from the smelteries of the International Nickel Company at Copper Cliff, Ont., and the Mond Nickel Company at Coniston, Ont., will amount to approximately 42,400 short tons. This production is estimated to be well over 80 per cent of the world's supply. At the present time all this matte is exported to the United States and Great Britain for refining purposes, but with the completion of the refineries now being installed by the International Nickel Company and the British America Nickel Corporation, Canada will, in 1918, commence the production of refined nickel within the Dominion.

Lead.—The lead production for 1917, estimated at 17,000 tons, will be greater than that of 1916, but complete returns are not available.

Lead bullion was produced chiefly by the Consolidated Mining and Smelting Company at Trail, B.C., with small contributions from smelters at Kingston and Galetta, Ont.

Zinc.—The zinc production for 1917, estimated as recoverable metal from ores refined in Canada and exported, was 15,500 short tons.

The establishment of an electrolytic zinc refinery at Trail, B.C., has been a step forward in placing the metallurgy of this metal in Canada on a similar basis to that of lead and copper. The production of refined zinc at Trail for the year is estimated at 10,250 short tons.

Molybdenum.—The production of molybdenite for 1917 is estimated to have been 145 short tons, valued at $290,122, of which 40·37 tons, or 27·38 per cent, was exported to France and the United States, the balance being converted to ferro-molybdenum in this country. The amount of ferro-molybdenum produced during the year is placed at 74·56 short tons, containing 68·13 per cent of metallic molybdenum valued at $336,700.

Tungsten.—Canada so far has been a negligible factor in the production of tungsten ores. A small shipment was recorded in 1913 from the Moose River district in Nova Scotia, but since that year no production of any size has been made.

A deposit of tungsten ore has undergone development since 1916 at Burnt Hill brook, in central New Brunswick, and some production of concentrate was made during 1917 from this property. The Moose River deposits in Nova Scotia were not operated, but some small production is expected from the Yukon Territory, where tungsten minerals have been found in the sluice-boxes of the placer-gold miners.

Chromium.—Canada is one of the important producing countries of chrome ore, which is so urgently required at the present time for the manufacture of special steels entering munitions.

The production of Canadian mines for 1917 was 23,327 tons, valued at $572,115, practically the whole of which was exported to the United States in the form of crude ore and concentrates. It is highly important that the output of the Quebec mines be increased considerably during the present year.

Manganese.—There is a very small production of manganese ores in this country, although there remains a possibility that certain low-grade deposits in the Maritime Provinces may eventually, by concentration methods, become of some importance.

Recommendations

It may be stated that the development of the country's mineral resources rests almost entirely with that portion of the public interested in mining, and while a relatively small percentage of the Canadian mining public are in a position to acquire the technical knowledge and capital required for mineral exploitation, by far the larger part are without capital, and quite unable to secure technical advice. It follows naturally that the mining public of the United States, being much larger in point of numbers and therefore possessing a preponderance of both capital and technical ability, is in a better position to exploit Canadian mineral resources than are the Canadians themselves, with the result that United States capital and technical direction dominate in the mineral production of Canada.

With the view, therefore, of rendering assistance to the mining industry of Canada, more particularly that portion of the industry concerned with munition supply, the Commission would recommend that means be taken to educate the general mining public in all matters directly concerning the mining of minerals and their preparation for the market. To carry out this educational programme to best advantage the Commission advises the establishment of additional technical laboratories, modeled after the existing testing laboratories of the Department of Mines.

The Department of Mines testing laboratories at Ottawa were installed with a view to educating the public in matters connected with the development of the mineral resources of the country. These laboratories are thoroughly equipped to examine, test, and report upon the value of metallic ores, coals, oils, non-metallic minerals, and structural materials.

The value of these laboratories to the public is beyond question, and the fact that during the past five years the staff and equipment has had to be increased over one hundred per cent in order to keep up with requirements indicates that the service is appreciated.

The laboratories have also been of great value to the Imperial Munitions Board in the securing of supplies of molybdenite for export to the Allied Governments, and have rendered continuous service in the physical and chemical examination of materials entering munitions.

The Commission is of the opinion that although the present laboratories of the Department of Mines in Ottawa have rendered valuable service to the country, their field of utility would be very largely increased through the establishment of branch laboratories in Nova Scotia and British Columbia. That the installation of such branch laboratories would materially assist in mineral production, cannot be questioned. The small mine owners and prospectors in the above mentioned provinces would be enabled to take full advantage of the facilities offered, which they are now unable to do owing to the excessive cost of forwarding large bulk samples to Ottawa for testing purposes.

It is recommended that in addition to the present installation of the Department of Mines in Ottawa, two additional research and testing laboratories be installed—one in Nova Scotia, and one in British Columbia, and furthermore, that the capacity of the present parent laboratory in Ottawa be doubled.

It is proposed that these laboratories should be an extension and under the control of the Departmental laboratories in Ottawa, and should be officered by the staff of the Department of Mines. Each laboratory should be fully equipped to deal with all the more important problems in connection with the utilization of mineral resources, and in order that the public should gain the fullest possible advantage from the installation of these laboratories, they should be operated somewhat on the following lines:

In all cases the work of the laboratories should be free to the public under the following conditions:

(*a*) Samples should be delivered, carriage paid, to the laboratories, and should consist of, except in special cases, at least one ton (2,000 lb.) of the material requiring examination.

(*b*) All products resulting from the examination of materials submitted should become the property of the laboratories, unless otherwise arranged.

(*c*) All reports of such tests, examinations, assays, etc., should be incorporated and published in the annual report of the Department of Mines.

In making these recommendations the Commission would respectfully draw the attention of the Government to the fact that the proposals do not call for any new organization, but rather for an enlargement of the present equipment, staff, and scope of the Department of Mines; and in view of the great importance of the mineral industry, being second only to that of agriculture, and because of its close relation to munitions supply, the Commission would solicit the earnest consideration of the Government for the proposals contained herein.

INDEX OF CANADIAN MINERAL RESOURCES

The Secretary of the Canadian Mining Institute wrote the Commission in October, 1917, stating that the American Institute of Mining and Metallurgical Engineers had invited the Institute to prepare an inventory of Canadian minerals required for war purposes in collaboration with the War Minerals Committee of the United States, and proposed that the Commission undertake the work. The proposal was accepted by the Commission, and, after consultation with members of the staff of the Department of Mines, circulars were printed and distributed to all members of the Canadian Mining Institute, asking for their assistance. It was fully recognized by the Commission that possibly over ninety per cent of the desired information could be secured from the published reports of the Department of Mines and the Provincial Bureaus, but it was decided that if by issuing these circulars information leading to the operation of even one or two mineral deposits was secured, the trouble and expense would be fully justified.

A card index, intended eventually to cover as completely as possible the mineral resources of the Dominion, was commenced by the Commission, the minerals required for munition purposes receiving first attention.

In January, 1918, Dr. Ferrier undertook the organization and general supervision of this work, which was carried on with the assistance of the Department of Mines. He prepared a filing system which, after consultation with Mr. J. McLeish and other officers of the Mines Branch and Geological Survey, was adopted, and Mr. A. M. Campbell was engaged to commence the compilation of the data for the Index.

The 'Card Index to Mineral Occurrences' originally established by the Mineral Statistics and Mines Division of the Geological Survey and later continued by the Division of Mineral Resources and Statistics of the Mines Branch, was placed at the disposal of the Commission by Mr. McLeish, Chief of the division, and served as the basis for the work. This index is a record of localities for the various economic minerals, with bibliographical references, the detailed information regarding each mine or occurrence being contained in the various other files and records of the division. The cards are small, measuring 5 by 3 inches.

Mr. McLeish has pointed out in his reports that, owing to the limited staff of the division and the lack of systematic reporting to it of information obtained by the field parties of the Department of Mines, it has been found impossible to maintain the necessary completeness of the index. In his report for 1917 he states[(1)]:

> In my first Summary Report on taking charge of this division in 1908, I described the 'Card Index to Mineral Occurrences'; the 'Mineral Occurrence Record File'; and the 'Clipping System for Mining Information', that had already been established as part of the organization of the Mineral Statistics and Mines Division of the Geological Survey.

(1) Mines Branch, Department of Mines, Summary Report for 1917, p. 140.

This indexing and filing has been continued in the Division of Mineral Resources and Statistics only in so far as our very limited staff would permit. In order that the division may carry out more completely the function 'to collect and preserve all available records of mines and mining works in Canada,' it will be necessary to provide a special staff for the purpose, and bring the division into the closest possible co-operation with the economic field work of the whole department and to provide that all field officers shall turn in to this Mineral Resources Record Office, copies of all data collected respecting mineral resources.

The incomplete files already available in this division have been of the utmost value to the members of the Mines Branch staff in planning their field work.

In devising a system for the Mineral Resources Index commenced by the Commission, the particular needs of the Division of Mineral Resources of the Mines Branch were borne in mind, as it had been definitely arranged that the Index as far as completed, together with all the material and equipment provided by the Commission for it, would be turned over to that division. This arrangement has now been carried out. The chief aim of the system adopted was to bring together in the one place *all* the information relating to each mineral occurrence. The individual cards, as fully explained farther on, provide space for the recording of the essential details regarding the mine or mineral occurrence, and are to be accompanied by document files containing the maps, plans, photographs, reports, statistics, newspaper clippings, etc., relating to it. The cards, if properly kept up, will show at a glance the *essential* data required in answering enquiries, and any further information on hand will be found in the document file, if there be one, corresponding to the card consulted.

The Commission strongly recommend the continuance of this most important work which is urgently needed at the present time when Canadian mineral resources are attracting so much attention.

A good start has been made, and if the work is now rapidly pushed forward, as it should be, by the Mines Branch with the necessary staff, until it includes the whole of the mineral resources of the Dominion, the Index will become of inestimable value as the central source of information which is now scattered throughout the numerous reports and departmental records.

Incidentally, the making of this mineral file will facilitate the object of the Imperial Mineral Resources Bureau in London, and the preparation of duplicate cards for the London Bureau should be kept in view.

Through the kindness of Dr. Haanel, Director of the Mines Branch, a room was provided for the Index in the Mines Branch Building and furnished by the Commission with steel filing-cabinets, an electric dry-mounting press, photograph and map trimmers, desks, typewriter, and other equipment. The stock of guide cards with mounted maps, printed index-cards and field information-blanks, labels, metal tabs, enlargements of provincial maps for area guides, and other material, is on hand in sufficient quantities to carry on the work for a long time to come.

Description of the Index

Filing Cabinets.—Steel filing-cabinets in 4-drawer sections and of two sizes, letter and foolscap, have been provided and placed in alternate position so that files to contain documents are immediately next those containing cards to which the documents relate.

Guide Cards.—Three kinds of guide cards, of the ordinary letter-size, are used. (See Plates LIV and LV).

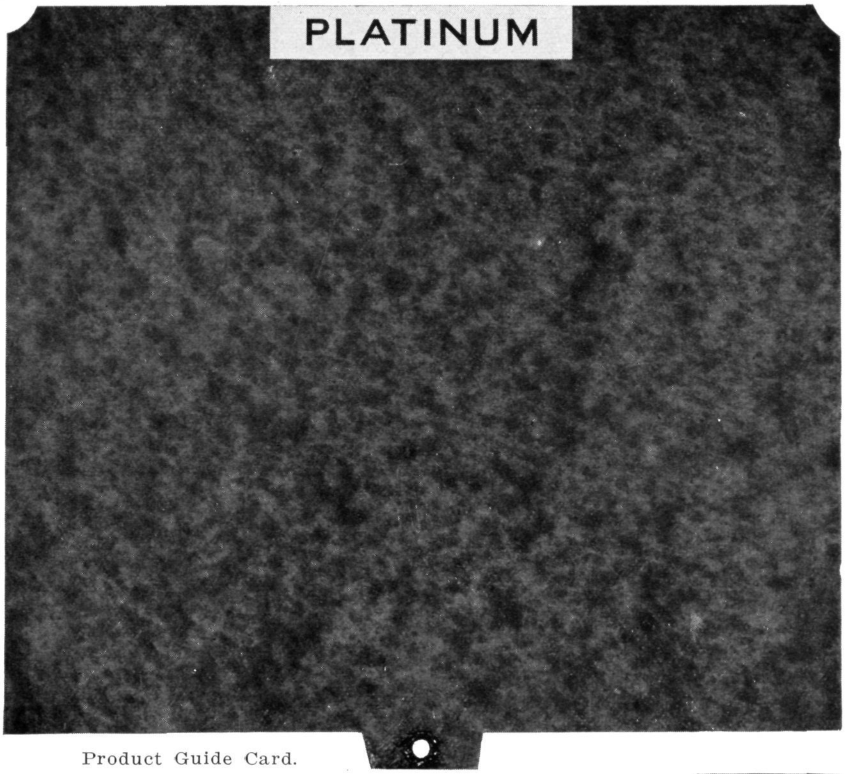
Those for 'Products' are of heavy brown fibre-board and project three-quarters of an inch above all the other cards. They bear the names of the various mineral products, such as gold, copper, iron, etc., in large bold type, as shown. The cards for each product are arranged under the 'Product' guide card, first, according to the province or territory to which they belong, and, second, according to the particular area in which the mineral deposit is situated. For this purpose two kinds of geographical guide cards, 'Province or Territory' and 'Area' cards (the ordinary stiff green pressboard letter-file guides) are used, each bearing a map affixed to it with mounting tissue by means of an electrically-heated dry-mounting press.

By permission of the Deputy Minister of Mines, the maps of the provinces and territories of the Dominion of Canada used for the 'Province or Territory' guide cards are the same as those prepared for the 'Catalogue of and Guide to the Publications of the Geological Survey,' by Dr. Ferrier, about to be published by that branch of the Department of Mines. They are divided by red lines into areas bounded by lines of latitude and longitude, each area designated by a letter and number according to its position on the map. The scales vary from 35 to 250 miles to 1 inch. The use of these maps for the Index links up its information with that contained in the publication referred to above. Removable metal tabs with the name of the province or territory are placed on the right-hand side of the cards.

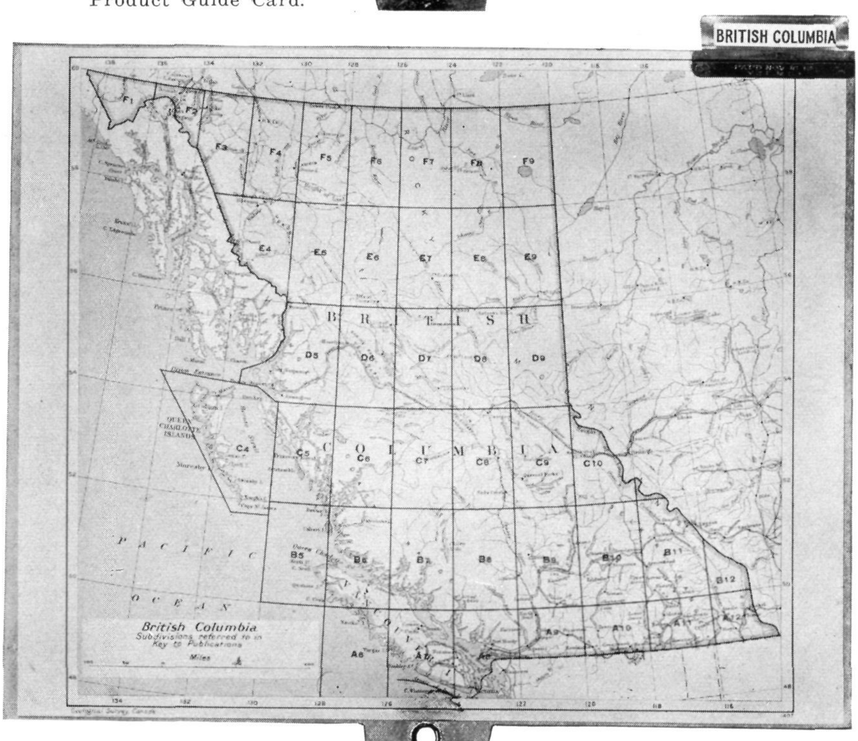
The second kind of geographical guide cards, the 'Area' cards, are of the same type and size, but each bears a large-scale map of one of the areas shown on the corresponding 'Province or Territory' guide card. The map scales vary from 7·89 to 17·5 miles to 1 inch. Each of these 'Area' guide cards has, on its left-hand side, a removable metal tab bearing the letter and number of the area. The positions of localities of minerals which yield the product indicated on the 'Product' guide card and lie within the boundaries of the area are shown by numbers corresponding to those on the record cards containing the detailed information regarding them.

Record Cards.—These are of three different colours, pale blue, pale buff, and salmon. The pale blue cards are used for records of *mines*, the pale buff for *prospects*, and the salmon for *occurrences*.

For practical purposes it was necessary to adopt a somewhat arbitrary classification. Properties which have passed the purely development stage and have made commercial shipments are classified as *mines* Those



Product Guide Card.



Province Guide Card.

MINERAL RESOURCES INDEX.
Guide Cards.

which have had more or less development work done on them but have not yet reached the shipping stage are classified as *prospects.* Records of occurrences of minerals of economic value which have not yet been located, or of which nothing definite is known, are classified as *occurrences.*

Provision is made for indicating by means of small removable coloured tabs that a mine has ceased producing or has been abandoned.

Properties recorded as *prospects,* on reaching the producing stage would, of course, by change of card, be placed in the *mines* class, and mineral *occurrences* when taken up and worked would be dealt with in a similar manner.

The record cards are printed on both sides. The back of the card is divided vertically into two equal spaces, headed 'Bibliography' and 'Remarks,' and the printed form is in reverse position with regard to that on the face. Both sides of the card can thus be read without removal from the file.

The printed headings are so spaced that when the cards are run through the typewriter the written lines fall accurately into their proper positions with regard to these headings.

The various headings are shown in the illustration and require but little explanation. (Plate LV).

The letter and number of the particular area in which the property lies is entered under 'Map Square' at the top of the card.

The entry number, which also appears opposite the spot indicating the locality on the large-scale map of the 'Area' guide card, is placed under 'No.' at the top of the card. A 'D' stamped after the entry number indicates that a file pocket with a corresponding number will be found in the document files. An index book, showing under which 'Product' guide cards the various entry numbers have been placed, should be kept.

In cases where the claim or property has a definite name this is entered under 'Name of Property.' Otherwise, a short description of its position is written on the line opposite 'Location.'

Under 'Location' the designations of the various territorial and survey subdivisions, which differ in the different Provinces, are given, so that full entries may be made according to the particular system in use in that part of Canada in which the property is situated.

Ample space is provided under 'Owners or Operators and Address' for recording changes in ownership or leases. The record also furnishes the address to which correspondence may be sent.

The subheadings under 'Description of Deposit' are self-explanatory. A brief entry in each case, giving the essential features, is all that is necessary. Where an ore is complex, yielding more than one product, e.g., a silver-lead-zinc ore, if the card entry is for *lead* the silver and zinc would be noted under the subheading 'Associated Minerals of Value' and cards dealing with the same property placed in the Silver and Zinc files.

The entries under 'Development Work' include brief notes regarding strippings, test pits, shafts, number of feet of sinking, raising, drifting, cross-cutting, etc., according to the stage of development, and also show the years in which the work was done. If the property is not provided with machinery for operation, the word 'Equipped' is crossed out, and vice versa. If this be done with a pencil, a change can readily be made when equipment is acquired, or again if it is withdrawn on abandonment of the property.

Under 'Production' space is provided for recording the nature of the material shipped, e.g., crude ore or concentrates, in addition to the annual tonnage or value figures.

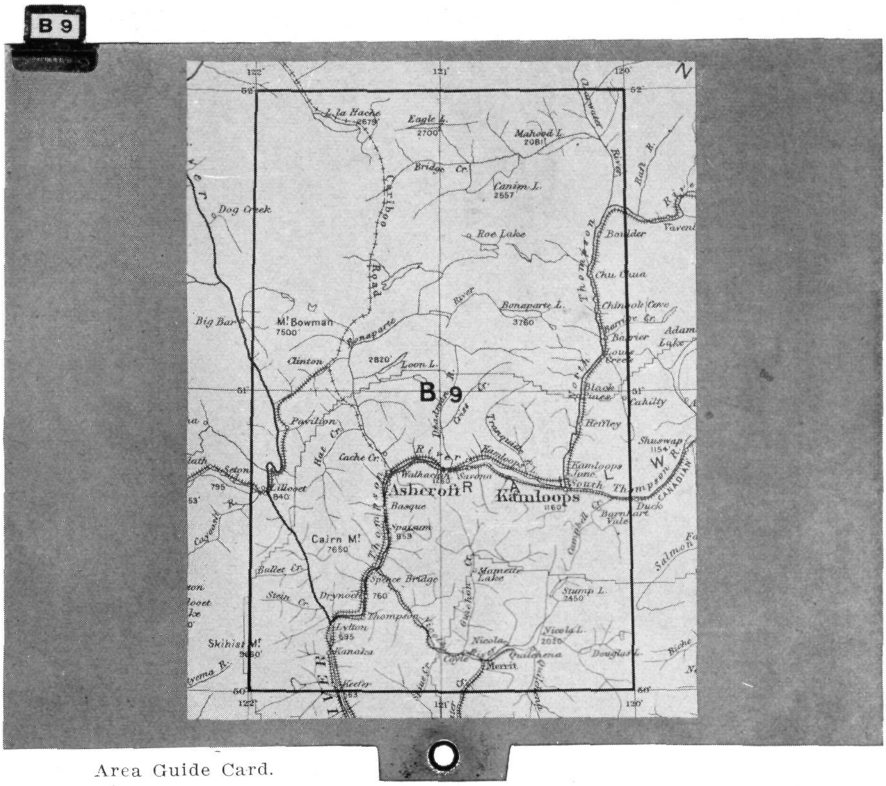
The 'Transportation' entries cover the name of the point from which the ore or material is shipped; its distance from the mine; the means of transportation, by rail, boat, etc., and its final destination.

Two classes of maps are provided for under 'Map References,' and copies of these should, if possible, be placed in the document files. Besides those which have been furnished by owners to the Mines Branch, geological and topographical maps, plans, and sections, relating to many properties, are contained in the reports of the Mines Branch, the Geological Survey, and the Provincial Bureaus, also in the mining journals.

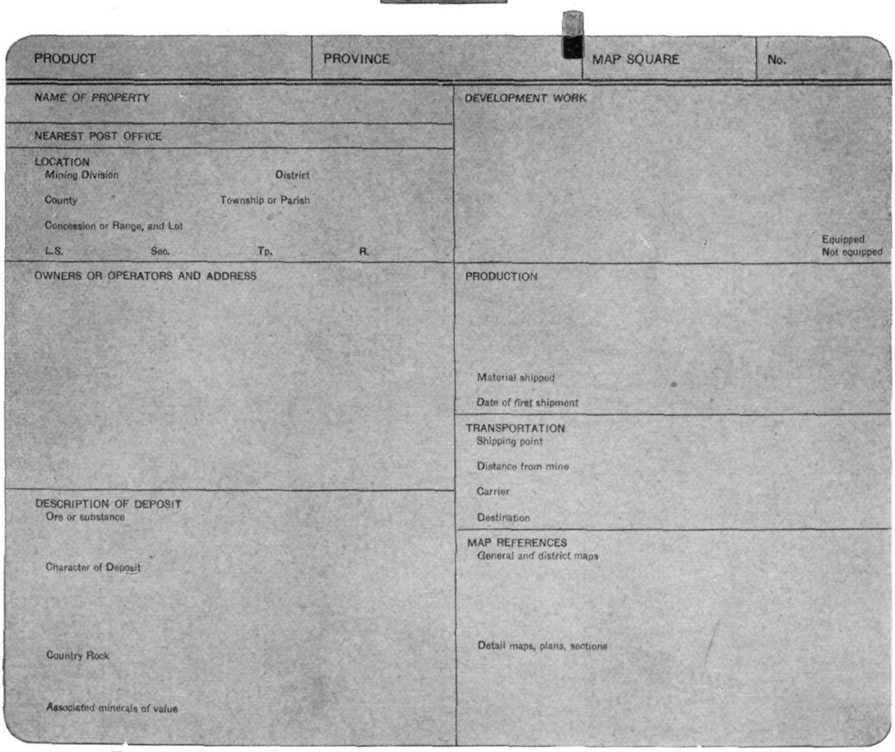
References to properties, to be found in official reports, mining journals, or other publications, are noted under the heading 'References' on the back of the card.

Additional information and comments, including references to private communications on correspondence files, are also entered on the back of the card, under 'Remarks.'

Information Blanks.—Blank forms identical with the record cards of the Index have been made up into pads and distributed to the officers of the Department of Mines in charge of field parties so that they may enter information obtained regarding mineral deposits and forward it promptly to Ottawa.



Area Guide Card.



PRODUCT	PROVINCE	MAP SQUARE	No.

NAME OF PROPERTY

NEAREST POST OFFICE

LOCATION
Mining Division District
County Township or Parish
Concession or Range, and Lot
L.S. Sec. Tp. R.

OWNERS OR OPERATORS AND ADDRESS

DESCRIPTION OF DEPOSIT
Ore or substance
Character of Deposit
Country Rock
Associated minerals of value

DEVELOPMENT WORK
Equipped
Not equipped

PRODUCTION
Material shipped
Date of first shipment

TRANSPORTATION
Shipping point
Distance from mine
Carrier
Destination

MAP REFERENCES
General and district maps
Detail maps, plans, sections

Record Card.

MINERAL RESOURCES INDEX.
Guide and Record Cards.

APPENDIX A

Steel Scrap Investigation

By J. DIX FRASER

Port Arthur, Ontario,
January 10, 1917.

GEORGE C. MACKENZIE, Esq.,
Secretary,
Canadian Munition Resources Commission.
Ottawa, Canada.

DEAR SIR:

In accordance with your letter of September 30 asking me to investigate the steel scrap situation in Canada in relation to embargo in force and verbal agreement arrived at with you in Ottawa, October 13, 1916, I herewith submit outline of trip and information received to date.

Outline of Trip.—It was agreed I should visit all munition plants in Canada and discuss steel scrap conditions with the owners or managers and obtain as much information as possible along other lines, but having a bearing on the scrap in connection with the manufacturing of shells.

Starting at Toronto, November 2, I called on twenty-two out of the twenty-six plants making shells in that city, and basing my opinion on information received, decided it would be a waste of time and expense to visit all the plants in Canada, as reliable information could be obtained by visiting representative munition plants at the important centres throughout the country. Acting on this opinion, I wrote asking if you agreed with me to send out a circular covering twelve questions and any additional questions you might suggest, to all shell makers. You agreed with my suggestion and sent out the following circular containing fourteen questions:

(1) Give size and average output of shells per month.
(2) Total tons scrap turnings made per month.
(3) Total tons shell ends and heavy scrap per month.
(4) Selling price scrap turnings f.o.b. cars works.
(5) Selling price shell ends f.o.b. cars works.
(6) Freight rates to nearest Canadian steel works.
(7) Freight rates to nearest American steel works.
(8) Total tons scrap turnings on hand.
(9) Total tons shell ends on hand.
(10) Can you sell all the scrap turnings you make in Canada at fair market price with embargo in force?

(11) Can you sell all the shell ends you make in Canada at fair market price with embargo in force?

(12) Do you dispose of your scrap to Canadian steel works or to Canadian scrap dealers?

(13) If Canadian steel works have declined to take your scrap borings and turnings, what reason do they advance for such refusal?

(14) What is your opinion *re* embargo on steel scrap?

The above questions cover the line of discussion I had with shell people and answers received through the mail.

After finishing my work in Toronto, I visited the principal cities and towns between Hamilton, St. Catharines, Windsor, and Guelph, this territory covering one of the most important parts of Ontario. I also visited points east of Winnipeg to Montreal, and Montreal east through Nova Scotia, making in all twenty-seven cities and towns and sixty-seven plants visited. The information obtained during this trip together with data received direct from munition plants represents in my opinion as reliable information as it is possible to get in connection with the scrap business.

Answers received to Questions asked.—Up to January 4 the following information has been received:

Shell Ends and Heavy Scrap

	Circulars sent	Replies received	Tons made monthly	Average price at works	Tons on hand
Nova Scotia...	10	6	3,387	$ 11.67	560
New Brunswick	8	4	78	11.62	35
Quebec...	40	24	1,742	12.58	268
Ontario...	113	88	3,135	14.15	1,007
Manitoba...	8	4	24	12.50	24
Saskatchewan	1	1	5	.....	25
Alberta	10	3	26	6.27	31
Newfoundland	1	1	8	5.00	...

Borings and Turnings

	Circulars sent	Replies received	Tons made monthly	Average price at works	Tons on hand
Nova Scotia	10	6	923	$ 4.42	1,300
New Brunswick	8	4	270	4.62	50
Quebec...	40	24	8,564	4.62	2,174
Ontario...	113	88	9,655	5.45	2,825·5
Manitoba...	8	4	657·5	4.44	55
Saskatchewan	1	1	50	....	800
Alberta......	10	3	97·5	3.18	185
Newfoundland	1	1	40	2.00	...

Summary of Answers.—Out of 191 circulars sent out, 131 replies received gave the following:

131 Munition Plants	Per month	Rate per year
Total capacity shells (all kinds)	2,000,000	24,000,000
Total tons shell ends and heavy scrap	8,404	100,860
Total tons shell ends in stock	1,950	
Average price per ton f.o.b. works	$ 10.54	
Total tons steel turnings made	20,357	244,284
Total tons steel turnings in stock	7,390	
Average price per ton f.o.b. works	$ 4.10	

If we assume the 60 munition plants not answering questions average the same output as 131 received, then we would have:

191 Munition Plants	Per month	Rate per year
Total capacity shells (all kinds)	2,900,000	34,800,000
Total tons shell ends and heavy scrap	12,200	146,400
Total tons shell ends in stock		
Total tons steel turnings made	29,500	354,000
Total tons steel turnings in stock		

Scrap Storage.—The total scrap carried in stock at munition plants is comparatively small, due largely to the fact that there is very little storage capacity. Arrangements exist with local dealers to remove scrap daily, or several times a week as the case demands. This prevents congestion at the shell plants, but scrap dealers may carry a large stock not covered by this report.

Questions 10, 11, and 14.—Eighty per cent of the replies answered 'No' to question 10.—'Can you sell all the scrap turnings you make in Canada at fair market price with the embargo in force?'

Seventy per cent of replies received answered 'Yes' to question 11.—'Can you sell all the shell ends you make in Canada at fair market price with embargo in force?'

There has been no serious complaint about shell ends and the general opinion is this scrap can all be sold at a fair price with the embargo in force.

The opinion expressed by a very large majority of shell makers is against the embargo on shell turnings unless it is a distinct advantage to the steel makers in the production of shell steel, and then always provided the steel manufacturer pays a fair market price. For all turnings produced over and above Canada's requirements no embargo should be placed on turnings going into the United States.

Opinions re Embargo by Prominent Men.—While this report will not permit of detailed opinions on this important question, a few may be given by representative men and companies.

Mr. F. P. Jones, General Manager, Canada Cement Co., Montreal: 'In my opinion no embargo should be placed on steel turnings, but there should be one on shell ends and all other classes of scrap.'

MR. F. C. BROOKS, Vice-President, Canadian Fairbanks-Morse Co., Toronto: 'My opinion is that we are forced to sell scrap at 30 per cent to 50 per cent under its value. We buy our material in the United States and have an arrangement whereby we are to sell the scrap back to them. We, however, cannot do this in face of an embargo and thereby lose on every ton sold here.'

MR. A. R. GOLDIE, Goldie & McCullough, Galt, Ont.: 'Think embargo should be taken off steel turnings.'

KERR & GOODWIN, Brantford, Ont.: 'We believe embargo should be lifted just as long as our manufacturers have more than they want.'

TAYLOR FORBES CO., LIMITED, Guelph, Ont.: 'Embargo should be lifted as quickly as possible.'

CANADIAN WESTINGHOUSE CO., Hamilton, Ont.: 'A good thing to keep scrap in country, but if embargo lifted could get better price.'

CANADIAN GENERAL ELECTRIC CO., Toronto, Ont.: 'Our opinion is that conditions did not warrant embargo.'

EASTERN STEEL CO., LIMITED, New Glasgow, N.S.: 'Embargo should be removed until steel makers pay fair price.'

PHOENIX FOUNDRY & LOCOMOTIVE WORKS, St. John, N.B.: 'Embargo should be raised or steel companies should pay more for scrap or reduce the price of their product.'

VULCAN IRON WORKS, LIMITED, Winnipeg, Man.: 'It seems there is more than enough scrap in Canada to meet requirements of eastern mills and we do not think as long as there is plenty of scrap to meet requirements an embargo should be placed on same.'

DOMINION BRIDGE CO., Montreal, Que.: 'Should be lifted as regards turnings or anything else which cannot be disposed of in Canada.'

MR. J. FRATER TAYLOR, President, Algoma Steel Corporation, Limited, Sault Ste, Marie, Ont.: 'Think embargo should be placed on all scrap during the war.'

DOMINION STEEL FOUNDRY CO., LIMITED, Hamilton, Ont.: 'Embargo should be left on as it keeps the price down.'

ELECTRIC STEEL AND METALS CO., Welland, Ont.: 'Should be left on to keep price down.'

Steel Turnings used and Melting Capacity.—In order to make a definite comparison of turnings produced and used in proximity to blast furnaces, steel works, and foundries, we will divide Canada into four districts as follows:

Maritime Provinces.—The total amount of steel turnings produced east of Campbellton, N.B., is approximately 1,800 tons per month or 21,600 tons per year. The present consumption of turnings in this district is 1,800 tons per month or 21,600 per year, while the total melting capacity based on 15 per cent turnings per ton pig iron and 30 per cent turnings per ton steel ingots—the percentage used at Hamilton—would be approximately 187,500 tons per year.

Quebec, Montreal, Ottawa.—Approximately 15,500 tons steel turnings are produced in this district per month or 186,000 tons per year. The present consumption is estimated at 3,000 tons per month or 36,000 tons per year, while the melting capacity is approximately 36,000 tons per year.

Toronto, Hamilton, Windsor.—Total turnings produced, 11,000 tons per month or 132,000 tons per year. Present consumption steel turnings—

9,200 tons per month or 110,400 tons per year. Melting capacity for all blast furnaces, steel works, and foundries, based on Hamilton practice but using only 8 per cent scrap in Port Colborne furnace—9,300 tons per month or 111,600 tons per year.

Western Canada from Sudbury.—Total steel scrap turnings produced in this district—1,200 tons per month or 14,400 tons per year. Present consumption 400 tons per month, or 4,800 tons per year. Total melting capacity, based on Hamilton practice, approximately 97,000 tons per year.

Summary of the Four Districts:

Total maximum blast furnace, steel works, and steel foundry melting capacity for steel turnings per year	432,000 tons
Net available melting capacity steel turnings within railway haul of munition plants per year.........	179,000 tons
Maximum amount steel turnings produced in Canada per year....................................	354,000 tons
Surplus amount steel turnings produced over and above net melting capacity...........................	175,000 tons

Attached to this report you will find five large sheets containing full details to the fourteen questions concerning scrap conditions in Canada, all of which is,

Respectfully submitted,

(*Sgd.*) J. DIX FRASER.

APPENDIX B

Cost of Construction and Operation of an Electrolytic Copper Refinery in the Niagara Peninsula of Ontario

By J. E. McALLISTER

The investigation, which is the subject of this report, has had for its object the determination of the cost of constructing and operating an electrolytic copper refinery in the Niagara peninsula of Ontario, having a capacity of 50,000 tons of refined copper per annum.

The estimates which follow are based upon the data given under the head of '**Basis**', and arrive at the conclusion that the expenditure for constructing a plant of this type would amount to $1,502,800, and the cost of operating the same would be $13·112 per ton (of 2,000 lb.) of refined copper produced.

In selecting the location of an industry of this type, the governing considerations are electric energy, temperate climate, fuel and other supplies, and labour conditions. Adequate transportation facilities are a necessity, and a location on tidewater possesses the obvious advantage of facility in receiving supplies by water freights, and in shipping the refined product by the same means. The location of a refinery, however, at or near that of the producing mines, does not possess distinct advantage, for the reason that the raw material coming in for refining would undoubtedly be a bessemerized product carrying 99 per cent copper. This could therefore be shipped from point of smelting to destination of the refined copper product under the one freight charge, the product being merely stopped for 'refining in transit.'

In compiling the following report the services, in a consulting capacity, of Mr. R. W. Deacon, Superintendent of the United States Metals Refining Company, at Chrome, New Jersey, have been utilized.

Conditions.—The refinery is to be equipped to handle 50,000 tons per annum of bessemerized copper (commonly known as blister copper) containing gold and silver, the output consisting of refined copper in the shape of wire bars, cakes or ingots; gold in the form of fine-gold bars; and silver as fine-silver bars.

The precious-metal values carried by the blister copper will have their bearing upon the cost of operation, as should the gold contents run high, the speed of deposition of the copper must, for economic reasons, be retarded. On this account it is assumed that the blister copper will assay not over 100 oz. of silver or 5 oz. of gold to the ton, these quantities being within the range of the precious metals contained in ordinary blister-copper production. The ground is also taken that the impurities in the blister do not consist of one seriously damaging element, such as arsenic or nickel, but are distributed over the various usual elements. It should be noted that blister copper, outside of these conditions, would require special treatment.

Basis.—The present cost of materials and labour in the Niagara peninsula has in the main been used as a basis of calculation, and the following are the chief items which have been entered into the same:

Labour. A base rate of 22½ cents per hour on a ten-hour day for unskilled labour, from which all other rates are scaled.

Power. High-tension alternating-current power delivered at low-tension terminals of transformers at the rate of $15 per H.P. year.

Structural steel. 5·5 cents per pound fabricated and delivered f.o.b. plant.

Copper. Rated at a quotation of 20 cents per pound for electrolytic wire bars.

Antimony lead. 13·5 cents per pound delivered.

Building brick. $13 per M. delivered.

Silicious refractory brick. $30 per M. delivered.

Machinery. Prices prevailing at the present time (March, 1916).

Bituminous coal. $4 per ton delivered.

Coke. $4.25 per ton delivered.

Cement. $1.35 per barrel delivered.

Lumber. Prices prevailing at the present time. ($25 to $35 per M., March, 1916).

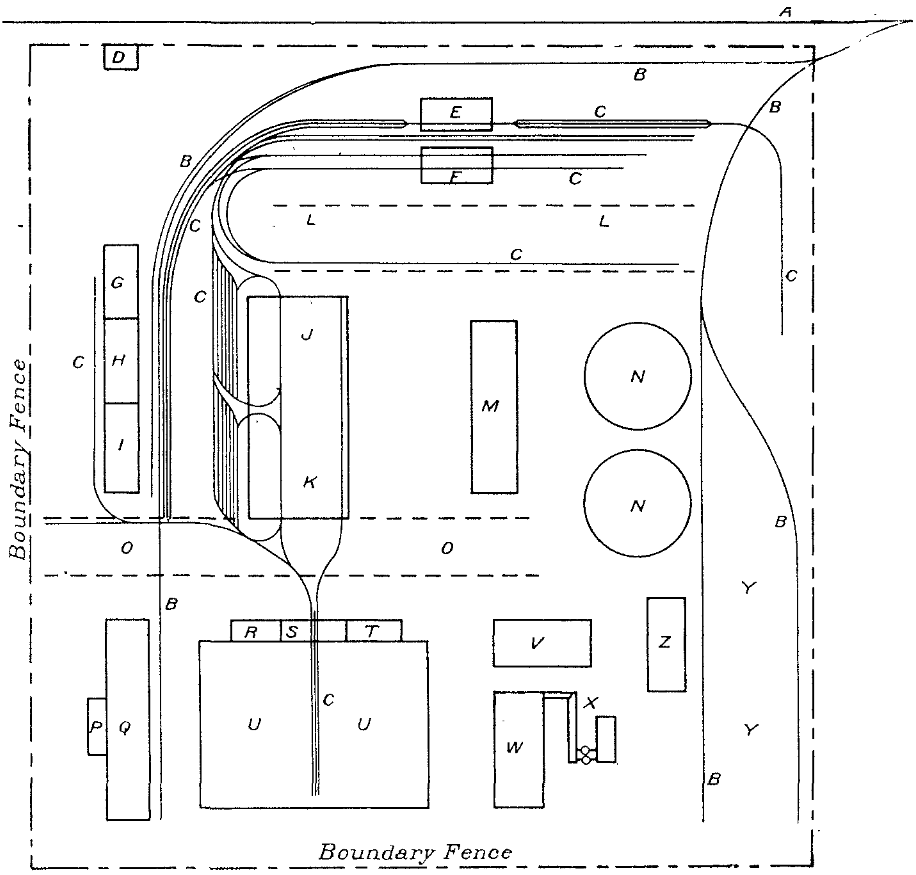
Plant Arrangements.—There is ample territory in the factory district of the Niagara peninsula for the selection of a suitable site. A ground plan of a refinery of this capacity is given herewith (see Fig. 3), and under this arrangement the plant would occupy a space of approximately 22 acres.

Referring to this plan, it is to be noted that the incoming material is delivered into the plant by standard-gauge railroad, the fuel to one side and the blister copper to the other. Subsequently the material is handled by an industrial railway system, operated by steam, and of either 24 or 30-inch gauge.

Following a shipment of blister copper through its various steps on this plan, it would be received over the railroad spur 'B', weighed in the control weighing room 'E', sampled in the sampling room 'F,' and then placed in the storage under the craneway 'L', from which it is taken as required to the furnace building 'K', and brought up to pitch in reverberatory furnaces, from which it is cast into anodes, the anodes being stored under the craneway 'O'. From this storage the anodes are delivered to the tank house 'U', where the electrolytic copper is produced, leaving the tank house in the form of cathodes, and placed in storage under the craneway 'O', from which point it is delivered to the reverberatory refining furnaces 'J', where it is melted and cast into the form required by the consumer.

During the electrolytic action from anode to cathode, slimes are formed in the tanks consisting of the impurities contained in the blister copper, as well as its precious metals, these slimes being subsequently treated in the department 'W', where the gold and silver are separated and turned out in the form of bars.

Fig 3.—Ground Plan of Electrolytic Copper Refinery



LEGEND

A. Railroad, Main Line
B. Standard Gauge R.R. Tracks in plant
C. Industrial Railway—principal tracks
D. Time Clock, Office and Plant Entrance
E. Control Weighing Room
F. Sampling Room
G. Office
H. Laboratory
I. Warehouse
J. Furnace Building, Refined Copper End
K. " " Anode End
L. Storage Craneway for Refined and Blister Copper
M. Machine and Repair Shop
N. Bosh water Reservoirs
O. Storage Craneway for Anodes and Cathodes
P. Transformer House
Q. Power House
R. Circulating System Pump Room
S. Anode and Cathode Weighing Scales
T. Tank House, Heating Plant
U. Tank House
V. Regeneration Plant
W. Slimes Refinery
X. Slimes Refinery Flue System
Y. Coal and Coke Storage
Z. Cupola Furnace Building for slag reclamation, etc.

A small cupola-furnace is added in which the slags from the reverberatory furnaces are treated, and their values recovered.

Plant Details.—In considering the equipment of the plant, its capacity permits of the installation of modern labour-saving devices in each department. In this connection the cost of installation is governed by the balance which obtains between decreased operating cost and the amortization of construction expenditure incurred to acquire such decrease. Special apparatus should be installed for transferring blister copper from railroad to industrial cars, and refined copper from industrial to railroad cars.

In the scale house 'E,' tandem scales would be installed for control weighing of the blister, the one scale checking the other. The accuracy of these scales is of first importance and would be aided by their capacity being considerably in excess of the ordinary load. In this case the copper would probably be weighed in quantities of 5 tons, and the capacity of the scales should therefore not be less than 12 tons, or double the weight of the industrial railway car with its load.

After weighing, the blister copper proceeds to the sampling room, where it is sampled by drilling a half-inch hole through each cake, for which purpose an ordinary drill press is used. After sampling, the blister copper is stored in the yard 'L,' from whence it proceeds to the anode furnace.

It is obviously necessary to maintain a sufficient quantity of sampled raw material in storage to permit the continuous operation of the anode furnaces.

The furnace building 'J-K' should be of steel construction containing at one end two anode furnaces for melting the blister, and at the other, two refined-copper furnaces for the melting and converting the cathode copper into merchantable form. Each anode unit would consist of a reverberatory furnace lined with silicious refractory brick, and having a capacity of 100 tons of copper per 24 hours. A sketch plan showing the approximate inside hearth dimensions is given herewith (see Fig. 4). It would be fired by slack coal and fitted with a waste-heat boiler to conserve the heat for maintaining the necessary temperature required by operations in other buildings, this boiler being also equipped for auxiliary firing for use when the furnace is not in operation, thus saving a separate boiler installation.

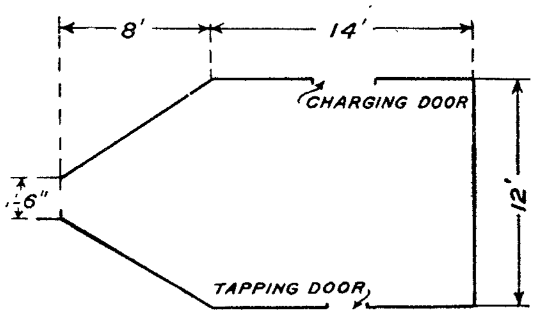


Fig. 4

The raw material would be charged into the furnace on one side from the industrial railway by means of a charging crane, and the molten copper automatically tapped from the other into anode moulds, the furnace being served at this side by a Walker casting-wheel and a 10-ton travelling crane.

The depth of the bath of molten metal for a furnace of this type would be from 21 to 24 inches, and a cycle of its operation throughout the 24-hour period would consist of:

Charging	1½ hours
Melting down	9 "
Refining and poling	7 "
Casting	6½ "
Total	24 hours

A sufficient storage of coal fuel should be carried to cover two months operations of both the anode and refined-copper furnaces.

It is necessary to maintain an excess of anodes in storage in order to feed the tank house, and for this purpose a storage yard is provided between the furnace house and the tank house.

In this same storage is held the cathode copper as delivered from the tank house for melting in the refined-copper furnaces, of which there are two, each being a duplicate of the reverberatory anode-furnace with the same capacity, and equipped in the same manner with waste-heat boilers, charging crane, and Walker casting-wheel.

The tank-house building should be a steel structure with either brick-filled or concrete walls, and a fireproof heat-insulating roof, and should be laid out in two bays housing 512 tanks, arranged in 16 sections of 32 tanks each, or 8 sections to each bay with a separate electrolytic circuit.

The circulation and heating systems are housed in annexes, and each bay should be provided with two 10-ton travelling cranes. The anodes would be lifted from the storage 'O' by 'finger' crane-hooks in batches of about 30, placed in rack cars, transported by the industrial railroad to the tank house, and unloaded by the travelling crane, which would also deposit each anode to its allotted space in the tanks.

Scales for interdepartment accounting are provided to weigh the incoming anodes and outgoing cathodes from the tank house.

The power house would be of steel frame with brick fill or concrete wall, and equipped with a hand-power travelling crane to facilitate the handling of parts for repairs. In it would be installed five electrolytic units, each consisting of a motor generator set designed to give a constant current of 5,000 amperes at a varying voltage of from 60 to 115, four of these being arranged to work in groups of two in parallel, directly to the two separate circuits in the tank house. The fifth would be connected to act as a spare for any of the others.

All the plant in the power house would be motor-driven, and in addition to the above units, it would contain bosh pumps, general-service pumps, hydraulic pumps, fire pumps, motor generator set to supply D.C. to cranes, high-pressure air-compressors for the operating of handling devices, etc.

The slimes carrying the precious metals are transferred from the tank house to the slimes refinery, the latter being equipped with steel tanks, boiling tanks, filter press, roaster, reverberatory furnace for the production of doré bar, silver-melting furnace, and gold crucible-furnace. These three furnaces would be connected to an outside collecting-flue system. It would also contain a motor generator set operating on 36 cells for the electrolytic parting of silver from gold, gold-refining pots, bullion balance, and safety deposit vault for the storage of doré, fine silver and gold.

In addition there should be an emergency department, consisting of repair shops, machine, blacksmith, carpenter shops, etc., also a warehouse for supplies, plant office, laboratory equipped for the accurate control-assays and determination of the various products of the different stages of operation. The equipment should also include a locomotive crane for the handling of fuel from the storage and other miscellaneous requirements.

The plant should be properly fenced, the operatives being passed by an attendant, both in coming in and going out. In this connection it is necessary to provide the slimes refinery with suitable accommodation so that operatives may change their clothing before entering and after leaving.

Construction Costs.—These are segregated by departments, and also further into the various units that go to make up the same, and would be as follows:

Furnace building	$ 67,500	
Two anode units	95,500	
Two refined-copper units	92,200	
Four cranes, two service, two charging	40,600	
Auxiliary equipment	84,800	
Total Furnace Department		$ 380,600
Tank-house building	$ 127,000	
Sixteen 32-tank sections and circulation system and equipment	258,000	
Electrolytic circuit conductors, etc	96,000	
Four service cranes	25,000	
Auxiliary apparatus	51,000	
Total Tank House Department		$ 557,000
Power-house building and crane	$ 42,000	
Five electrolytic motor generator sets and equipment	116,000	
Motor-driven pumps, etc	32,200	
Auxiliary apparatus	30,200	
Total Power House Department		$ 220,400
Carried forward		$ 1,158,000

Brought forward		$ 1,158,000
Slimes-refinery building	$ 38,000	
Settling and boiling tanks, filter press and roaster	16,500	
Furnace and flue system	22,100	
Electrolytic parting-cells and equipment	18,800	
Gold-refining equipment	2,600	
Auxiliary apparatus	11,700	
Total Slimes Refining Department		$ 109,700
Shops-building and equipment	$ 31,000	
Office and laboratory and warehouse equipment	44,000	
Sampling apparatus	7,500	
Control weighing scales and housing	7,400	
Storage cranes, craneways and locomotive crane	36,700	
Receiving and shipping apparatus	3,600	
Industrial locomotives and cars	47,800	
Industrial tracks and railroad sidings	24,500	
Miscellaneous auxiliary apparatus	7,600	
Bluestone and acid necessary to make up electrolyte	25,000	
Total Miscellaneous		$ 235,100
Total		$ 1,502,800

Details of Operation.—The raw material handled by the plant will be almost entirely in the form of blister copper, consisting of cakes about 30 inches long by 20 inches wide and 3 inches thick. Its quantity and value is determined by the scale house, sampling room, and laboratory. It is first weighed and then sampled by drilling a half-inch hole entirely through each slab. An ordinary drill press will be used for this purpose, and the slab drilled alternately from top and bottom by the so-called checker-board method. The location of the hole drilled in each slab will be governed by a template covering the entire surface of the slab, and having a half-inch hole in the centre of each square inch. The holes in the template are numbered and used in consecutive rotation and templates are provided for both top and bottom surfaces of the slabs. The drillings from each shipping lot are put through a grinding machine, the quantity reduced by means of a splitting machine to about 5 lbs. in weight, which constitutes the sample. This should be ground and re-ground until all passes through a 16-mesh sieve. If the blister copper contains appreciable quantities of precious metals, the sample should subsequently be sifted through a 40-mesh sieve, and the coarse and fines kept separate in order to insure accuracy of the determination, as the precious metals have a tendency to stay with the larger particles.

Metal Losses.—In the manipulation of the various steps of refining the copper there will be unavoidable mechanical losses, which, however, will to some extent not be in evidence, as there are corresponding mechanical losses in determining the values by assay. This is particularly the case where the blister copper contains minute quantities of gold, in which event the unavoidable loss in assaying will sometimes be greater than the proportionate loss in refining, and the gold recovery by the refinery will be more than 100 per cent of the amount as determined by assay.

In general, however, it is safe to figure that a plant of this type will operate with a recovery of:

	Per cent
Copper	99·6
Silver	100·0
Gold	100·0

Two methods of accounting for the incoming copper by the refinery are generally employed. The refinery will either pay for the blister copper with its contained precious metals, deducting sufficient to cover its metal losses and making a charge for refining, or else it will undertake to return to the shipper refined metals corresponding to those contained in the blister copper after deducting its refining charge. In the latter case the refining charge must include the metal losses of the refinery as well as the operating cost and profit.

Tank House.—This department must be kept at a uniform temperature of about 80° F., causing a tendency in cold weather to 'sweating' on roof and walls, on account of the large amount of moisture evaporated from the electrolytic tanks. For this reason the heating should be preferably by the circulation of dry hot air to absorb the evaporated moisture. The tank solutions must be maintained at a temperature of approximately 150° F., the copper electrolyte consisting of about 4 per cent copper in the form of sulphate, together with about 12 per cent of free acid.

During the deposition of the copper the electrolyte becomes in course of time polluted by the impurities contained in the anode copper, on account of which periodically a certain amount of the electrolyte is drawn off and treated in the regenerating plant, the purified solution being returned to the electrolytic-copper tanks.

The rate of deposition of copper on the cathode will be governed by the current density, which should not amount to more than 20 amperes per square foot of anode surface for copper carrying up to 100 ounces of gold and silver to the ton. Should the amount of precious metals be appreciably less, the current density may be increased up to say 30 amperes, thereby increasing the speed of deposition and shortening the time of operation, but should the deposition take place too quickly there is danger of occluding precious metals with the cathode copper.

A cycle of operations in the tanks at the 20 amperes current density would occupy from 3 to 4 weeks time.

One section of the tank house is devoted to the preparation of cathode starting-sheets, for which purpose a copper plate coated on each side with oil or graphite is used as a cathode blank, and a thin layer of copper deposited thereon by electrolysis. This is stripped off from each side and forms the cathode starting sheet.

In the routine operation the electrolytic tanks are first charged with anodes, and then hung with cathode starting-sheets and the current started. It is kept on for a prescribed number of days, varying from 10 to 12; then the cathodes which have been formed on the starting-sheets are removed, the solution lowered in the tanks, the anodes taken out temporarily, and the slimes removed and sent to the slimes refinery. The anodes are then replaced, fresh cathode starting-sheets hung, and, the current turned on for another period of 10 to 12 days, then the 'pulling' is repeated, except that upon this occasion what is left of the anodes is removed and goes back as scrap to be re-melted in the anode furnaces. It will be seen, therefore, that for each anode going to the tanks, two cathodes of lighter weight are formed.

The theoretical deposition of the copper would be approximately ·062 lb. of copper per ampere day and a current efficiency of at least 90 per cent should be acquired. The necessary pressure would be about 0·4 volts per tank, and upon this basis the rate of deposit should amount to about 6 lb. of cathode copper per kilowatt hour.

Refined Copper.—The cathodes are weighed upon leaving the department, and stored, from which point they are fed to the refined-copper furnace for melting into the shape required by the consumer, e.g., ingots, wire bars, cakes, etc.

Slimes Refinery.—The precious-metal slimes reclaimed from the electrolytic tanks would amount to about 30 tons per month, containing about 440,000 oz. of gold and silver. The slimes are first freed of the electrolyte by settling until they contain about 50 per cent moisture. Then they are boiled with sulphuric acid to remove soluble copper, after which they are put through a filter press and roasted. This roasted product is combined with a portion of unroasted slimes to make up a furnace charge. The result will be the melting of about 20 tons per month of slimes containing from 15 to 25 per cent moisture, the melt taking place in a small reverbertory furnace, the product of which is doré bars.

These form the anodes for the electrolytic deposition, which takes place in an electrolyte slightly acidified with nitric acid, the silver being deposited on cathode blanks in crystalline form, and the gold settling as a black mud containing about equal quantities of gold and silver. The resulting silver crystals are scraped off the cathode blanks, washed and melted into fine silver bars.

The gold mud is purified by treatment with nitric acid to part the gold from the silver, the solution going back to the silver electrolytic tanks, and the gold sand melted with borax into fine gold bars.

Elapsed Time in Refining.—It has been pointed out that there should be a storage of blister copper maintained previous to the melting operation for the production of anodes, and also a storage of cathode copper between the tank house and the final re-melting furnace. In addition to this, there is the time occupied by the operations in the furnace building and the tank building.

As a result of this, the time occupied by the plant under consideration between receiving raw material and obtaining therefrom the metals in refined form would be from 50 to 60 days in the case of the copper, 65 to 75 days for the silver, and 70 to 80 days for the gold.

The value of the material, with its consequent interest loss during this elapsed time, must therefore be taken into consideration, either in the refining charge imposed by the plant, or in the form of a deferred date in paying for the incoming blister copper. The latter is the usual method, but the shipper is on the other hand entitled to draw upon the refinery, upon presentation of bill of lading, for from 90 to 95 per cent of the value of the shipment by paying the usual bank interest charge for the amount of the draft during the period agreed upon, which would correspond to approximately the elapsed time noted above.

It should also be noted that the settlement quotations, in the case of metals of fluctuating value like copper and silver, should be based on the market quotations at the time the refined metals are ready for sale, and not at the time the blister copper is shipped by the consignor. By this means the refinery protects itself from violent fluctuations in the price of copper.

Operating Costs.—In compiling the following costs of operation, it is assumed that metal losses, and also interest on payments advanced, will be taken care of in the charges made by the refinery. These items, therefore, need not be included. The costs have been figured in dollars per ton of refined copper on the basis of the unit of production of each department, and finally converted into a total cost for all operations, in each case segregating the amount for labour and material.

This would be the manner in which the actual operations of the plant would be recorded in order to keep track of the efficiency of the different departments.

A plant arranged as proposed, should safely acquire the following operating costs:

	Labour	Material	Total per ton
Anode making	$ 1·155	$ 1·213	$ 2·368
Electrolytic refining	2·025	2·464	4·489
Refined-copper casting	1·100	1·304	2·404
Slimes refined	·463	·461	·924
General expenses	·926	·464	1·390
Interest on investment (5 per cent)	.....	1·537	1·537
Total	$ 5·669	$ 7·443	$ 13·112 per ton of refined copper.

In order to indicate the expenditure of the refinery on various items, the above costs may be transposed to the following basis:

Labour	$ 5·669
Material	1·332
Fuel	1·895
Power	1·301
Overhead	1·378
Interest on investment	1·537
Total	$ 13·112 per ton of refined copper.

Supplies.—The approximate monthly quantity of supplies used by the plant would be as follows:

Electric power	1,465,000	K.W.H.
Soft coal	1,750	tons
Coke	140	tons
Fuel oil	10,000	gallons
Sulphuric acid	50	tons
Silicious brick	39,000	(9 inch equivalent)

Employees.—Exclusive of executives, clerks, and foremen, the operation of the plant would require about 350 men, divided in approximately the following proportions:

Unskilled	110
Semi-skilled	155
Skilled (mechanics, power-house men, etc.)	85
Total	350

(*Sgd.*) J. E. McAllister,
Consulting Engineer.

Toronto, Ontario,
April 4, 1916.

APPENDIX C

Nickel-Copper (Nicu) Steel, with a discussion of its Physical Properties

By T. W. HARDY and JOHN BLIZARD

Introductory

At the request of Mr. George C. Mackenzie, Secretary of the Munition Resources Commission, the Director of the Mines Branch, Department of Mines, ordered that an investigation be made of the properties of certain samples of nickel-copper steel, made by the Nicu Steel Corporation. This Corporation intends to produce an alloy steel, with the trade name of Nicu steel, directly from nickel-copper ores and slags, such as exist in the Sudbury district.

The process consists of, first, the desulphurizing of these ores which are chiefly sulphides of nickel, iron, and copper; secondly, the reducing and smelting of this roasted ore or slag, or both, to produce a nickel-copper pig; and, finally, the refinement of the pig to an alloy steel.

The samples forwarded for examination were from two heats, and were made under approximately commercial conditions at the steel plant of the Canada Cement Company, Montreal. Mr. H. A. Morin, of the Nicu Steel Corporation, Limited, furnished the following information regarding the manufacture of these heats.

Heat No. 4 was made from ore which had the following average composition:

	Per cent
Iron	46·0
Nickel	1·3
Copper	0·28
Silica	19·0
Alumina	3·8
Sulphur	8·0
Lime	2·7
Magnesia	1·3

As this ore had been exposed to the weather for some years since mining, the nickel-copper content was considerably less than in freshly-mined ore. The roasting of the ore was carried out in furnaces of the reverberatory type, which had been designed for heating steel shell-blanks. The results of roasting were satisfactory, the original sulphur content being reduced after a five-hour run at a temperature of 760° C. from 8 per cent to from 0·3 to 0·6 per cent. An electric furnace of the Heroult type was used to reduce and smelt the roasted ore to a pig. This furnace was the only one available, and while not ideal, served the purpose well. Six to eight charges, each consisting of:

	Lb.
Roasted ore	1,400
Burnt lime	525
Coke breeze or coal	375

were charged at intervals and, when smelted, tapped as a whole. The average analysis of the pig produced showed:

	Per cent
Nickel	2·20
Copper	0·40
Manganese	0·18
Silicon	1·75
Carbon	3·00
Sulphur	0·09
Phosphorus	0·07
Iron (by difference)	92·31

The slag produced contained only traces of nickel and copper. The pig was refined to steel in a basic open-hearth furnace, by a process identical with the one used in the manufacture of ordinary carbon steel.

The composition of the final product was reported as follows:

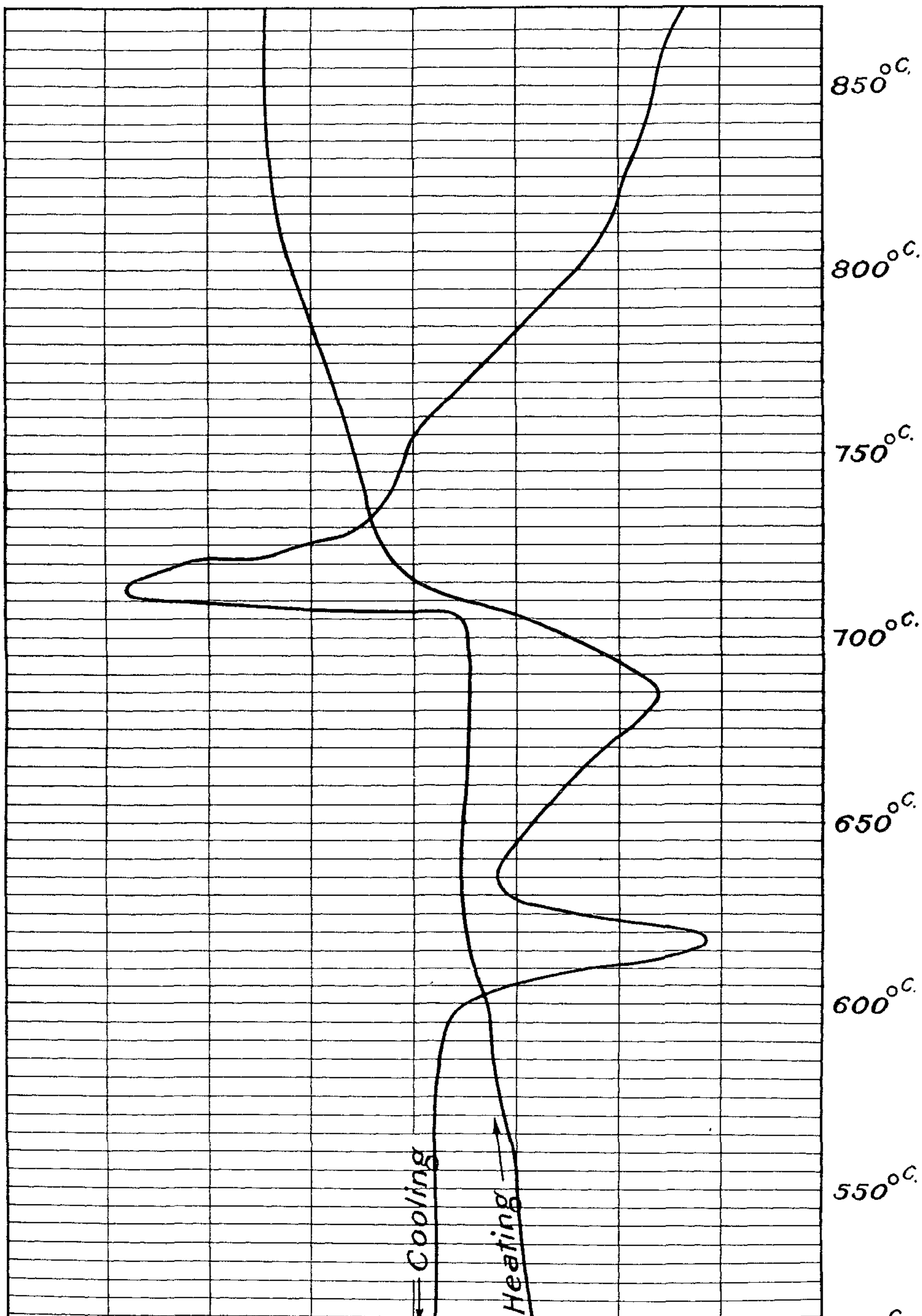
	Per cent
Carbon	0·28
Silicon	0·014
Sulphur	0·038
Phosphorus	0·005
Nickel	2·16
Manganese	0·58
Copper	0·41

From this analysis it may be noticed that the nickel-copper content aggregates 2·57 per cent, which is less than the 3·5 per cent aimed at. This discrepancy is due in part to the low nickel-copper content of the original ore and partly because a considerable amount of iron was absorbed from the bottom and sides of the furnace, which had been used for a long time previously for making pig iron from scrap steel.

Heat No. 10 was made from Copper Cliff slag, which is produced in large quantities in the smelting of the Sudbury ores, only partly roasted, in a blast matting-furnace.

An analysis of the slag showed its composition to be:

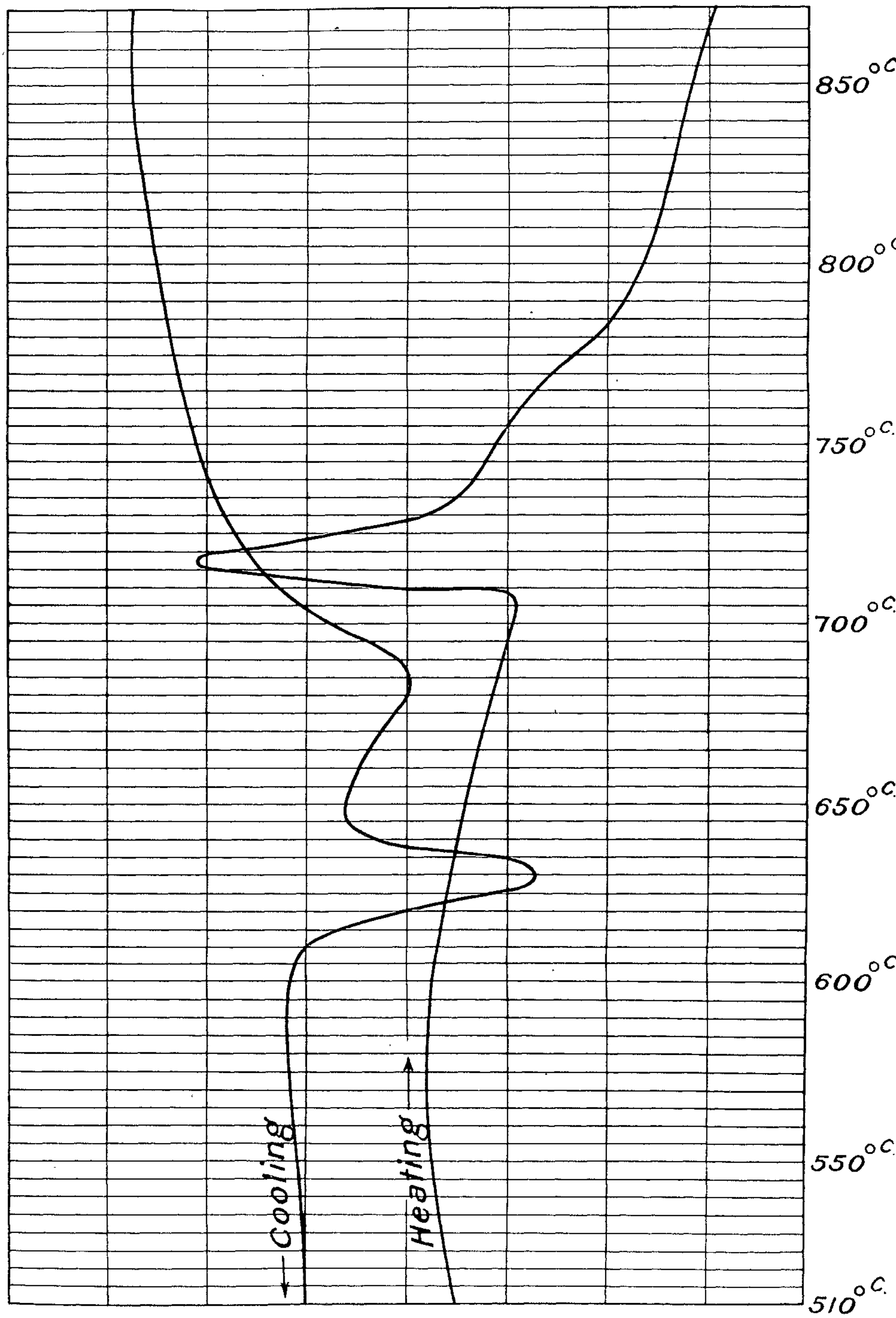
	Per cent
Nickel	0·45
Copper	0·30
Iron	46·14
Sulphur	2·20
Silica	22·30
Alumina, lime, and magnesia	20·00



NICU STEEL.

Temperature difference - differential curves.

Heat No. 4.



NICU STEEL.

Temperature difference - differential curves.

Heat No. 10.

The process of manufacturing steel from the slag was similar to that from the ore, with the exception that the roasting operation was omitted as unnecessary. The steel produced from the slag had the following composition:

	Per cent
Carbon	0·34
Silicon	0·019
Sulphur	0·041
Phosphorus	0·017
Nickel	1·33
Manganese	0·63
Copper	0·46

The aggregate nickel-copper content is naturally less than that in the steel made from the ore, but it could easily be increased by the addition of roasted nickel-copper ore, in the manufacture of the pig iron.

Tests

Samples.—The steel received for examination consisted of 4 one-inch bars; 2 from Heat No. 4, and 2 from Heat No. 10. Samples from each were analyzed and the results are tabulated.(1) These figures show that nickel-copper steel, free from objectionable amounts of sulphur and phosphorus, has been made on an approximately commercial scale from Sudbury ore and slag by the Nicu process.

Heating and Cooling Curves.—In order that the heat-treatment of the steel might be carried out in a rational manner, it was deemed advisable to determine the thermal characteristics of the steel from each heat. These are shown in the heating and cooling curves (Plates LVI and LVII).

Heat-Treatment.—Since nickel steel, like most alloy steels, is generally used in the heat-treated condition, this steel was given various heat-treatments in order to show just what effect such treatments would have on its tensile properties. For each bar the mode of procedure was as follows:

The bar was cut into 4½-inch lengths, and each given a mark of identification. The first of these pieces was laid aside for testing 'as rolled'. The second piece was heated in a muffle furnace to a temperature of 800° C., held at that temperature for 15 minutes, and allowed to cool slowly in the furnace. A third piece was treated similarly to the second piece, except that, instead of cooling in the furnace, it was allowed to cool freely in the air. The remaining pieces were all heated to 800° C., and maintained at that temperature for 15 minutes; those from one bar of each heat were quenched in water, and those from the other in oil. After quenching they were then reheated, or 'drawn' in a lead bath to

(1) See pp. 231, 232.

temperatures varying from 350°C. to 600°C. They were maintained at the drawing temperature for 20 minutes, then removed and allowed to cool freely in air.

Tensile Tests.—The $4\frac{1}{2}$-inch pieces were turned into test-pieces of the form adopted by the International Association for Testing Materials. This test-piece is one-half inch in diameter for two inches of its length, with three-quarter inch threads at the ends. There was no difficulty in machining the steel, though it was necessary to run the lathe at a somewhat lower speed when turning the pieces which had been quenched in water and drawn to 350°C. The turnings from all specimens were very tough and broke off only in fairly long pieces.

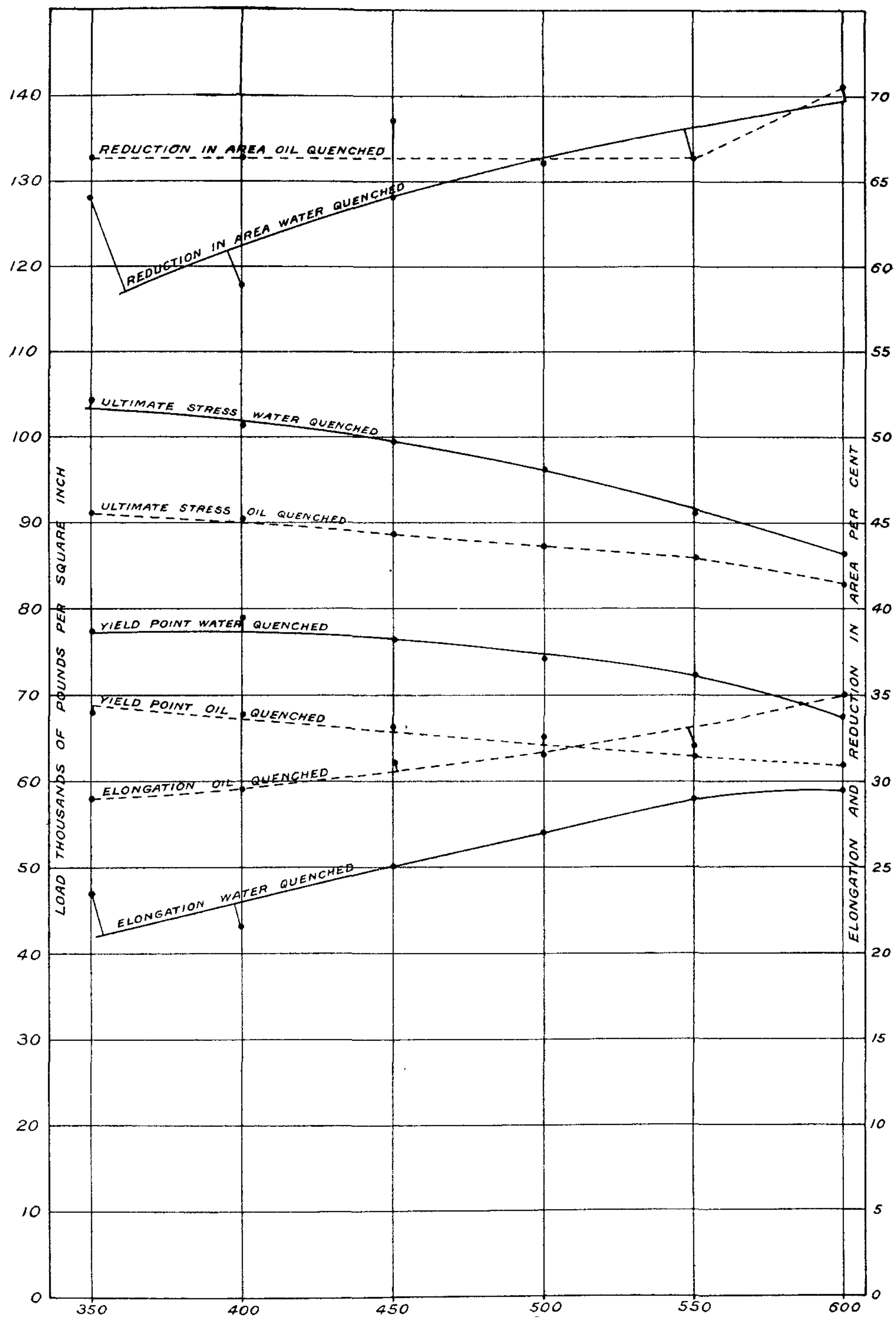
The testing machine was an Olsen 3-screw power-testing machine of 200,000 lb. capacity. The yield point was obtained by observing the movement of multiplying dividers placed on the specimen. For every specimen the yield point as indicated by this movement coincided with a marked drop of the beam. The results of the tests are shown in tables,(1) and also graphically in the form of separate diagrams, for each heat. These diagrams (Plates LVIII and LIX) are constructed to show the variation of the properties of the steel tested with the drawing temperature. While they show the general effect of the drawing temperatures upon these properties, it will be seen that several observed points do not fall on the curves.

Microstructure.—Photographs were made showing the microstructure, magnified 75 diameters, of certain of the water-quenched pieces of both heats, and also of both heats in the annealed and 'as rolled' conditions. The microsections were taken from the ends of the test-pieces, and photographs taken of a plane transverse to the length of the test-piece. The structures shown are similar to those of ordinary nickel steels that have been treated in a like manner, and the photographs are not reproduced here.

Discussion of Results.—The results of these tests show plainly that steel possessing the high combination of tenacity and ductility that is characteristic of ordinary nickel steel has been made, both from ore and slag, by the Nicu process. They do not indicate that the copper content is detrimental to the properties of the steel. At the same time there is insufficient evidence to warrant the conclusion that the copper has or has not any material beneficial effect on the physical properties of the steel.

Of late years a number of investigations have been carried out which strongly point to the conclusion that a considerable proportion of the nickel in a nickel steel may be replaced by copper without materially altering the properties of the steel. While this idea is to a certain extent in accordance with our knowledge of the separate effects of these two metals on the properties of steel, there is no doubt that a systematic investigation into the question of the effect of copper on the properties of nickel steel is

(1) See pp. 231, 232.



Drawing temperature in degrees centigrade.

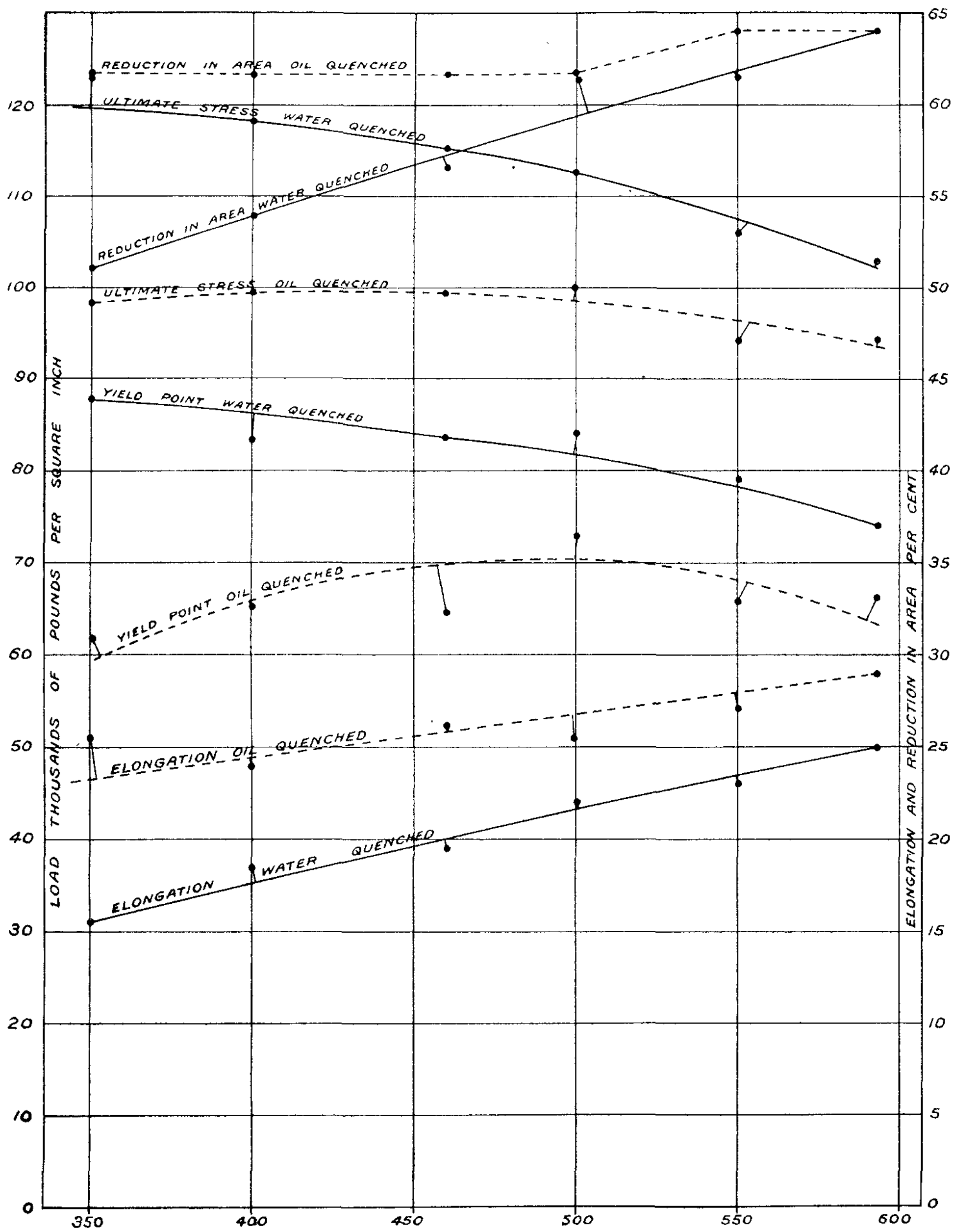
NICU STEEL.

Heat No. 4.

Tensile tests on:

A. Water quenched from 800° C.

B. Oil quenched from 800° C.



Drawing temperature in degrees centigrade.

NICU STEEL.

Heat No. 10.

Tensile tests on:

A. Water quenched from 800° C.

B. Oil quenched from 800° C.

very desirable. If it could be proved definitely by further investigation that it is possible to replace from one-quarter to one-half of the nickel in a 3½ per cent nickel steel by a similar amount of the cheaper metal, copper, without materially changing its properties, the results would be of importance, not only to the Nicu Steel process, but also to the nickel steel industry in general.

General Remarks

Influence of Nickel on the Physical Properties of Steel.—The advantages obtained by the addition of nickel to steel have been well known for many years, and nickel steel is one of the most common of the alloy steels in use today. Nickel dissolves in iron in all proportions, but the steels of the greatest commercial importance contain less than 5 per cent nickel and not more than 1 per cent carbon. Steels coming within these limits are, like plain carbon steel, pearlitic on slow cooling. Notwithstanding this structural similarity, however, the physical properties of pearlitic nickel steels are considerably superior to those of the corresponding carbon steels. The addition of nickel to plain carbon steel in the production of pearlitic nickel steel results in a considerable increase in strength, particularly in elastic limit, while the ductility is decreased but little, if at all. To develop fully the high physical properties which they are capable of possessing, nickel steels must be heat-treated, and in this condition their superiority over similarly treated carbon steels is more apparent than when neither the nickel nor the carbon steels are heat-treated. Heat-treated nickel steel is not only stronger, but is tougher and has greater resistance to wear and shocks than a similarly treated carbon steel.

In the majority of the nickel steels manufactured to-day, the nickel content does not exceed 3½ per cent and the carbon content is generally less than 0·50 per cent. Steels of this class find a wide application in structures where a high combination of strength and ductility combined with a saving in weight are essential factors. Among the more common applications of these nickel steels may be mentioned rails and bridge members, for which they are used without heat-treatment; other and perhaps more common applications are automobile and engine parts, machine parts, and gun forgings, for which purposes the steel is practically always heat-treated.

Influence of Copper on the Properties of Steel.—The effect of copper on the properties of steel has been the subject of much discussion. For a long time copper, even in very small amounts, was supposed to cause red-shortness, and this view is still held by some. Of later years, the researches of several able investigators have proved that copper, within certain limits, is not only harmless, but really improves the properties of the steel. As a result of these researches, it may be conservatively stated that, in proportions not exceeding 0·75 per cent copper does not make steel red-short provided that the sulphur content is not high. There seems to be no doubt that an amount of sulphur, say 0·08 to 0·1 per cent, that would not cause serious trouble in steel free from copper, would, in conjunction with a few tenths of one per cent of copper, produce serious red-shortness.

The results of these investigations also show that the presence of small amounts of copper makes steel more resistant to corrosion. They also show that the general effect of copper, in small amounts, on the tensile properties of the steel, is to increase the tensile strength and yield point, and to decrease the elongation and reduction of area.

It seems probable that the red-shortness and segregation that sometimes accompany copper when present in steel in an amount exceeding 1 per cent have their ultimate explanation in the fact that copper is but slightly soluble in iron. Since nickel unites readily with both copper and iron, it is reasonable to assume that the presence of nickel will permit larger amounts of copper to be used without introducing the above defects. This effect of nickel in increasing the solubility of copper in steel, together with the fact that copper resembles nickel in its effect on the cold properties of the steel, lends weight to the probability that copper may replace a considerable proportion of the nickel in a nickel steel without materially altering its hot or cold properties.

Acknowledgments. — Acknowledgments are due to Mr. H. S. Foote, who prepared and photographed the microsections (not reproduced here); to Messrs. H. A. Leverin and F. W. Baridon, who determined the chemical composition of the steel; and to Mr. E. S. Malloch, who assisted in the tensile tests.

NICU STEEL TESTS—HEAT NO. 4

Chemical Analyses

Analysis by	Bar	Carbon	Phos-phorus	Man-ganese	Sulphur	Silicon	Nickel	Copper	Cobalt
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Nicu Steel Co.	..	0·28	0·005	0·580	0·038	0·014	2·16	0·410	....
Mines Branch	A	0·262	0·012	0·522	0·061	0·009	1·98	0·470	0·16
" "	B	0·267	0·006	0·532	0·036	0·006	1·96	0·450	....

SERIES A

Pieces from Bar A, quenched in Water from 800° C. and drawn to various temperatures

Heat Treatment and Physical Properties

Test No.	Heat Treatment			Physical Properties			
	Heated to	Quenched in	Drawing temperature	Yield point	Ultimate strength	Elongation (in 2 in.)	Reduction in area
	Degrees C.		Degrees C.	Lb. to sq. in.	Lb. to sq. in.	Per cent	Per cent
1	800	Water	350	77,400	104,400	23·5	64·0
2	"	"	400	78,900	101,200	21·5	58·8
3	"	"	450	76,200	99,400	25·0	64·0
4	"	"	500	74,400	95,800	27·0	66·1
5	"	"	550	72,100	91,000	29·0	66·2
6	"	"	600	67,500	86,400	29·5	70·8
7	"	Cooled freely in air		56,000	79,000	30·0	59·0
8	"	Cooled slowly in furnace		51,000	72,000	31·0	53·0
9	As rolled			47,400	76,700	33·0	59·0

SERIES B

Pieces from Bar B, quenched in Oil from 800° C. and drawn to various temperatures

Heat Treatment and Physical Properties

Test No.	Heat Treatment			Physical Properties			
	Heated to	Quenched in	Drawing temperature	Yield point	Ultimate strength	Elongation (in 2 in.)	Reduction in area
	Degrees C.		Degrees C.	Lb. to sq. in.	Lb. to sq. in.	Per cent	Per cent
1	800	Oil	350	68,000	91,000	20·0	66·3
2	"	"	400	67,700	90,300	29·5	66·3
3	"	"	450	66,200	88,700	31·5	68·5
4	"	"	500	65,000	87,100	31·5	66·3
5	"	"	550	62,600	85,900	32·0	66·2
6	"	"	600	61,900	83,000	35·0	70·5
7	"	Cooled freely in air		57,500	77,900	34·0	61·5
8	"	Cooled slowly in furnace		54,000	73,100	31·0	59·0
9	As rolled			47,800	73,300	34·0	58·8

Notes: 1. All heat treatments made on the full section (1 inch Rounds), and test-pieces (A.S.T.M. Standard 2 inch with threaded ends) machined from the heat-treated stock.
2. This heat was made from Sudbury ore.

NICU STEEL TESTS—HEAT NO. 10

Chemical Analyses

Analysis by	Bar	Carbon	Phosphorus	Manganese	Sulphur	Silicon	Nickel	Copper	Cobalt
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Nicu Steel Co.	..	0·340	0·017	0·630	0·041	0·019	1·33	0·460	....
Mines Branch	A	0·355	0·025	0·547	0·043	0·017	1·31	0·570	0·13
" "	B	0·347	0·024	0·554	0·050	0·023	1·30	0·572	....

SERIES A

Pieces from Bar A, quenched in Water from 800° C. and drawn to various temperatures

Heat Treatment and Physical Properties

Piece No.	Heat Treatment			Physical Properties			
	Heated to	Quenched in	Drawing temperature	Yield point	Ultimate strength	Elongation (in 2 in.)	Reduction in area
	Degrees C.		Degrees C.	Lb. to sq. in.	Lb. to sq. in.	Per cent	Per cent
1	800	Water	350	87,600	123,000	15·5	51·0
2	"	"	400	83,400	118,000	18·5	53·8
3	"	"	460	83,600	115,000	19·5	56·5
4	"	"	500	84,000	112,500	22.0	61·6
5	"	"	550	79,000	106,000	23·0	61·6
6	"	"	600	74,400	102,800	25·0	64·0
7	"	Cooled freely in air		52,000	81,000	30·5	59·1
8	"	Cooled slowly in furnace		48,400	76,400	32·0	53·8
9	As rolled			53,500	84,600	32·0	59·1

SERIES B

Pieces from Bar B, quenched in Oil from 800° C. and drawn to various temperatures

Heat Treatment and Physical Properties

Piece No.	Heat Treatment			Physical Properties			
	Heated to	Quenched in	Drawing temperature	Yield point	Ultimate strength	Elongation (in 2 in.)	Reduction in area
	Degrees C.		Degrees C.	Lb. to sq. in.	Lb. to sq. in.	Per cent	Per cent
1	800	Oil	350	62,200	98,300	25·5	61·6
2	"	"	400	65,200	99,400	24·0	61·6
3	"	"	460	64,700	99,400	26·0	61·6
4	"	"	500	72,900	99,800	25·5	61·6
5	"	"	550	65,700	94,200	27·0	64·0
6	"	"	600	66,200	94,200	29·0	64·0
7	"	Cooled freely in air		53,000	81,500	29·0	59·1
8	"	Cooled slowly in furnace		40,700	76,400	31·5	59·1
9	As rolled			53,500	82,000	29·5	56·5

Notes: 1. All heat treatments made on the full section (1 inch Rounds). Test-pieces (A.S.T.M. Standard with threaded ends) were then machined from the heat-treated stock.
2. This heat was made from Sudbury slag.

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