THE JOURNAL

OF THE

Canadian Mining Institute

1908

EDITED BY THE SECRETARY

VOLUME XI

" The Institute as a body shall not be responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at its meetings."—*By-Laws, Par. xxxix.*

PUBLISHED BY AUTHORITY OF THE COUNCIL AT THE SECRETARY'S OFFICE, 413 DORCHESTER STREET, W., MONTREAL, AUGUST, 1908.

CANADIAN MINING INSTITUTE

List of Officers and Members of Council since the Establishment of the Institute showing the years during which office has been held.

PRESIDENT

Coste, Eugene, 1903, 1904.
Fergie, Charles, 1901, 1902.
Fowler, S. S., 1900.
Hardman, J. E., 1899.
Keffer, Frederic, 1907.
Miller, Dr. W. G., 1908.
Smith, G. R., 1905, 1906.

VICE-PRESIDENT

Adams, Dr. F. D., 1901, 1902, 1903, 1905, 1906.
Barlow, Dr. A. E., 1908.
Cantley, Thomas, 1905.
Carlyle, W. A., 1899.
Chambers, R. E., 1903, 1904.
Coste, Eugene, 1902.
Dawson, Dr. G. M., C.M.G., 1899.
Donkin, Hiram, 1899, 1900.
Drummond, Geo. E., 1899, 1900, 1908.
Duggan, G. H., 1905, 1906, 1907.
Fergie, Chas., 1900.
Fraser, Graham, 1901, 1902.
Goodwin, W. L., 1905.
Hedley, R. R., 1901, 1902.
Hobson, J. B., 1903, 1904.
Keffer, F., 1905, 1906.
Kirby, E. B., 1904.
Leckie, R. G., 1905, 1906.
McArthur, James, 1900, 1901.
Miller, Dr. W. G., 1907.
Porter, Dr. J. Bonsall, 1907, 1908.
Robertson, W. F., 1907, 1908.
Smith, G. R., 1903, 1904.

COUNCILLORS

Adams, F. D., 1899, 1900, 1904, 1907, 1908.
Aldridge, W. H., 1905, 1906, 1907.
Barlow, Dr. A. E., 1905, 1906, 1907.
Bennett, B., 1902, 1903.
Blue, Archibald, 1899.
Blue, John, 1905, 1906.
Brent, Charles, 1899, 1900.
Brewer, Wm. W., 1908.
Brock, R. W., 1907, 1908.
Browne, David H., 1907, 1908.
Cantley, T., 1903, 1904, 1905, 1906.
Chambers, R. E., 1901, 1902.
Cirkel, F., 1903, 1904.
Cole, Arthur A., 1908.
Coll, C. J., 1905, 1906.
Coste, Eugene, 1899, 1900.
Cowans, J. R., 1899, 1900.
Craig, B. A. C., 1905, 1906, 1907.
DeKalb, Courteney, 1901, 1902.
Dimock, C. 1899.
Drury, H. A., 1908.
Duggan, G. H., 1903, 1904.
Fergie, Chas., 1908.
Fowler, S. S., 1898, 1899.
Fraser, Graham, 1904.
Galt, E. T., 1899, 1900.
Gilman, E. W., 1907, 1908.
Gilpin, Dr. E., 1903, 1904.
Goodwin, Dr. W. L., 1903, 1904.
Gwillim, J. C., 1905, 1906, 1907, 1908.
Hardman, John E., 1908.
Haultain, H. E. T., 1907, 1908.
Hay, Col. A. M., 1905, 1906, 1907.
Hedley, Robt. R., 1900, 1905.
Hobson, J. B., 1899, 1901, 1902.

COUNCILLORS—*Continued*

Hopper, R. T., 1899, 1900, 1905, 1906, 1907, 1908.
Keffer, Frederic, 1902, 1903.
Kerr, D. G., 1903, 1904.
Kirby, E. B., 1900, 1901, 1903,
Kiddie, Thos., 1905. 1906, 1907.
Kirkgaard, P., 1901, 1902.
Leckie, R. G., 1901, 1904.
Lewis, James F., 1900, 1901.
Libby, W. L., 1899, 1902.
Little, W. F., 1901, 1902.
Macdonald, Bernard, 1900, 1901.
McArthur, James, 1899.
McCall, J. T., 1901, 1902.
McConnell, R. G., 1900, 1901.
McEvoy, J., 1904, 1905, 1906, 1907, 1908.
McNab, A. J., 1908.
McNaughton, G. F., 1900, 1901.
Meissener, C. A., 1899, 1900, 1905.
Miller, Dr. W. G., 1904, 1905, 1906.
Obalski, J., 1898, 1905.
Parrish, S. F., 1903, 1904.
Parsons, W. F. C., 1908.
Poole, H. S., 1900, 1901.
Porter, J. Bonsall, 1902, 1903, 1905, 1906.
Robb, D. W., 1901, 1902, 1905, 1906, 1907, 1908.
Robbins, Frank, 1902.
Robertson, W. F., 1904.
Shields, Cornelius, 1902, 1903.
Sjostedt, E. A., 1902, 1903.
Smith, F. B., 1905, 1906, 1907, 1908.
Smith, Geo. R., 1899, 1901, 1902.
Smith, J. Burley, 1900, 1901.
Smith, O. B., 1908.
Stewart, R. H., 1908.
Tonkin, J. H., 1903.
Turner, A. P., 1902, 1903.
Tyrrell, J. B., 1908.
Williams, H. J., 1903, 1904, 1905, 1906.
Willmott, A. B., 1905.

SECRETARY

Bell, B. T. A., 1899, 1900, 1901, 1902, 1903.
Coste, Eugene, (Acting Secretary) 1904.
Lamb, H. Mortimer, 1905, 1906, 1907, 1908.

TREASURER

Brown, J. Stevenson, 1900, 1901, 1902 1903, 1904, 1905, 1906, 1907, 1908.
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MEETINGS

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CANADIAN MINING INSTITUTE

ANNUAL MEETING

Ottawa, March 4th, 5th & 6th, 1908

The tenth Annual General Meeting of the Institute was held at the Russell House, Ottawa, on Wednesday, Thursday and Friday, March 4th, 5th and 6th, 1908.

The members in attendance assembled in the drawing-room of the hotel, on Wednesday morning at 10 o'clock. The meeting was called to order by the President, Mr. Frederic Keffer, Engineer of the B.C. Copper Co., Ltd., Greenwood, B.C., who in opening the proceedings said: "We are honoured to-day by the presence of the Minister of Mines, the Hon. William Templeman, who has kindly consented to address you (applause). It is scarcely necessary to inform the Honourable Minister that this Institute is a very representative body. It has now a membership of, in round numbers, seven hundred, and we include on our roll virtually all the mining men of standing of the Dominion. It has already played a very important part in promoting the welfare of the great industry it represents. Its purpose in bringing together the mining engineers of the country is to disseminate technical knowledge, to raise the standard of achievement and, in general, to foster an industry which—already important—is but on the threshhold of a development which possibly, nay probably, will make Canada the greatest mineral producing country in the world (applause).

"Another and parallel aim of the Institute is to serve the cause of education. Ever since our organization, many years ago, we have done our best to aid young men entering the profession. By offering annually prizes for competition, by establishing college branches, and by other means, we have secured the interest of these young men and many of them are now members of the Institute, while at present we have a student membership of over a hundred. You, Mr. Templeman, and your government have been liberal and consistent in aiding our development and our work, and it is the ambition of the Council and the members at large to prove to you by our works that your assistance has been wisely bestowed.

"Now, gentlemen of the Canadian Mining Institute, I have the honour to introduce the Honourable William Templeman, Minister of Mines, who will welcome you to the capital city of the Dominion." (cheers).

ADDRESS BY THE HON. THE MINISTER OF MINES.

THE HONOURABLE WILLIAM TEMPLEMAN, (Minister of Mines), who was greeted with applause, said: "It was the intention of Sir Wilfrid Laurier to be here to-day to welcome you to the city of Ottawa, but I regret to say he has been compelled on sudden notice to leave the city, and so is unable to be present on this occasion. I have very great pleasure indeed in being here to welcome the members of the Canadian Mining Institute to the city of Ottawa. I understand from what you have just said, Mr. President, that the Institute has grown in numbers and influence very considerably during the last few years. The Department of Mines of Canada, of which I have the honour to be the head, is as yet young and inexperienced and it is a satisfaction for me to know that we have an organization of this high character, composed as it is of mining engineers, geologists, men versed in the technical and practical side of mining, in short so thoroughly representative of the mining industries of the country, to give us aid and counsel at all times. (hear, hear). I appreciate what you have said, Sir, that Canada is destined to become one of the leading mining countries in the world. It is because, coming as I do from the province of British Columbia (which we are vain enough to sometimes think is one of the leading mining provinces of the Dominion) and having a more or less superficial knowledge of the mining resources of that province and the development that has taken place there during the last fifteen years, that I induced my colleagues to constitute a Mines Department. (hear, hear). The Mines Department of the Dominion of Canada has not yet been completely organized; we hope to greatly extend its field of usefulness. We have had some difficulties to contend with, but I am glad to say these are being rapidly overcome and I know that there is in the minds of my colleagues a desire to foster and encourage the mining industry of Canada. The Dominion Mines Department occupies a somewhat different position from that occupied by the Mines' Departments of the several provinces. We have not, of course, anything to do with legislation affecting mining in those provinces, which control and own their own minerals; but in the new provinces of the West—in Manitoba, Alberta and Saskatchewan—in which the Dominion Government controls the mining rights, we continue to exercise jurisdiction. But the Dominion Mines Department has, apart from this, a great and useful work to carry out. For example, we can encourage mining along educational lines, and that I can assure you is one of the main objects we have in view; moreover, we purpose encouraging by experiment and investigation the great interests you are assembled to promote. I am not at the moment prepared to say more to you; I am a novice facing experts; I cannot speak about mining from the standpoint of experience or technical skill. I can, however, assure you again that in so far as the Mines Department of Canada is concerned we stand to help in the development of the mining industries of the country. (applause). We know enough about those resources of Canada to believe, as the chairman has said, that we will soon become one of the greatest mining countries in the world. I extend again a cordial welcome to you on behalf of the Prime Minister and of myself. I trust that your meetings will be interesting and profitable to yourselves and to the country, and that the results will be beneficial to the interests you have so much at heart. I would, however, counsel you not to imitate Parliament too closely and have all night sessions, for in my opinion that is not a very desirable thing. I offer my best wishes for the success of this meeting and of the Canadian Mining Institute." (applause).

LETTERS OF REGRET AT INABILITY TO ATTEND.

At the conclusion of Mr. Templeman's address the Secretary read letters of regret at inability to be present from Dr. J. F. Kemp, Columbia University, N.Y., Mr. John Duer Irving, of Yale University, Mr. S. F. Emmons, Geological Survey of the United States, and Mr. Alfred C. Lane, State Geologist, Lansing, Michigan.

TELEGRAM OF SYMPATHY TO DR. LOW.

Dr. J. Bonsall Porter then asked permission to move that the secretary be instructed to despatch a telegram to Dr. A. P. Low, Deputy Minister of Mines, at present convalescing in the West Indies, expressing the sympathy of the Institute in his illness and its thanks for the interest he had always shown in the work, and the assistance he had been ever ready to afford, the Institute in the past.

The resolution was seconded by Mr. Geo. R. Smith, and was carried unanimously.

PAPERS—WEDNESDAY MORNING SESSION.

The following papers were then read and discussed:

THE CLASSIFICATION OF COAL, by D. B. Dowling, Ottawa.

THE CARBON MINERALS OF NEW BRUNSWICK, by Dr. R. W. Ells, Ottawa.

ON SECONDARY EDUCATION, by H. H. Stoek, Scranton, Pa.

OCCURRENCE OF TUNGSTEN ORES IN CANADA, by Dr. T. L. Walker, Toronto, Ont.

TOPOGRAPHICAL METHODS USED FOR THE SPECIAL MAP OF ROSSLAND, B.C., by W. H. Boyd, Ottawa, Ont.

WEDNESDAY AFTERNOON SESSION.

Upon re-assembling at 3 o'clock, the President announced that Dr. J. Bonar, Deputy Master of the Royal Mint, at Ottawa, had kindly intimated that members of the Institute would be welcome to visit that institution at any time during their stay in the city.

The following papers were then read and discussed:

GOLD IN THE EASTERN TOWNSHIPS OF QUEBEC, by J. Obalski, Quebec, Que.

CANADIAN GRAPHITE, by H. P. H. Brumell, Buckingham, Que.

*HANDLING THREE THOUSAND TONS OF ORE PER DAY AT THE GRANBY MINES AND SMELTER, PHOENIX AND GRAND FORKS, B.C., by A. B. W. Hodges, Grand Forks, B.C.

* Paper read by Mr. R. R. Hedley in the absence of the author.

NOTES ON COSTS OF DIAMOND DRILLING IN THE BOUNDARY DISTRICT, B.C., by Frederic Keffer, Greenwood, B.C.

WEDNESDAY EVENING SESSION

At the evening session, 8 p.m., Dr. Wm. Campbell, of Columbia University, New York, delivered a most interesting address on the subject of "Metallography as applied to Engineering." The lecture was admirably illustrated by lantern slides. At the close of his address Dr. Campbell extended a hearty invitation to members of the Institute visiting New York to inspect his laboratories and apparatus at Columbia University.

DISCUSSION.

THE PRESIDENT:—I, and I am sure all here, have listened with a great deal of pleasure to the very excellent address of Prof. Campbell, and on behalf of the Institute I am pleased to extend to that gentleman a very warm welcome to our convention.

DR. STANSFIELD:—I wish to say a few words in appreciation of the address of Dr. Campbell, and especially in appreciation of his beautiful-photographs. Dr. Campbell began working on metallography a number of years ago in a laboratory of which I was in charge, and I believe that his original work in that line was on a piece of work I had originated, that of the constitution of the copper-tin alloys, which I had worked out with the acid of the recording pyrometer, taking cooling curves. At my suggestion Dr. Campbell proceeded to complete the work by means of the miscroscope, although at that time I could not give him very satisfactory apparatus. After that he went to New York, where he has ultimately obtained the very satisfactory results we have seen this evening. Dr. Campbell began his work at the Royal School of Mines in London, where they now have a very satisfactory apparatus for this line of investigation. The Metallurgical Laboratories at McGill are also well equipped for such work.

DR. PORTER:—This is a matter of immense importance to geologists and students of ore deposits. We have with us several people eminently qualified to speak on this subject, in relation to the question of steel rails, for instance, which is an affair of crying importance. We have also petrographers and geologists, and I think we could have a very interesting discussion on this paper.

THE PRESIDENT:—I would suggest a few words from Dr. Adams.

DR. ADAMS:—I am afraid that I am scarcely competent to adequately discuss this subject, Mr. Chairman, but I may say that the point which has always struck me in connection with this very interesting metallographic work is that it brings out so strikingly the resemblances in structure which exist between alloys or compounds of metals and rocks. The structure of cementite, as we saw it so beautifully on the screen this evening, is strikingly similar to that of graphic granite. There are many other structures which are developed in these metallic rocks, if we may so style them, which are precisely similar to those we are accustomed to see under the microscope in ordinary rocks made of minerals. I desire to convey my sincere congratulations to Dr. Campbell for his excellent paper, and to express my great admiration of the photographs which he has thrown upon the screen and by which his remarks were so admirably illustrated.

PROSPECTING IN THE ROCKIES.

MR. D. B. DOWLING, then read a paper on "A Prospecting Trip in the Rocky Mountains." in which he gave an entertaining account of a summer spent in the hills and valleys of that section of country, and showed a series of very beautiful slides, many of which were coloured.

In moving a vote of thanks to Mr. Dowling, Dr. Porter said: "We have listened with great pleasure to Mr. Dowling's very interesting address, but I think we should compliment him in particular upon his very excellent slides, which are very tastefully coloured, and I should like to ask who was responsible for that work? It is about the best I have seen.

MR. DOWLING:—I did it myself. To colour my slides I used a dye which I obtained from a Chicago firm, and which I applied in the ordinary way with a brush, diluting the dyes as needed with water.

The vote of thanks was seconded by Dr. Adams and unanimously carried.

MR. E. D. INGALL, then read a short paper entitled "A NOTE ON A SYSTEM OF CONVENTIONAL SIGNS FOR SHEWING MINERALS OCCURRENCES ON MAPS, ETC."

THURSDAY MORNING SESSION.

The session opened at 10 o'clock, and was devoted to matters of business detail in connection with the affairs of the Institute.

The President, MR. FREDERIC KEFFER, delivered his annual address as follows:

PRESIDENTIAL ADDRESS.

In reviewing the past year it is gratifying to be able to note a substantial increase in the membership of the Institute. At our last meeting the roll included some five hundred names, whereas at the present time we have, in round figures, a membership of seven hundred. The professional standing and character of the gentlemen we have admitted to membership during this period is also a matter for congratulation, since the list includes so many men actually engaged in building up the mining industry of Canada—men widely known in their several fields of work.

One of the important tasks undertaken during the year by the Council of the Institute, is the establishment of branch libraries in the more important mining centres, a work which cannot fail to add to the usefulness of the Institute.

Another important business now before the Institute is the coming visit (next Fall) of distinguished representatives of the leading engineering and mining societies of Great Britain, who will come out as guests of the Canadian Mining Institute to participate in a proposed tour of the mineral regions of the Dominion, inclusive, if possible, of the Province of British Columbia. As a resident of the latter province, I think that I may safely promise, on behalf of my fellow members in that field, that we will do all in our power to make that visit a pleasant and profitable one for our London guests.

Last January there was organized at Nelson, B.C., a Western Branch of the Institute, in order that members resident in the Western Provinces, of whom very few indeed can attend the annual meetings usually held in Eastern Canada, may enjoy the advantages of personal association and interchange of ideas. About thirty members were in attendance, and although there were fewer present than had been hoped, still those who did attend included many of those foremost in the mining industry of the Province, and the meeting was thoroughly representative. Mr. A. B. W. Hodges, the Acting Manager of the Granby Cons. M. & S. Co., Ltd., owning the greatest copper mining and smelting works in Canada, was elected President, and Mr. E. Jacobs, Editor of "The Mining Record," of Victoria, a gentleman well and favourably known throughout the Dominion by his journalistic work in connection with mining, was elected Secretary-Treasurer. A strong council of nine members, representing Alberta, British Columbia and the State of Washington, was also elected. It is the intention to hold meetings every four months in various parts of the territory covered by the branch, so as to give members an opportunity to attend a meeting at least once each year. It was felt that in this way only could the proper spirit be fostered, and a lively interest in the Institute maintained.

That this interest needs to be awakened was amply demonstrated when notices were being sent out to members in respect to the Nelson meeting. Although a return addressed postal card was sent to every member, and all required of him was to reply "Yes" or "No" to the questions asked, but fifty per cent. of the members responded; while to the notices sent out last September the response was even less satisfactory. We hope to change all this in the West and make the Institute and its work a live issue; and its meetings so valuable that members will realize that they cannot afford to remain away. And if this Institute is to occupy the position it can and should, it is imperative that the interest of all members should be enlisted and that we should all work together as for a common cause.

In conclusion, it is related that when the Declaration of Independence was signed in 1776, some wag amongst the subscribers said—"Gentlemen, we must all hang together now, for if we don't we shall assuredly all hang separately." It is much the same with our organization. We must all hang, work and strive together for a *national* Canadian Mining Institute of which we can all be proud. Nothing short of this is worth while. (applause).

The Secretary (Mr. H. Mortimer-Lamb) then read the annual report of the Council for the year 1907–1908, as follows·—

REPORT OF THE COUNCIL FOR THE YEAR, 1907–08.

MEETINGS.

The Ninth Annual Meeting of the Institute was held at the King Edward Hotel, in the city of Toronto, on March the 6th, 7th and 8th, 1907. The attendance was the largest in the history of the Institute and the occasion was also noteworthy in that the members were afforded the privilege of entertaining a number of distinguished guests from the United States, who took an active interest and part in the proceedings. Other meetings have been held during the year under the auspices of the local branches of Cobalt and Toronto; whilst an important meeting of Western Members, for the purpose of organizing a Western Section and for the reading of papers, was held at Nelson, B.C., on Jan. 15th, 1908.

Five regular meetings of Council have been held at Headquarters, the attendance having been generally above the average of former years.

PUBLICATIONS.

Thirty-five papers were presented at the Annual Meeting, and these with the discussions thereon, and a Report of the Proceedings of the Meeting, now constitute Vol. X. of the Journal of the Institute, which has been issued to members in good standing.

At a meeting of the Council in October last, it wes decided to publish thereafter advance proofs of papers contributed by members, reports of Branches and Affiliated Societies and other matter of general interest to the membership, in the form of a quarterly Bulletin. The first number of this Bulletin has been placed before you.

MEMBERSHIP.

The increase in the membership during the year is exceptionally gratifying, there having been elected since the last Annual Meeting one hundred and sixty one members, thirty-four associate members, thirteen corresponding members, and four student members, or a total of two hundred and two, representing an increase in membership for the year of over forty-five per cent.

BRANCHES.

This large increase in membership is mainly attributable to the interest that has been awakened in the work of the Institute in the Provinces of British Columbia and Alberta, and in the Cobalt District of Ontario. In the latter District, a Branch was successfully organized on the 15th of April last, Mr. Arthur A. Cole having been elected Chairman and Mr. G. R. Hardy, Secretary. The branch holds regular monthly meetings for the reading of papers and for the discussion of questions of local interest. The Western Section or Branch, to which already allusion has been made, was organized at Nelson, B.C., on Jan. 15th, 1908, with a membership in round figures of a hundred and fifty, including members residing in British Columbia, Alberta and the adjacent United States territory. A vote having been taken, Mr. A. B. W. Hodges, General Manager of the Granby Consolidated Mining, Smelting and Power Co., Ltd., of Grand Forks, B.C., was elected Chairman, and Mr. E. Jacobs, of Victoria, B.C., Secretary of the Western Branch. The Council desires to record its appreciation and to express its grateful acknowledgment of the valuable services rendered, in connection with the organization of the Western Branch, by the President of the Institute, Mr. Frederic Keffer, who undertook and carried out all the arrangements for the meeting, the success of which may be almost entirely credited to his personal efforts and zeal.

On Feb. 13th, 1908, a Montreal branch of the Institute was organized with Mr. George E. Drummond as Chairman, and Mr. J. W. Bell, Secretary. This branch contemplates holding monthly meetings during the winter months.

DEATHS AND RESIGNATIONS.

The Council records with profound regret the deaths of the following members:—Mr. John Blue, Eustis, Que.; Dr. W. H. Drummond, Montreal; Dr. E. Gilpin, Jr., Halifax, N.S.; Mr. T. R.

Gue, Halifax, N.S.; Mr. George T. Marks, Port Arthur, Ont., and Mr. Tyndall Phipps, Reno, Nevada.

The following gentlemen have resigned their membership:—

Messrs. F. Bacon, T. B. Bacon, Thomas Barnes, W. Caldwell, W. J. Chalmers, H. E. Coll, D. Ford, H. W. Hixon, H. W. MacInnes, H. Montgomery, Robert Murray, F. N. Speller and J. J. Campbell.

LIBRARY AND READING ROOM.

The library and reading room at headquarters have been freely used by members and visitors during the year. Upwards of two hundred volumes have been added to the library shelves, including transactions of technical and learned societies, official reports, periodicals, and exchanges. The Secretary is now engaged in arranging for the establishment of libraries, at all the principal mining and industrial centres of the Dominion, for the convenience of members residing elsewhere than at headquarters; and it is hoped that this proposal, which has already met with much encouragement, will be carried into effect within the next few months.

DEPUTATIONS

Acting under instruction of the Council, Messrs. Adams, Porter and the Secretary, last November, waited on the Honourable the Minister of Mines and the Honourable the Minister of Finance, at Ottawa, and urged that the vote annually granted to the Institute by the Federal Parliament be increased from three to five thousand dollars. This additional assistance was asked for in consideration of the extension of the Institute's field of usefulness, and of further proposals looking to that end. The Council has much pleasure in stating that the larger sum has in consequence been included in this year's estimates.

Deputations have also waited on the Honourable the Minister of Mines for the Dominion, Mr. Templeman, and on the Honourable the Minister of Mines of Ontario, Mr. Cochrane, to ask for financial assistance in connection with a proposal to invite representatives of the leading mining and engineering societies of Great Britain and the Continent to visit Canada this summer as the guests of the Institute to take part in a general excursion of members to all the important mining regions of the Dominion, from Ocean to Ocean. The Council has every reason to believe that substantial financial assistance will be given the Institute in carrying out this programme.

FEDERAL DEPARTMENT OF MINES.

The creation by Act of Parliament last spring of a Federal Department of Mines, the desirability and need of which has been persistently urged by the Institute on frequent occasions in the past, is worthy of special remark. This department has been placed under the Ministerial control of the Honourable William Templeman, who, as is well known, has keenly at heart the welfare of the mining industry of the Dominion, and is earnestly desirous of promoting its growth and prosperity. In this desire he has the loyal support and active co-operation of Dr. A. P. Low, the Deputy Minister, (whose present disability in consequence of long and severe illness, the Council notes with profound regret); and of the Director of Mines, Dr. Eugene Haanel, and the acting Director of the Geological Survey, Mr. R. W. Brock, the executive heads of the two branches of, respectively, Mines and Geology. The good service the Department has already rendered the country in general, and the mining industry, in particular, is already evidenced in the publication of the several valuable monographs and other reports of an economic nature issued during the past twelve months.

STUDENTS' COMPETITION AND AWARDS.

After receiving the report of the judges, Messrs. Charles B. Going and Frederick Hobart, the Council awarded the President's gold medal, for the best paper submitted by a Student Member during the year, to Mr. Frank E. Lathe, of McGill University, Montreal, in addition to a cash prize of twenty-five dollars. Cash prizes of twenty dollars were also awarded to the following gentlemen: Mr. G. R. McLaren, of the School of Mining, Kingston, Mr. W. J. Dick, of McGill University, Montreal, and Mr. C. V. Brennan, of McGill University, Montreal.

The following extract from the Report of the judges may be of interest to members: "The undersigned, appointed by you judges of the student papers submitted to the latest annual meeting of the Institute, would respectfully report as follows: The first place should be accorded to the paper on 'Basic Open-Hearth Steel Manufacture as carried out by the Dominion Iron and Steel Company at Sydney, Cape Breton,' by Frank E. Lathe. This is an excellent monograph, carefully written, with full attention to details, and especially to the costs and expenses of manufacture; a point in which many technical papers are deficient. It shows also a fair sense of proportion; that is, of the relative importance of the various parts. This paper unquestionably takes the first place. It is to be regretted that it cannot be published in full, as some of the details of costs, etc., were given to the writer on condition that they should not be made generally public. The two papers 'The Cariboo Consolidated Hydraulic Plant, Bullion, B.C.,' by W. J. Dick, and 'Underground Mining Methods at the Quincy Copper Mine, Michigan,' by G. R. McLaren, appear to be of nearly equal excellence. The former should, perhaps, have the preference, as relating to a Canadian topic. The Quincy paper has a number of sketches which serve to illustrate its text, but which might have been more carefully executed. The paper on 'The Oldham Stering Gold Mine, Nova Scotia,' by C. V. Brennan has merit, and only falls a little below the two mentioned in this paragraph. The paper by G. D. Drummond on 'The Use of Chemical Analysis in Iron Blast Furnace Practice and some notes on Laboratory Methods' is a monograph constituting a record of practice and experience of considerable value."

H. MORTIMER-LAMB, *Secretary.*

The Secretary added:—

In reference to the increased membership I might also add that during the year the membership of the two Student Societies, namely, those of McGill University and Queen's, has in each case doubled, largely as a result of the energy and enthusiasm of the Secretaries of these branches. The Council desires to congratulate these gentlemen on their exertions.

The Treasurer (Mr. J. Stevenson Brown) then read the following report:—

TREASURER'S STATEMENT.

YEAR ENDING FEBRUARY 1ST, 1908.

RECEIPTS.

Balance from last year		$1,354.20
SUBSCRIPTIONS—		
405 Ordinary Members at $10.00	$4,050.00	
8 Student Members at $2.00	16.00	
72 University Members at $1.00	72.00	
Arrears collected	224.00	4,362.00
SALE OF PUBLICATIONS		47.60
DOMINION GOVERNMENT GRANT		3,000.00
ONTARIO		1,500.00
INTEREST		50.80
SUNDRIES		6.10
ANNUAL MEETING—		
Banquet Tickets, etc.	$415.50	
Cobalt Trip Subscription	660.00	1,075.50
		$11,396.20

LESS

Disbursements per Statement	7,923.51
Balance on hand	$3,472.69

J. STEVENSON BROWN,
Treasurer.

Audited and Certified Correct,

P. S. ROSS & SONS,
Chartered Accountants.

MONTREAL, February 17th, 1908.

SUMMARY STATEMENT.

SHOWING DISTRIBUTION OF DISBURSEMENTS TO THE VARIOUS WORK AND BUSINESS OF THE INSTITUTE.

PUBLICATION—		
Transactions, Vol. X.	$1,917.05	
Postage and Express	197.92	
Sundries	243.14	$2,358.11
LIBRARY—		
Rent	$500.00	
Telephone	40.00	
Binding	40.63	
Sundries	17.50	598.13

MEETINGS—		
Annual Meeting and Cobalt Trip	$2,267.56	
Other Meetings	165.10	
		2,432.66
SECRETARY'S OFFICE—		
Secretary's Grant	$500.00	
Printing, Stationary, etc.	100.25	
Postage, Phones and Telegrams	58.84	
Travelling Expenses	756.25	
Sundries	57.13	
		1,472.47
TREASURER'S OFFICE—		
Treasurer's Grant	$500.00	
Printing, Stationery, etc.	53.75	
Postage, Telegrams, etc..	66.78	
Bank Charges on Cheques and Drafts.	92.40	
Sundries	70.61	
		783.54
SUNDRIES—		
Deputations.	30.25	
Advertising	45.84	
Prizes	85.00	
Subscriptions paid twice	20.00	
Various.	97.51	
		278.60
		$7,923.51

J. STEVENSON BROWN,
Treasurer.

In connection with the financial statement it may be remarked that the year just closed has been one of unusual activity; the receipts and disbursements have far exceeded those of any preceding year, while the cash balance at the credit of the Institute is the largest in its history.

The only liability outstanding at the close of the fiscal year is balance owing for printing and binding in connection with Volume X of the Transactions, the account for which had not been rendered before the books and accounts were closed.

It is gratifying to note the marked increase in the revenue derived from membership fees, amounting to $1,160.00 or nearly forty per cent., and which increase is largely due to the energy displayed by our Secretary in obtaining new members. The figures compared with last year are as follows:—

For year ending 1st February, 1907	$2,978.00
For year ending 1st February, 1908	4,138.00
Increase	$1,160.00

The net balance at the credit of the Institute at the close of each fiscal year since 1900 is shown in the following table:—

1900		$484.87
1901		630.61
1902		957.40
1903		1,682.49
1904		1,909.58
1905		658.52
1906		1,191.84
1907		1,354.20
1908	3,472.69	
Less Liability	700.00	2,772.69

Respectfully submitted,

J. STEVENSON BROWN,
Treasurer.

The Treasurer added:—I may say in reference to the balance of $3,474.69, that there is an unpaid account due in respect to Volume X of about $700, and the balance shown will be reduced by that amount as shown above.

AUDITOR'S REPORT.

The President read the report of the Auditors as follows:—

Montreal, Feb. 19th, 1908.

To the President and Councilors of the
Canadian Mining Institute,
Montreal.

Gentlemen:—

We beg to report that we have audited the receipts and disbursements made by your Treasurer on behalf of the Institute for the year ended on the 31st January, 1908.

The revenue for the year according to the books has been properly accounted for, while the cash disbursements have been properly covered by satisfactory vouchers which have been properly approved.

We have checked the detail of the amounts as they appear under their respective heads in the Statement to be presented to your Annual Meeting and have certified the Statement as correctly setting forth the transactions of the Institute according to the Books of Account.

We have also checked the Bank Accounts throughout the year and verified the balances at the date of the Statements.

The recording of the transactions has been done in a very clear and concise manner, and the interests of the Institute in this direction have been well guarded.

All of which we have pleasure in reporting.

(Signed) P. S. ROSS & SONS,
Chartered Accountants.

The Report of the Council was adopted after some discussion in the course of which, Mr. Coste, Chairman of the Toronto Branch, stated that the members of the branch met regularly once a month, and sometimes more frequently, the attendance being generally between twenty-five and thirty. Members visiting Toronto were always welcome at the meetings. The branch had been no charge on the Institute.

In connection with the Treasurer's Statement, Mr. J. B. Tyrrell suggested that it would be an advantage if in future the accounts and balance sheet were published in advance of the meeting and distributed to members.

REPORT OF COMMITTEE ON MINING LEGISLATION IN ONTARIO.

(Report of Committee appointed at annual meeting held in Toronto on March the 6th, 1907, to confer with the Ontario Government regarding "An act to supplement the revenues of the Crown," which was at that time in discussion by the Government).

Your Committee, consisting, of Mr. R. W. Leonard, representing Coniagas Mines, Cobalt; Mr. David H. Browne, representing the Canadian Copper Co; Mr. A. B. Wilmott, representing The Lake Superior Corporation, Co.; Col. A. M. Hay, representing The Tretheway Silver-Cobalt Mining Co.; Mr. John E. Hardman, representing The Canadian Iron and Furnace Company and the Drummond Mines, Limited, and Mr. A. D. V. Adler, Chairman of The Cobalt Mines Committee, with power to add to their number, discussed the subject with the Premier, The Minister of Mines, and the Provincial Secretary on the 6th of March, 1907, and presented the resolution passed by the Canadian Mining Institute at that Meeting.

The result of this conference was that the Institute was requested by the Minister of Mines, through the Committee, to cease all opposition to the Bill on assurance—which was given by the Minister—that the government would amend the Bill at its next session to make it more nearly meet the wishes expressed by the Committee, as it was too late then to undertake any amendments during that session.

We were also requested to present to the Minister of Mines, during the ensuing autumn, some suggestions that would assist in such a revision.

The proposed "Act to supplement the revenues of the Crown" was passed, exacting a royalty of three per cent. on the gross output of all mines yielding a profit of over $10,000 per year after allowing of certain deductions for cost of labour, etc., involved, which royalty this Institute disapproved of in the resolution presented to the Government on the occasion referred to.

With the object of assisting the Department by suggesting amendments as requested by the Minister, your Committee, through its Chairman, entered into correspondence with the Minister of Mines in August last requesting information to enable the committee to consider the subject intelligently. The information desired included the acreage in the province held as mining land; revenues from the same; the acreage taxed as mining lands, and that exempted from taxation; the revenues from this possible source; the number of mining companies incorporated in Ontario, with their capitalization; the revenue derived from them in various ways; the total revenues of the Crown (from various forms of taxation) from the mining industry, etc., etc.

After much correspondence (copies of all of which are in the hands of the Secretary) and several interviews with the Department, your Committee failed to obtain much information to assist them in their efforts; but learned that such information is not in the possession of the Department in such form that it can be readily referred to. The following facts were obtained, however, which, though incomplete and therefore unsatisfactory, are worthy of noting:—

The Province received from mining alone in 1906 a revenue of $250,121.

As this was before any large revenue was received from the Crown from Cobalt properties, it may perhaps fairly represent the income of the Province in taxes on *mining* only up to that time.

In 1906 there were 263 mining companies organized in Ontario, with a total capitalization of $184,677,000.00, and 18 foreign mining corporations licensed with a total capitalization of $12,536,000.

The Deputy Minister of Mines in conversation with the chairman of your Committee, stated that he estimated roughly that there were probably about 800,000 acres of land held as mining property in the province.

With such scanty information available your Committee decided that it would be unwise to make any recommendations other than to request that a Royal Commission be appointed to investigate the subject in its entirety, and a resolution to this effect was presented to the Minister of Mines in November last after receiving recommendations from the Cobalt and Toronto branches of the Institute, endorsing that suggestion.

The request of the Committee was not favourably received by the Minister of Mines, who considered it a reflection on the Government and on his Department; but your Committee is nevertheless in the hope that legislation amending the Act (as promised by the Government a year ago) partially—at least—removing the just ground of dissatisfaction of the mining industry, will be passed at this session.

Signed, R. W. LEONARD,
Chairman of the Committee.

On a motion of Mr. Craig, seconded by Mr. Hobart, the report of the Committee was adopted.

APPOINTMENT OF SCRUTINEERS.

The following gentlemen were appointed by the meeting scrutineers of the ballots for the annual meeting of Officers and Council: Messrs. Frederick Hobart, New York; Mr. R. W. Brock, Ottawa, and Dr. A. W. G. Wilson, Montreal.

AMENDMENTS TO BY-LAWS.

DR. J. BONSALL PORTER, Chairman of the Committee appointed by the Council to offer suggestions for amending the By-laws, presented the Committee's recommendations, notification of which had been issued by the Secretary prior to the meeting.

DR. PORTER:—"At the February meeting of the Council it was decided that in view of criticisms of certain by-laws and the friction arising from inadequate and defective regulations it would be desirable to carefully revise the by-laws with a view to improving their efficiency, and of affording lesser opportunity or occasion for differences of opinion. A Committee consisting of Dr. Barlow, the Secretary and myself was appointed to study the by-laws and make such recommendations as we thought fit. We held many sessions and began by considering the by-laws of similar societies of this and other countries, and our recommendations are based on the information so obtained."

DR. PORTER then read the proposed amendments clause by clause, and the following were adopted:—

2. To amend Section 2, lines three and four to read: "Associate Members shall be entitled to vote, but may not hold office."

7. After the word Field Parties, add:—"And the principal officers of the Mines Branch of the Federal Department of Mines, etc."

8. Amend the last three lines as follows: "On the election of a candidate he shall be immediately notified by the Secretary. On the receipt of the notification he must pay to the Treasurer the regular fees before he can be entitled to the privileges of membership. Should he fail to do so within six months from the date of the notification of his election, such election shall be void. Membership shall date from the day of the election."

12. After the word "Council," line two, add "or of any ten members in good standing."

13. After the word "year," line three, add "Persons elected after six months of any fiscal year shall have expired shall pay only one half of the dues for that fiscal year."

16. Add as follows: "Any member who, for non-payment of dues, has been struck off the roll of membership, may again, if the Council approve, join the Institute on payment of all arrears."

16*a*. Add as follows: "Any member may compound his fee and become a life member on payment of a sum of $100, which is to be invested by the Council, the interest only to be used for current expenses."

16*b*. "The Council may, for sufficient cause, exempt from payment of dues any member distinguished in his professional career, who, from ill-health, advanced age, or other good reason assigned, is unable to pay such dues."

18. Strike out the words "Secretary and Treasurer" on second and third lines.

25*a*. "The Council at the first regular meeting after the close of the Annual Meeting shall appoint a Finance Committee, a Committee on Publications and a Library Committee and shall proceed to appoint a Secretary and a Treasurer or a Secretary-Treasurer and such subordinate officers as may be necessary for the proper conduct of the business of the Institute at such salaries as it may deem fit. The appointment of a Secretary and of a Treasurer or a Secretary-Treasurer shall be conducted by letter-ballot of the whole Council, and such candidate or candidates as shall receive a majority of votes shall receive the appointment."

It was decided after discussion that the Amendment 25*a* should not become operative until a vacancy should occur in either or both offices.

A vote of thanks was then passed to the Committee for the excellent work they had done in connection with the revision of the by-laws.

THURSDAY AFTERNOON SESSION.

The session opened at 3 o'clock, when the following papers were read and discussed:—

THE IRON ORES OF CANADA, by Dr. C. K. Leith, University of Wisconsin, Madison, Wis.

THE IRON ORES OF ONTARIO, by A. B. Willmott, Sault Ste. Marie, Ont.

ELECTRIC SMELTING IN CANADA, by R. Turnbull, St. Catherines, Ont.

POSSIBILITIES OF ELECTRIC SMELTING, by Dr. A. Stansfield, McGill University, Montreal.

THE SMOKING CONCERT.

Under the auspices of the local Reception and Entertainment Committee, a Smoking Concert was given in the Dining Room of the Russell Hotel, on Thursday evening. A capital programme of songs and dialogues was arranged and refreshments were also provided. Mr. E. Drew Ingall, of the Geological Survey of Canada, acted as chairman, and performing the duty of the office in a most acceptable manner.

FRIDAY MORNING SESSION.

The first business of the day was the discussion of the following resolution, moved by Mr. Geo. R. Smith and seconded by Mr. John E. Hardman:

RENEWAL OF LEAD BOUNTY ACT.

"That the Canadian Mining Institute in annual meeting "assembled, in continuation of its policy and action taken in the "past does hereby endorse the request of the Lead Miners and "Smelters of British Columbia, now before the Government, for "an extension of the Lead Bounty Act for a further period of five "years, with an increase in the minimum price of lead, fixed by "the bounty from £16 to £18 pounds per 2,240 lbs."

MR. J. E. HARDMAN:—This is a matter that can very well attract the attention of the Institute for a few moments, and I shall have great pleasure in seconding this motion. A few words may be said to illustrate the matter a little more clearly than it has been illustrated in the press. When you realize that the lead mining industry of British Columbia, which has been the only lead mining industry of the Dominion, was, five years ago, without any bounty or any help whatever, when the duty on lead imported into the United States was such as to interfere very materially with the success of the mines, particularly of the Slocan district, and when you further understand that after the granting of the Government bounty the production rose at once from 6,000 tons per annum to 22,000 to 23,000 tons per annum, that the amount of labour employed, to the consequent benefit of the Dominion as a whole, was thereby very greatly increased, and when you further consider that during five years out of the appropriation granted by the Dominion Government of $2,500,000 as a maximum, only $750,000 was claimed under the statute, and that by help to that extent from the Dominion Treasury the output has increased to something over $9,000,000 worth of lead and, including the silver, to $14,000,000, I think you will all concede that this is a matter of truly national importance. Our charter says we are incorporated for the purpose of taking concerted action upon such matters as affect the mining and metallurgical industries of the Dominion and the encouragement and promotion of these industries by every lawful means, I can conceive that it is the duty of this Canadian Mining Institute to do all in its power to assist the Minister of Trade and Commerce and the Minister of Finance to make up their minds that the request of the lead miners and smelters of British Columbia is a legitimate one and is backed up by the concensus of mining opinion in the Dominion of Canada as represented by this Canadian Mining Institute. (Applause.) We have here gentlemen from British Columbia, who, I am sure, will give us additional facts and figures, but as a member of this Institute representing the whole of the Dominion of Canada, and coming personally from the Province of Quebec, I have great pleasure in extending my sympathies to the men who are struggling to to develop this industry.

MR. LOUIS PRATT, of Sandon, B.C.:—We feel that a resolution of this nature if passed by the Institute would be of great assistance to us in obtaining what we think is a very fair demand. We are asking the Government to extent the Lead Bounty Act for another period of five years, and to raise the stable minimum price of lead on which the bounty is paid from £16 sterling to £18 per long ton. I may explain that five years ago we asked the Government to make the limit £16. This they granted. We thought at that time that this provision would be sufficient, and it was. Since then, however, conditions have changed somewhat. Two or three years ago the by-product we were selling to the U.S. was a source of revenue to us; and in some cases represented our profit, but at the present time we are unable to sell our lead in that market. Meanwhile a duty of 20 per cent. has been imposed by the U.S. Government not only on zinc, but on zinc and its contents. The duty is 20 per cent. on the silver contained in the zinc, and our zincs carry fairly high values in silver. That product we cannot ship at any price, and we have no market for it. We are asking the government for this increase in the price, but we are not asking for any more money. The limit of the bounty paid is $500,000 in any one year, and when that is earned it is no longer operative for that year. We ask merely that the earning capacity of the bounty be increased. We have placed before the members of the Institute, copies of the memorial which we have sent to the Government and that affords a fair explanation of the whole situation. We would feel very grateful if the Institute would pass this Resolution. We are merely asking for a continuation of the bounty which has been in force for nearly five years and which ceases on the 1st June next. I shall be glad to answer any questions.

MR. MCNAUGHTON:—I am not at all familiar with the conditions of the lead industry in British Columbia. I would therefore like to ask if there is at present a profit in mining and smelting lead in British Columbia. If there is a profit it seems to me the industry should stand on its own feet.

MR. PRATT:—In so far as lead is concerned there is no profit. It has been demonstrated that were it not for the silver contents, it would be impossible for us to mine a ton of lead and sell it in the Canadian market at a profit. Every ton of lead that is mined, is mined at a loss. It is the silver in the lead that has helped us through. To relate the difficulties under which the B.C. lead industry labours, would be a long story; but one of our principal difficulties is to find a market. We are at the extreme end of Canada and our marketing charges are very high, and now we are cut off from the American market by 1½ cents on lead ores, and 2⅛ cents per lb. on pig lead or $42 a ton. The freight rates on lead to markets other than the United States make it impossible for us to mine the lead itself at a profit.

MR. T. M. GIBSON:—I would like a little further and clearer understanding of the matter. My impression at the present time is that the bounty which is to expire shortly provides that the bonus is payable upon lead when the selling price of pig lead in the London market is under £12/10s. per ton. It is proposed that that standard price shall be changed?

MR. PRATT:—Yes, it is changed in this way: The bounty will be paid up to £14/10s. and ceases entirely at £18. When the London market is £18 there will be no bounty payable.

MR. HEDLEY:—It guarantees a minimum price of £18 to the producer of lead.

MR. GIBSON:—Is the bounty sufficient to raise the price to £18 in any case?

MR. HEDLEY:—It is sufficient to raise it to that and no more.

MR. G. R. MICKLE:—What they are asking for is the extension of the time during which the money already voted may be available. And at the outset of the memorial, it asks for a continuance of the bounty. I think that is misleading.

MR. RETALLACK:—I wish to correct Mr. Mickle. The specific request is for a continuation of the bounty period for five years with a vote of $500,000 in each individual year. We are asking for a further bounty for five years, $500,000 a year earning capacity and with the price of lead fixed at £18 instead of £16.

MR. HAULTAIN:—Is there any increase in the bounty payable?

MR. RETALLACK:—No.

MR. H. MORTIMER-LAMB (Secretary):—The lead mining industry in British Columbia has laboured in recent years under a good many disabilities. Some few years ago it was in a more or less flourishing condition and there was a very considerable production of lead. Then suddenly the lead market in the United States was closed by restrictive duties and at the same time an agitation came about to change the hours of labour from 10 hours to 8 hours a day. That had a disastrous effect on the lead industry and it languished. In view of the principle adopted by the Dominion Government in dealing with the steel industry of this country, British Columbian operators felt they were as much entitled to a bounty for the stimulation of the lead industry, as were the iron and steel men of the east, whose industry was thus subsidised; and it was the unanimous wish of the Boards of Trade of British Columbia that this bounty should be granted and it was granted. In the last two or three years the London price of lead has so increased that it has not been necessary to utilize anything like the amount available for bounty purposes, but since we have had a depression the price has lowered, and the last state of the industry is worse than the first. Unless this bounty is renewed I think I am quite correct in saying it would be impossible that the development which is now going on as a result of this bounty system should continue. I believe that ultimately the lead mining industry will be on an independent footing, if it has sufficient encouragement at the present time. Unless this bounty is granted the development of the lead industry in Canada will cease. I think it is up to the Canadian Mining Institute to accede to this request of our western members. (applause).

MR. EUGENE COSTE:—There is no question but that a great many of our industries, even our mining industries, need some help to promote their development, and this is clearly one of the cases in which an industry does need help. I think our friends from British Columbia are absolutely entitled to this vote for the encouragement of the lead industry.

MR. J. C. MURRAY:—There is a purely provincial matter appertaining to British Columbia that has an indirect bearing on the lead bounties. There recently has been put in force in British Columbia an enactment abolishing coal royalties altogether and imposing a flat tax of 10 cents on coal, and 15 cents a ton on coke. To my mind that creates a somewhat anomalous situation. That tax will inevitably fall upon metallurgical and mining industries and its tendency will be to offset the benefit of the bounty. I think that in this discussion that might be given some attention.

The resolution was put to the meeting and unanimously adopted.

MR. MORTIMER-LAMB:—Now that we have passed this resolution I think it would help these gentlemen who are with us to-day, if a deputation were appointed to wait on the Government in connection with this matter and present the views of the Institute. I suggest that the President should appoint a deputation from the Institute.

MR. EUGENE COSTE:—That is a very good suggestion.

The suggestion of Mr. Lamb was put in the form of a motion and unanimously agreed to.

MR. PRATT:—I wish to extend to the Institute the thanks of the silver lead miners of British Columbia, for this action, and I feel sure that this resolution coming from this national body will be a great help to us in our undertaking. I thank you very much.

MR. EUGENE COSTE:—I think our British Columbia friends may always depend on the help of the members of this Institute for the encouragement of any mining industry in their province.

STATISTICS OF MINING.

MR. J. McLEISH, of the Geological Survey Ottawa, presented to the meeting the preliminary report for the year 1907 on the Mineral Production of Canada.

The statement placed the value of the aggregate production of the year at $86,183,477. The two following tables show the total increases and decreases in value of the more important products:

Product.	Increase	Decrease.
	$	$
Copper	758,170	....
Gold, Yukon	....	2,450,000
Gold, all other	....	780,436
Pig iron, (from Canadian ore)	257,907	....
Lead	....	556,351
Nickel	586,573	....
Silver	2,669,766	....
Other metallic products	137,930	....
Asbestus	444,900	....
Chromite	....	18,958
Coal	4,828,219	....
Corundum	....	27,051
Gypsum	....	824
Natural gas	182,160	....
Petroleum	295,328	....
Portland cement	210,021	....
Other net increases	588,815	....
	10,959,789	3,833,620
Total increase	7,126,169	

It becomes interesting at times to compare the relative importance of the various industries in respect of their total values, and the following table has been compiled to show for the years 1907 and 1906, the position in the scale of importance of a number of mineral products, constituting together about 95 per cent. of the total.

Product.	Quantity.		Value.	
	Increase.	Decrease.	Increase.	Decrease.
	%	%	%	%
Metallic—				
Copper	3.18	....	7.07	....
Gold	....	....	....	28.10
Pig iron (from Canadian ore only)	2.79	....	14.95	....
Pig iron (from both home and imported ore)	8.94	....	16.64	....
Lead	....	12.89	....	18.01
Nickel	....	1.40	6.55	....
Silver	50.47	....	47.17	....
Non-metallic—				
Asbestos and asbestic	10.16	....	21.59	....
Coal	7.66	....	24.47	....
Corundum	....	16.79	....	13.19
Feldspar	....	25.75	....	27.1
Gypsum	13.55	....	....	.13
Natural gas	....	....	31.21	....
Petroleum	38.45	....	38.77	....
Portland cement	11.74	....	6.63	....

"It will be observed that a slight increase is shown in copper output, a decrease in British Columbia being more than offset by an increase in the copper contents of the Sudbury nickel-copper ores. A very large decrease in gold production—over 28 per cent.—practically represents a falling off in every district, with the possible exception of Nova Scotia.

"In pig iron production, a substantial increase is indicated. New furnaces were in operation at Hamilton and Port Arthur. The production of lead was less by about 13 per cent. Nickel shows but little change. The output of silver was over 50 per cent. greater than in 1906, and this despite a falling off in British Columbia, the large increase being entirely due to the shipments from the Cobalt district.

"Amongst the non-metallic products, the asbestos industry shows substantial progress, an increase of 10 per cent. in quantity with higher prices. Coal mining also shows a steady growth in all fields, with higher prices realized. Natural gas and petroleum production also shows large increase, and this is particularly gratifying as indicating that these fields in Ontario have not yet reached the exhaustion point. Portland cement, with incomplete returns, shows an increase of nearly 12 per cent.

Mr. McLeish then addressed the meeting as follows on the subject of

"METHODS OF COLLECTING STATISTICS"

MR. McLEISH:—Although I am down upon your programme for a paper on the "Compilation of Mining Statistics," I must frankly confess I have not prepared a paper on the subject. I have been so busy with the actual labour of compiling statistics, that I have been unable to find sufficient leisure to write upon the subject, which is not only a broad one, but requires careful thought and study.

" I informed your worthy Secretary some time ago, however, that in presenting a Statement of Mineral Production during 1907, I might perhaps be able to say a few words on the subject of collecting and presenting or publishing Mineral Statistics in Canada.

"In this country, as you all know, we have nine separate and distinct Provincial Governments, each of which, with one or two exceptions has entire control of its Mining Lands and Mining Laws and Regulations; while the Federal Government controls the Mining Lands and administers the Mining Laws in the unorganized territories, and, to a limited extent, in the new Provinces of Alberta and Saskatchewan.

"From the Provinces of Nova Scotia, Quebec, Ontario and British Columbia, we have Annual Reports of the Mining Bureaus and these reports include amongst a mass of information concerning the mining industry, annual statistics of production. I think I am probably safe in saying that in no two of these Provinces are the mineral statistics collected and presented in exactly the same way. There is no co-operation between the Provinces for the purpose of presenting the information in a uniform way, nor is there any machinery for bringing about such co-operation.

The Federal Government also through the Department of Mines provides for the collection and publication of Mining Statistics, there is no clearly defined or well-understood co-operation between this branch and any of the Provincial Bureaus.

"The result, gentlemen, is very disconcerting, particularly to the British or foreign student of our Mineral Statistics. When he consults the various reports, he is at a loss to underst and the different results, unless he has a great deal of leisure to thoroughly study and understand the actual meaning of the different statements presented, and as a rule the differing statements are quite explainable by the different methods adopted in collecting and publishing the results. All the provinces do not use the same year, as for instance, in Nova Scotia the year used is the period of twelve months ending with September. In British Columbia, while the year used is ostensibly the Calendar year, the figures of production of metals represent the smelter return *received* during the year. Then again in some cases, the total output whether shipped or not, is included as production, while in other cases only the actual sales or shipments are included as production. Methods of valuation also differ. In Nova Scotia the production is not valued at all. In Ontario the shipping value or the value computed at the selling prices of the products of the mines or works is used. In British Columbia, the average price of the metal for the year in the New York metal market is the basis, with a deduction of from 5 to 10%.

"The Federal Department of Mines uses the average value of the metal for the year without any deductions for metallic ores, and shipping values for non-metallic ores.

"This subject has been brought up many times before, and has, I believe, received much attention at the meetings of the Canadian Mining Institute.

"At the annual meeting of the Institute in 1903, a large committee was appointed to look into the whole question, and although some members of the committee did a great deal of investigation, no practical results have been achieved. At least no report has been made. Nevertheless, I think the subject is worthy of further attention, and I think also that a great deal of assistance could be obtained from the mining men themselves in the solution of the problem.

"It must be somewhat irritating to the mining accountant to have a number of differing schedules of questions "thrown" at him for answer in January, making it necessary perhaps for him to go over his books as many times as he has enquiries, and particularly if he has other important duties to perform for his firm, such as getting out annual statements. I am not surprised that our circular requests for information are not always promptly answered.

"It is not merely the Dominion and Provincial Mines Departments who collect statistics. The Census Bureau, various labour bureaus, the mining journals, the American Iron and Steel Association and perhaps even the Secretary of the Mining Institute, all combine to worry the mineowner. The Government will not even pay bounties without very detailed information as to production.

"A beginning towards the solution of the difficulty might be made by securing, if possible, uniformity in the schedules of questions asked by the different Mining Bureaus and by the Dominion Department, and this uniformity might perhaps be most easily secured by combining all the questions asked by the different bureaus into one schedule. That is to say, obtain as much detail as possible, instead of merely asking output, or sales and shipments, only, ask for both, and stock on hand also if advisable. In this connection I would commend our statistics on cement production. It has been our experience that if we ask for output only, some will make returns showing output, while others will make returns showing shipments and the result will therefore be less correct than if more detailed information is asked.

"Another important question arises as to the desirability or otherwise of making prompt publication of results at the expense of accuracy, this method of publication of course to proceed only and not supercede the publication of complete and final statistics. It is well known that for metallic ores, smelter returns are seldom received until from one to three months after shipment, therefore complete returns cannot be expected until well on in the year following the one covered.

"If a preliminary report, then, is advisable—and I think that it is—could that not best be secured by systematically making two collections of statistics of metallic ores, the first a partial estimate obtained late in December or early in January, and the second a complete report obtained when available?

"In fact, in order to secure statistics of production in the Cobalt district in time for publication on the first of March, we have had to follow this very method.

"There are many other important features connected with the collection and publication of mining statistics that I should like to discuss, but I am afraid I shall have to leave them till some other time."

Mr. GIBSON (Deputy Minister of Mines, Ontario):—"I have a statement here which gives the Mineral production of Ontario for the past year.

"Returns to the Bureau of Mines show that the output of the mines and general works of Ontario for 1907 was as given in the following tables. The aggregate value of the production, based upon the selling price of the products at the place of production, was $24,949,475 being $2,561,092 in excess of the value for 1906. The returns are not absolutely complete, and the figures are therefore subject to revision.

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MINERAL OUTPUT OF ONTARIO, 1907.

Metallic.	Quantity.	Value.
		$
Gold, oz.	3,810	66,399
Silver, oz.	10,005,749	6,155,166
Cobalt, tons	751	104,426
Nickel, tons	10,972	2,271,616
Copper, tons.	7,373	1,045,511
Lead	....	....
Iron ore, tons.	205,295	482,532
Pig iron, tons.	286,216	4,716,857
		14,842,507
Less value Ontario iron ore (120,177 tons) smelted into pig iron		282,702
		14,559,805

Non-Metallic.	Quantity.	Value.
		$
Arsenic, tons	712	2,782
Brick, common, number	73,882	2,108,891
Tile drain, number	15,500,000	648,683
Brick, pressed, number	69,763,423	499,417
Brick, paving, number	3,732,220	73,270
Building and crushed stone	....	675,000
Calcium carbide, tons	2,677	173,763
Cement, Portland, bbls	1,653,692	2,777,478
Cement, Natural Rock, lbs	7,239	5,097
Corundum, tons	2,683	242,608
Feldspar, tons	12,328	30,375
Graphite, tons	2,000	20,000
Gypsum, tons	10,186	19,652
Iron pyrites, tons	15,755	51,842
Lime, bus	650,000	425,000
Mica, tons	456	82,929
Natural gas	....	756,174
Peat, tons	200	1,040
Petroleum, Imp. gallons	27,621,851	1,049,631
Pottery	....	54,585
Quartz, tons	56,585	124,148
Salt, tons	48,735	379,771
Sewer pipe, tons	....	627,588
Talc, tons	1,870	5,010
		10,389,670
Add metallic production		14,559,805
		24,949,475

Mr. Gibson:—As Mr. McLeish has pointed out there is a very decided difference in the method of computation employed as between the Ontario Bureau of Mines and the Dominion Geological Survey. Both of these methods differ in turn from the methods employed in British Columbia, in Nova Scotia and Quebec. I quite agree with the sentiments expressed by Mr. McLeish that there should be a nearer approach to uniformity in the method of presenting the statistics of the various provinces. I am quite ready at any time to co-operate with the Dominion Geological Survey and with the officers of the various Provincial Departments to secure these results. I can conceive of no reason why the Provincial Bureaus should not be quite ready to furnish the Geological Survey with the information that they may receive. I have always been ready and am now ready to assist in securing co-operation to that end. The different methods adopted by the different Provincial Bureaus are productive of different results;

and comparisons based upon these different results are necessarily misleading. For instance in the item of nickel—Ontario being the only nickel producing province in the Dominion—if you look at the results presented by Mr. McLeish for last year and the returns presented by the province of Ontario you will find they agree very nearly as to the quantity of nickel produced, but they differ very materially in the value attached to that item. For instance in the Dominion statistics we find the quantity of nickel produced last year is 21,189,000 pounds or roughly speaking 10,594 tons. The statistics for Ontario give 10,968 tons which corresponds very closely with the quantities as given by Mr. McLeish; but in Mr. McLeish's figures, I do not think he includes the nickel contents of the Cobalt ores which accounts for the difference in figures. But the value that is given in the Dominion statement is $9,535,000, while the value of nickel in our statement of returns is $2,271,000. The explanation of this is that in the preparation of our figures we take what may be regarded as the selling price of the nickel in the form in which it is produced, while the Dominion report adopts the price of the refined metal in the New York market. I think there are reasons to be given for and against both methods of computation; but I conceive that the object of statistics is to present a fair and accurate and honest statement of facts. It does not seem to me that it is quite fair to take the credit for the money and the labour that is expended in a foreign country in refining the metal, seeing that we do not get the benefit of that in Ontario. The actual value to the country, from the public point of view, is that of the nickel in the form in which it leaves the country, and the capital and labour expended in the further treatment of the mattes in England or in the United States should not be credited to Ontario, and it is not strictly accurate to claim the benefit of these in the returns. That difference of principle in calculation leads to a difference of results. The same thing applies to copper, and, more or less, to many of the other items. As one of the leading purposes of statistics is to furnish a basis for comparisons, the results will be necessarily vitiated if the methods of preparing these statistics are discordant. It is a little difficult once a certain system or standard has been adopted to change from that system or standard, because if you do so it is difficult to make a comparison of one year with another. So far as I am concerned, I would be quite willing to meet with the officers of the Dominion Geological Survey, and with the officers of the various Provincial Bureaus, to see if we cannot agree upon some common scheme both of collecting and presenting these statistics with a view of obtaining something like uniformity of results. I have referred to nickel and copper as illustrating the point I am endeavouring to make; I might also mention iron ore and pig iron. The production of iron ore in Ontario last year was 200,000 tons, and the production of pig iron 286,216 tons. Both of these items are included in the Ontario statement of production with their values attached to each. But in arriving at the value of the metallic production we deduct the value of the iron ore which is smelted into pig iron in Ontario so as to avoid duplication of the value of the iron ore. Having included it as iron ore it is not fair to include it again when it is converted into pig iron. The Dominion Statistics treat the matter differently. Only the exports of Canadian ore are reckoned in the table of values, and only the quantity of pig iron produced from Canadian ore. There is probably room for difference of opinion as to what is the proper method to be adopted; but the manufacture of pig iron is a metallurgical industry and whether the ore is of domestic or foreign origin, surely the product of that metallurgical industry should be included in the value of the total metallurgical products of the country. The various non-metallic products are treated by the Dominion Department and by the Ontario Bureau of Mines in a very similar manner and there is not the same difference of results. The value of the crude oil is given in each case so far as the petroleum is concerned. There is some difficulty, as those who have to deal with mineral statistics will acknowledge, in drawing hard and fast lines between raw and finished products, because what is one man's raw material is another man's finished product; and if you are going to reckon the value of the raw material only, when you come to the manufacture of an article such as cement and bricks and products of that class, then you will exclude them altogether; because the raw materials are of very little value, and it is practically the labour expended on them that gives them any value at all. (applause).

Mr. Obalski:—I quite endorse everything that Mr. McLeish and Mr. Gibson have said regarding the advantage of uniformity in collecting statistics. I beg to present the following statistics for the province of Quebec:

SUMMARY STATEMENT OF THE OUTPUT OF THE MINES IN THE PROVINCE OF QUEBEC FOR THE YEAR 1907.

Kind of Minerals. (Tons of 2,000 lbs.)	Wages Paid	Number of Workmen	Quantities Shipped or Used	Gross Value
Bog iron ore	28,974	100	22,681	80,231
Calcined Ochre	20,197	75	2,300	29,430
Raw ochre	....	....	2,700	5,400
Chromic iron	31,801	76	6,407	63,130
Copper ore	103,884	250	29,574	160,455
Asbestos	930,061	2,141	61,833	2,457,919
Asbestic	....	....	29,193	27,293
Mica, trimmed, pounds	....	....	550,247	199,848
Mica, untrimmed	10,600	288	91	24,030
Phosphate	....	....	408	3,410
Graphite	15,000	75	120	5,000
Magnesite	15,000	....	35	....
Slate (square)	15,000	50	4,336	20,056
Flag stones (yards)	1,350	6	3,000	2,550
Cement (barrels)	170,000	350	....	640,000
Granite (cubic yards)	238,761	653	51,873	560,236
Lime (bushel)	33,500	124	556,000	96,000
Bricks	300,000	1,462	94,000,000	525,000
Tiles and pottery	....	....	....	270,000
Limestone (cubic yards)	155,882	515	97,710	223,580
	2,153,010	6,165		5,391,365

MICA AND CHROME

The production of Mica shipped, may be summed up as follows for 1907.

	Lbs.	Value.
1/2 Thumb trimmed	204,276	$30,633.00
1/3 "	139,240	34,891.00
2/3 "	86,003	44,460.00
2/4 "	71,852	49,235.00
3/5 "	24,248	20,090.00
4/6 "	12,597	13,083.00
5/8 "	4,074	5,347.00
Total thumb trimmed	542,290	$197,739.00
Split	7,957	2,109.00
	550,247	199,848.00
Crude mica having undergone a first classification, 150 tons (2,000 lbs. to a ton)		24,330.00
Total value		$223,878.00

The Mica Industry in the Province has employed 275 workmen of which 150 have worked on the mines and the others to the classification. The work has been done during periods of 3 to 12 months and a sum of $100,600 has been paid in salaries.

The production of Chrome for 1907, has been as follows (2,240 lbs. tons.)

	Gross Tons.	Value.
1st Class in lumps	145	$ 1,925.00
2nd Class in lumps	3,536	33,485.00
Concentrated	2,040	27,720.00
Total	5,721	$63,130.00

Corresponding to 6,407 tons of 2,000 lbs.

76 workmen were employed during periods of 4 to 11 months.

ASBESTOS.

The production during the year of 1907, from the different districts of the Province, is as follows:—

	Tons of 2,000 lbs. Tons.	Value.
1st Class (crude)	1,487	$367,438
2nd Class (crude)	2,938	456,073
Fibre	19,905	772,513
Paper stock	37,655	846,145
Total	61,985	2,441,919
Asbestic	29,193	27,293
Total value		$2,469,212

2,081 workmen have been employed, and $915,061 represents wages paid. The principal mines have been operated throughout the year.

MR. OBALSKI (continued):—Our mineral production in Quebec seems to be very low, but if you study the manner in which the statistics are compiled, you will find the explanation. In Ontario they place a value on the pig iron less the value of iron ore and the same way with other metals. We do not do that.

Our returns are relatively small, but if calculations were made on the basis adopted by Ontario we should show a valuation of eight instead of four and a half millions. I quite agree with these gentlemen that it is desirable there should be a uniform method of computing these statistics. I think a committee should be appointed to bring that about, and for my part I would be pleased to give the Federal Government any statistical information I may possess relating to Quebec. I think we should do something towards making our returns comparable; for, at present, they are not comparable. The return from each province should agree with the total shown by the Federal Government for all Canada.

MAJOR LECKIE:—The basis for preparing these returns should be the quantity and not the value. For instance a year ago copper was 25 cents a pound while now it is only half that price, and, when, therefore, you give the returns in values they are misleading. When you speak of a certain amount of nickel being in the ore, whether it is an average of one per cent. or anything else, it is a nuisance; it is of no value; in fact it costs something to get rid of it; it is not to be taken into consideration at all in the way of values. In the case of the nickel in the Cobalt ore it is much the same thing. The separation of the nickel from the copper is rather an expensive metallurgical operation and therefore I think the matter of values is a very indefinite sort of thing. These statistics should be based simply on quantity.

DR. GOODWIN:—This question has been brought up on several occasions and discussed and yet nothing has been done. It seems to me that from the facts stated this morning something should be done and what may be done is for the Institute to memorialize the Minister of Mines to authorize the Geological Survey to arrange for a conference with the Provincial authorities. The initiative would naturally come from the Dominion Department. The Dominion officials could meet with the proper officials of the different provinces and see if they cannot devise some common system of valuing the different mineral products so that the statistics given out by the provinces shall be concordant with the statistics given out by the Dominion. I would therefore be glad to move:

"That the Canadian Mining Institute in annual meeting "assembled would respectfully suggest to the Minister of Mines "that a conference be arranged between the Deputy Minister of "Mines and the Deputy Ministers of the Provincial Bureaus to "devise, if possible, an uniform method of compiling statistics and "valuing mineral products."

Mr. Tyrrell:—I second that motion, and think that some such plan should be adopted as soon as convenient. There should be some definite plan of valuation. If the Dominion government is wrong it should get away from its error as quickly as possible. If the Dominion system is right the provinces should lose no time in adopting it too. It seems to me that the Canadian plan of valuation should approximate as nearly as possible the United States' methods.

Mr. McLeish:—I am pleased to know that Mr. Gibson and Mr. Obalski are willing to lend their assistance towards the securing of more uniform statistics. A willingness and desire for more uniform results on the part of those responsible for the collection of the statistics is a large step forward in securing the desired object. The question, however, is scarcely one of right or wrong methods, as is sometimes argued, but rather one of point of view. In publishing statistics in the Department at Ottawa we have practically adopted the same system as is used in the United States. In Great Britain, however, the system used is more analogous to that used by Mr. Obalski for the Province of Quebec, that is to say, giving in a general table the output of the crude ore, thus with nickel, instead of giving the amount of matte or nickel in the matte, the quantity and value of the ore only would be given, and further detailed information would be given in other parts of the report.

The subject—nickel—selected by Mr. Gibson as an illustration of the different methods of valuation used, is unfortunate and not quite representative, inasmuch as nickel is only produced in one district in Canada, namely Sudbury, including Victoria Mines, and the operations are all of the same class, the ore being roasted and smelted and matte produced and shipped. With copper, however, the material is shipped out in several different forms, in some cases as ore, in others as matte and again as blister copper. If we take the value of the copper in the ore, add that to the value of the copper shipped as blister copper, and then to the copper contained in the matte shipped and state the production as so much copper with such and such value, we have a total valuation which has but little meaning. That is one of the reasons why a uniform system of valuation has been adopted, so that comparisons between various countries and districts might be made. This subject has often been thrashed out before, but there is one point at least upon which I am sure we can all agree, and that is, as Dr. Leckie has stated, that after all quantities are the most important.

If we can secure uniformity in quantity and the method of valuation is distinctly stated, we shall have achieved some progress.

MR. FRALECK:—One thing is clear, the methods are entirely opposed to each other. There can be no compromise, although each method of computation possesses its own merits. I could never understand why we could not have the results given to us by both methods; that is by two columns showing values by different methods of computation with an explanation stating how the results are arrived at. It seems to me the extra clerical work envolved would not be very great.

MR. T. W. GIBSON:—In the report of the Bureau of Mines last year that method was adopted. First a table was given based on the methods heretofore followed, and a second table giving the values of the metals as refined, thereby attempting a comparison on both bases. Tables of that kind serve a useful purpose and there is no difficulty in compiling them.

MR. LEISH:—The difficulty is that with six or seven different provinces it would mean as many tabled columns.

DR. WOODMAN:—Would it be possible for the Committee suggested by Dr. Goodwin to take into account the scope to be covered by the statistics. In Nova Scotia in the '60s and '70s some serious attempts were made to find out the amount and value of all the metallic and non-metallic materials produced in that Province. The custom lately, however, has been to take notice of only such materials as pay a royalty to the Government. The non-metallic minerals, such as gypsum, brick clay, in fact practically everything except coal, iron and gold, were exempt from royalty. In the case of iron especially there arose an anomalous situation due to the fact that a large proportion of the small amount of iron produced in the Province came from districts where the mineral rights went with the land, so that there was no royalty and no sworn reports, and the government did not take the trouble to find out with any accuracy the amount of iron ore produced. This year in the Report of the Mines Department, some effort has been made to return to the old basis, and there has been a partial reorganization of the clerical end of the Mines Department. But this still leaves much to be desired and I would like to see the proposed committee try to persuade the Nova Scotia Government to include in it all its economic mineral products. They are not large outside of coal, and that is all the more reason why we should keep accurate account of what we have. Private protests have done no good, but an inter-provincial committee such as suggested would have a weight because of its character which no local organization could hope for. I think they would get what they want, as it is not so much a matter of expense as of method.

Mr. Willmott:—May I suggest a difficulty which should be provided for. That is that we are mining different grades of iron ores in the various provinces, and therefore a comparison by tonnage is misleading. Would it not be possible to add a column showing the average per cent. of iron in the ore mined? There is, moreover, a tendency to bring on lower grade ores, and it would be interesting to be able to make that comparison later on.

The resolution was then unanimously adopted.

In the absence of the author the Secretary then read a paper by Mr. E. Jacobs, of Victoria, B.C.; entitled, "Mineral Production of British Columbia in 1907."

CHEAP TRANSPORTATION FOR PROSPECTORS.

The following resolution was then moved by Mr. J. B. Tyrrell, seconded by Mr. T. L. Walker: "That the Canadian Mining Institute ask the various railways of Canada to issue tickets to prospectors at reduced rates, similar to the tickets now sold to home-seekers; the records of such tickets to be endorsed on the Miners' Licenses held by such prospectors.

Mr. Tyrrell:—It seems to me that this is a matter which the railways would only require should be brought to their attention to take action thereon. For years they have been issuing tickets at a rate of about a cent a mile to home-seekers with a view to encouraging the settlement of the agricultural sections of western Canada. It seems to me that certainly similar aid should be given to encourage the exploration and development of the mineral areas. I believe if this Institute will place itself on record as recommending the proposal the railway companies would act on the suggestion.

DR. WALKER:—Clearly the railways should be approached in this matter. The prospectors would of course be defined as men holding mining licenses.

The resolution was put to the meeting and unanimously agreed to.

The following papers were then read and discussed:—

PROGRESS WITH THE GRÖNDAL PROCESS OF CONCENTRATION AND BRIQUETTING OF IRON ORES, by P. McN. Bennie, Niagara Falls, N.Y.

A NEW IRON ORE FIELD IN EASTERN CANADA, by J. E. Hardman, Montreal, Quebec.

FRIDAY AFTERNOON SESSION.

The Session opened at 3 o'clock and the following papers were read and discussed:—

MINERALS AND ORES OF NORTHERN CANADA, by J. B. Tyrrell, Toronto.

ORIGIN OF THE SILVER IN JAMES TOWNSHIP, by Dr. A. E. Barlow, Ottawa.

STUDENT PAPERS.

DR. J. BONSALL PORTER announced that a number of students had been present with papers, but had been compelled to return home.

THE SECRETARY:—We had thirteen student papers this year and two more have been sent in, making a total of fifteen, which is the largest number of Student papers ever received by the Institute in any one year.

REMOVAL OF HEADQUARTERS TO OTTAWA.

DR. A. E. BARLOW, of Ottawa, then presented the following resolution in regard to the removal of the headquarters of the Institute from Montreal to Ottawa:

"Resolved that it is in the best interests of the Canadian Mining Institute that its headquarters should be moved from Montreal to Ottawa."

DR. BARLOW:—In explanation of this motion, I would observe that the question of the location of headquarters is determined by Article 5 of the Charter of the Canadian Mining Institute which was adopted by the Parliament of Canada in 1898. This article recites that "the head offices of the Institute shall be in the city of Montreal or in such other place as may from time to time be determined by a vote of two-thirds of the members of the Institute." To obtain such a vote necessitates a referendum, by letter ballot, addressed to all of the members of the Institute. I do not intend this afternoon to go at length into the various reasons which to my mind make such a move highly desirable, but would simply ask this meeting for the necessary authorization to send out a circular letter addressed to all the members of the Institute and thus determine the wish of the majority in regard to this matter. I do not care at this moment to mention the primary object for this removal, but I may be permitted to point out that as all of our printing is done in Ottawa (where it can be done to better advantage and cheaper), the Secretary has been obliged to make frequent and, in some cases, prolonged visits to this city. In addition to this it may be mentioned that of late years we have not only received a very substantial annual grant from the Dominion Government to aid us in our work and publication, but also occasional grants for certain special objects, such as that for which we are at present asking to aid us in entertaining certain representative European mining men whom we have invited to Canada this summer. To secure such very necessary assistance requires very considerable attention and explanation on the part of the Secretary and certain members of the Council. During the discussions at Council in regard to the selection of the place for the present annual meeting, and in answer to my invitation extended on behalf of the Ottawa members of the Institute, one of the main objections raised was as to the adequacy of our hotel accommodation. This was not very serious, as I pointed out that surely men, who in the daily pursuits of their profession were accustomed to "roughing it," could doubtless overlook any disadvantage in this respect if such really existed, in consideration of the many other advantages and attractions offered by the capital. Now, however, gentlemen, that you have experienced the hospitality of the Russell hotel I hope you will go away with a much more favourable impression of the capital's ability to look after visitors. I may repeat, moreover, that there is a deep-rooted conviction amongst many of the members that the Institute, being a national one, should have its headquarters at Ottawa. There are many members in the Mines Department of Ottawa who are brought into very close touch with the mining development of Canada, whilst the presence of the headquarters of the Institute here would be a constant reminder to the Department of the real reason of its existence. Our Secretary at headquarters would then be surrounded by a great number of men with intimate knowledge of the mining development in the several localities covered by their examinations, men who are altogether unbiassed and interested only in the true development of the mining interests of the whole Dominion, and, as a consequence, of the well-being of this Institute. I therefore leave this matter in the hands of this meeting and move that a referendum be agreed upon and submitted at the earliest opportunity to the whole of our membership, the vote to be taken by letter ballot.

This motion was seconded by Mr. Coste, who in speaking thereto said:—"Dr. Barlow has put the matter very clearly and forcibly. In view of the fact that Ottawa is the capital of the country it seems to me impossible to get away from the fact that this city is the natural headquarters for a national institution such as ours.

MR. J. E. HARDMAN:—While acquiescing in the sentiments expressed by Dr. Barlow as to the advantage of having at the same place as the headquarters, a body of educated scientific men with whom the Secretary might frequently consult, I submit that this question like every other has two sides. I think, speaking as one of the oldest members of this Institute, and one who has had a fair share in its past history, that one of the objects of the Canadian Mining Institute is to maintain, so far as is possible, its independence in all matters pertaining to the mining and metallurgical industries of the Dominion. I remind you of this, because it must be considered in connection with the question of the proposed removal of headquarters. Ottawa is the seat of the Dominion Government and by having our headquartess here, the Institute would come, more or less, for good or ill, under the influence of the Department of Mines divided into the branches of Geological Survey and of Mines. I submit that it is a matter worthy of careful consideration whether under these circumstances the Institute could maintain its independence of character.

"In regard to the matter of our annual grant from the Dominion Government, we have heard the Treasurer's report, in which we have, or did have at the end of the fiscal year, a favourable balance of $3,000. We have also heard the report as to the greatly increased membership during the past year or two. I submit, as a critical Institution, which we are entitled to be, our independence apart from these grants is greatly to be desired, and I think we can fairly say that with our rapidly increasing membership, we may hope during the next few years to derive a sufficient income from membership fees to render us independent of Dominion or Provincial grants.

"I mention this to give you thought before the final referendum is made. I have no objection to the referendum, but wish to impress upon you the necessity for consideration before you decide one way or the other. A great many reasons could be adduced, with success I think, why the headquarters of the Institute should remain where they are.

"At Montreal you are in closer touch with the east and west than is the case in respect to any other city in the Dominion. We have a considerable number of members in the Maritime Provinces, and they can reach Montreal more readily than any other city in Central Canada. Those from British Columbia are in as close relation with Montreal as with any other city in Canada.

"There is another feature which in the Institute's earlier years was of importance, and will be again in years to come; namely, that a great many people arriving in Canada from England, France, Germany and other European countries, especially in summer, land directly at Montreal. It seems to me therefore that Montreal, which by your charter is at the present time your headquarters, and must remain so until two-thirds of the members decide that it shall be removed, is geographically a good location for your headquarters.

"Referring again to the desirability of the Institute maintaining its independence, I submit that it is of first importance that we should as far as possible remain free from the suspicion of being influenced by any government or bureau. In the past the Institute has had occasion to offer suggestions to the Dominion Government in matters touching the welfare of the mining industry, and to oppose legislation which appeared to be prejudicial to our interests; and it seems to me we might lose that independence of attitude if our Secretary, Treasurer and prominent officials resided in Ottawa and thus came more directly under government influence.

DR. GOODWIN:—As a very old member of the Institute I sympathize more or less with Mr. Hardman's view touching the independence of the Institute. Yet I think he has exaggerated the danger of a loss of independence by this proposed move. The fact is, our former Secretary lived for many years and transacted his business in Ottawa, and in Mr. B. T. A. Bell's time we had no fear of undue influence biasing him to the disadvantage of any pressure we might desire to bring to bear upon the government. It seems to me that that consideration need not trouble us. The point to consider is whether Ottawa is more advantageously and conveniently situated than Montreal to warrant the proposed change.

DR. PORTER:—There is no doubt that the headquarters should be where the majority of members of the Institute wish. Mr. Hardman, however, has called attention to several matters which should be carefully considered before any decision is arrived at. An additional reason has occurred to me which, together with those advanced by Mr. Hardman, seem to me sufficiently strong to justify us in leaving well enough alone at present. One very desirable feature of the Institute is its national character. In order to preserve this to, perhaps, the greatest possible degree it seems to me we should keep our members, and particularly the members of the Council, interested in the affairs of the Institute. I contend that Montreal as the business centre of the Dominion is more likely to be visited during the course of a year by members of the Institute and Council than any other city. A large number of members of the Council and our most prominent mining men, are managers or directors of mining companies having their headquarters at Montreal, and require to attend their directors' meetings there. In consequence these members representing the large concerns of the

Maritime Provinces and also of the West, visit Montreal in the course of the year, and the Secretary and staff can thus keep in touch with a greater number of the members of Council than if the headquarters were moved to Ottawa. It has been said that as long as the headquarters remained at Montreal a few of us, of whom I am spoken of as one, take an undue part in the affairs of the Institute. Wherever the headquarters may be, certain members will be more active than others, who, living at a distance, can only occasionally attend the meetings. But if the headquarters were removed to Ottawa, I think the result would be that a still smaller average number would attend the meetings of the Council and the society would be more than ever under the control of a few. I believe it would be a mistake to move to Ottawa. Ottawa is very easily reached from Montreal, but is no nearer to Toronto than Montreal, hence just as now the interested members would attend the meetings and *vice versa*. I am, however, prepared to second Dr. Barlow's motion for a referendum. All I ask is that the members have the facts on either side and consider them thoroughly before voting.

MR. GWILLIM:—We, western members of Council, have been under some disability in being obliged to attend meetings in Montreal. If Ottawa were headquarters, the members from both east and west would travel there, and thus counteract any suspicion of local influences. Also Ottawa is not a university town. If the headquarters are in a university town, that university has advantages over the others. As to the contention that more people go to Montreal than to Ottawa I should imagine that Ottawa as the Capital would bring as many men from the wider portions of the Dominion as Montreal. If Westerners go to Montreal it is not to remain long; while if they come to Ottawa they stay here some time and are more likely to attend meetings. Quebec is not so great a mining Province as Ontario which has come into great prominence of late, and the large membership from the latter province should not be obliged to travel to one corner of the country. Obviously Ottawa is the more central.

MR. LEONARD:—I conceive that Montreal is at present the metropolis and business centre of the Dominion. The majority of members of the Institute are business men. They occasionally have business with the government at Ottawa, but for once my business calls me to Ottawa it calls me to Montreal half a dozen times. Montreal certainly would be more central to me although I live at St. Catherines, and I am thus in closer touch with the headquarters at Montreal than if it were at Ottawa. Montreal is also a university city, and although I am not a McGill man I think it a good argument to advance that one college should derive the benefit of the Institute headquarters rather than that this advantage should be denied to all.

"Then again a number of the members of the Institute are members of the Canadian Society of Civil Engineers. I for one am. I may say my own experience is that mining and civil engineering go very closely together, and should continue to do so more and more. I advocate an affiliation of some sort between this Institute and the Canadian Society of Civil Engineers, with a view to the joint publication of transactions. During the past few years the head offices of the Institute have been in the Civil Engineers' building, and this has been a great advantage to me when visiting Montreal. This may not benefit many others, but I think it is a point that should be remembered."

COL. HAY:—If this matter had come up yesterday I should have voted to remove to Ottawa. But last night all differences that would have influenced me in that direction were sunk, never, I hope, to be raised again, and under these circumstances I do not think there is any comparison as between Montreal and Ottawa for headquarters. For one thing Montreal has good hotels and the accommodation in this town is not to be compared with that of Montreal. But apart from that, business men only require to travel where business calls them, and the headquarters of this Institute would be in that respect much more convenient to me in Montreal than in Ottawa. I think we are all now assured that the Montreal members have no selfish reason for desiring the headquarters to remain there, and we owe a deep debt of gratitute to those Montreal gentlemen who have devoted so much of their time to the work of the Institute. We cannot therefore do better than allow the headquarters to remain in that city.

THE SECRETARY:—It was remarked yesterday that a vote by letter ballot was unsatisfactory, since many members not present at the meeting at which the subject to be voted upon was discussed, refrained from exercising their franchise, for the reason that they failed to thoroughly understand the matter at issue. I suggest, therefore, that a committee be appointed in connection with this matter, to include the mover and seconder and such other members as hold strong views one way or the other, and that they prepare a statement giving the pros and cons of the case for the consideration of the membership at large. If you submit a referendum without affording this information you will probably only get replies from those who know already how they intend to vote.

Dr. Porter:—Mr. Leonard spoke of a matter to which I should also like to refer, that is the possibility of a closer relationship between this society and the Civil Engineers' Society at Montreal. The possible rivalries and disagreements between the two societies are now matters of ancient history. It has been the hope of many of us, including a considerable minority of the Institute council, that the two societies should arrive at some working arrangement in regard to the publication of their reports, etc. Last year a report was presented to the effect that it would be possible without increasing the fees of either society to arrange for a common distribution of the transactions. This would be mutually helpful. It could be done by pooling the editorial work. If the headquarters were removed from Montreal to Ottawa any effort in this direction would be out of the question. We hope before long to be able to submit a proposal to this end and for that reason I should like to see matters left as they are. It is a world wide custom to have the headquarters of all learned societies at the national metropolis, and we cannot get away from the fact that Montreal is the metropolis of Canada.

Mr. Coste:—The first point raised by Mr. Hardman that if the Secretary and Treasurer were to reside at Ottawa, they would come under governmental influence is not well taken, especially now that we have decided that in future these officers shall be appointed by the Council, which is the supreme directing body; and we can trust the members of the Council to preserve their independence of view.

It has also been suggested that Council meetings shall be held at places other than the headquarters. But that cannot be done without changing the by-laws. Meanwhile it is hardly fair to compel members of the Council who live away from Montreal to go so far to attend the meetings. It means that Toronto members for example must each spend $30 or $40 on each occasion, besides the loss cf their time. The directing body must meet at headquarters, and these should be at the most convenient point to all concerned. From that criterion we find that the Council meetings at Montreal have not been well attended. Members from the east scarcely ever attend, and it has been very difficult at times to secure a quorum. A majority of us believe that Ottawa would be more convenient, while, too, Ottawa would be neutral ground.

Dr. BARLOW:—In regard to what Mr. Hardman said in reference to a possible danger to our independence of action by the removal of headquarters to Ottawa, he is well aware that the late Secretary lived here a great many years, and he was not accused of being influenced. While the Hon. Mr. Templeman emphasized that he gave us this aid as a body, he has never even hinted that he desired to interfere with our independence, but tendered it because he knew we would use the grant to advance the mining interests of the Dominion. As to the attendance of members from the east, I have heard that argument used so often in favour of Montreal, when any change has been mooted, that I am tired of it. If these eastern men attend the Council meetings occasionally, it has been so occasionally that I have not appreciated the fact. We want to get away from these sectional jealousies as far as possible, and it would be in the best interests to move to Ottawa, for here you would have "Peace, perfect Peace." (Laughter.)

The motion to take a referendum vote on the question of transferring the headquarters to Ottawa was then adopted unanimmously.

DR. BARLOW:—I strongly approve of the Secretary's suggestion to appoint a joint committee to place the question in a fair light, and on both points of view before the whole membership.

THE PRESIDENT:—That may be very properly left to the Council as a whole, and I think the case will be fairly set forth.

NOTES ON MINING LAWS.

Dr. W. G. Miller, in introducing the discussion on this subject, said that he desired to lay stress on certain basic principles, which are important to the mining industry in all parts of the Dominion. He did not wish to discuss points in connection with mining laws, which are of interest only in individual provinces or districts. Mining men may differ in details on mining laws, but he believed it would be found that they were agreed on the broad principles on which the laws governing the industry should be based.

Dr. Miller said that there was a tendency, in Eastern Canada especially, to deal with mining lands and mining rights on the same basis as agricultural rights, but he held that agriculture and mining should be considered to be two distinct industries. Mineral rights should be dealt with in such a way as to encourage mining as much as possible. If one man will not work a mineral deposit, another should be given a chance to do so, and no one should be allowed to tie up mineral properties indefinitely.

The best way to keep the titles of mineral lands clear is by having an annual acreage tax. Certain men in some parts of the Dominion now hold mineral rights of hundreds or even thousands of acres of land. The owner of the surface rights, in many cases, pays the taxes, while the owner of the mineral rights may hold them indefinitely, without working them, which tends to discourage the industry.

Dr. Barlow:—In Ontario the fact that a certain party has applied for a working permit is made known to the public by a notice posted at the Recorder's office. You are not granted the permit for 60 days, during which time anyone has a right to prospect on the territory applied for and if he makes a discovery during this time which can be passed by the Inspector, he secures the location, even although you have been working zealously and intelligently to make such discovery. I do not think that this is a good system, because a competent man who is generally well known as such, advertises the fact that he considers the area in question a promising one and many men are watching and waiting for just such information which they hope to be able to turn to advantage. I do not think such publicity should be given to the granting of these permits. It is this fact that prevents many from applying for what seems at best a very doubtful advantage.

Mr. Gwillim:—The working permit seems to be somewhat misunderstood. The provision is made for a working permit chiefly for lands on which a discovery cannot be made without a great deal of work. The sixty day interval prevents the blanketing of lands before they have been prospected in the ordinary way.

The man who has the working permit has at least as good a chance to make a discovery within the sixty days as has any one else. It is taken advantage of in that district at any rate.

MR. TYRRELL:—The greatest difficulties that we have to contend with are the complexities of the present mining law in Ontario, and the great uncertainty of the interpretations that will be given to it by the judges and lawyers. Until each section is so interpreted everything is hazy and indefinite, and by the time they are so interpreted the miners will have less chance of understanding it than they have at present. It will probably be too complex to be understood by any one. At present the only safe man is the man who keeps close to the officials who interpret the law.

For instance the law would appear to make the discovery of valuable mineral the very first requisite to the acquisition of a mining claim, and consequently a claim that is staked without actual discovery of some sort is not validly staked at all. But in the case of *Cashman vs. The Cobalt and James Mines* it was held that any claim which has been staked, whether a discovery has been made or not, remains closed to others until it is thrown open to staking by the Mining Recorder, whether the claim is within an inspection area or not. Another man may dispute the right of the first staker, as provided by the Act, but he gets no advantage from this. The claim may be thrown open for staking; and he may join in the stampede to restake it, but that is all. He cannot hold any discovery that he may have made on the claim thus fraudulently held by the first staker, and of course he will not waste his time disputing claims that he cannot obtain except by collusion with officials.

Secondly I favour the final disposal of ground to a miner after he has done a certain amount of work. Men cannot interest capital in mining enterprises unless they are given a good title to the ground on which they are working, so that it is very essential, as a final condition of the mining laws, that an absolute patent should be given to the ground. The leases that were given by the Dominion government for mining areas in the Yukon Territory did enormous injury by almost entirely preventing the introduction of capital to install large works. But a patent is only necessary where large mining enterprises are undertaken, or where a considerable amount of money has been, and is being spent on the mine. Therefore before a patent is issued it is only reasonable that a considerable amount of money should have been expended in development.

Poor people working mines should be allowed to hold them on leases at a small rental and to work them from year to year without being required to take out a patent unless they wish to do so.

Thirdly, as far as staking and holding property are concerned, I am strongly in favour of this first condition—and it seems to me that it is a condition that appeals to every mining man who is attempting to develop a claim—namely, that as long as a man is definitely at work on his claim he should be allowed to hold it, and that no inspector or anybody else should be able to go on the property and say to the locator "You have no discovery and you must get off." If a man has faith enough in a mineral location to spend his time and money in its development, that should be sufficient evidence of his *bona fide* intentions. It is entirely contrary to all ideas of a rational mining policy having in view the development of a new country, for the Government to demand a statement of discovery as long as a man is living on the ground and working it. When the locator has made a discovery he can report that fact to the government and, if necessary, an inspector may be sent to verify it. Then such holding conditions as are proper may be imposed. But so long as a man is working his ground and developing it, he should not be turned off it, whether his discovery is real or imaginary.

What I may think to be a discovery, nine out of ten men may consider is not one; and we know perfectly well that some of the greatest mineral discoveries were made by enthusiasts whose efforts were originally ridiculed. It is therefore a good policy to encourage and not discourage the enthusiast. Let him go on and work the ground and discover minerals if he can. His work will, in the long run, redound to the benefit of the whole community.

MR. WILLMOTT:—I agree with Dr. Miller in advocating the keeping of the surface and the mineral rights separate, and I think the Ontario Government is making a mistake in transferring the mineral rights with the land to the farmers.

Also I agree with the idea of the increased land tax, which will tend to stop the tying up of large blocks. But I do not agree with the provision requiring discovery. I always disagreed with that, and think my opinion is being justified by the way in which that provision of the law is being dropped. It was originally "discovery" over the whole province, but this was never enforced except near Cobalt, and it is now being withdrawn there. In that connection I have further to criticize the present Ontario law, which is so largely a matter of "orders in council" that it is impossible for the ordinary man to keep in touch with it or know at any given time just what is the state of the law.

For example I was lately in Cobalt, and was surprised to find that inspection was no longer required there. I do not take the Ontario *Gazette*, and do not suppose many prospectors do; but unless you take the *Gazette* you cannot keep in touch with what the government is doing. The recorder's office was the only place where I could learn that inspection was now being applied only to the Montreal river division and to a portion of the Coleman division. The system is far too complicated. We have altogether too many legal difficulties to overcome in securing titles to our properties and the law should be so simple that all can understand it.

I take the position that when a man goes on to a property, if he is the first comer it should be his as long as he works it. It is commonly remarked by investors that our titles are bad, and that the difficulty of securing title is so great that people will not invest in Ontario mines. That is a very serious charge. It may be difficult to substantiate it but that is the belief. It is absolutely necessary that titles should be beyond suspicion and that any man with a legitimate claim to a property should be able to get it without a lawsuit. As matters stand to-day if you buy a valuable property you buy a lawsuit with it.

MR. J. M. CLARK:—The remarks of Mr. Tyrrell call for certain comment. He suggested that the courts created the difficulties by their interpretation of the mining law. That is not the case. The judges, of course, gave decisions in conformity with the Act and of its provisions as applied to inspection. The whole difficulty arose from introducing an utterly wrong and indefensible principle into the mining laws of Ontario, and this was done by the Legislature. The judge had no option but to carry out the statute and interpret it as best he could. But when a mischievous principle is introduced into a law, as the principle of inspection necessarily is, the mischief has much more far reaching consequences than can possibly be anticipated when the law is introduced, and I think that is the history of the whole matter. Recently, I met a gentleman from Mexico who said he had read the Act six times over in an effort to find out what our Ontario mining law really was, and after each study he came to the conclusion that he could not tell where he was at. The difficulty is not with the judges but with the defective law, which is so uncertain that it is difficult for anyone to interpret what it means. That difficulty would be eliminated if the act were made to enunciate only sound principles of mining law, set out in understandable language. This I am sure could be done.

These difficulties will always occur in Ontario until you have a definite, clear and certain law. You can have no certainty of title if the law can be changed from day to day by order in council. Therefore if you would avoid these difficulties you must talk not to judges and lawyers, but to the Legislature in order to secure a mining law, which is intelligible and understandable to the lay miner.

MAJOR LECKIE:—It is not only necessary to have the rights of the miner clearly defined and separated from those of the agriculturist, but also, in Ontario, from those of the lessee of the timber limits. We have great trouble with these men who hold leases of the timber. Another thing, it should be clearly understood that once the government grants a lease or patent under certain conditions that these conditions shall not be changed either by order in council or by the Legislature. Our rights should be clearly defined and unchangeable, otherwise it will be impossible to interest capital in the development of our mines. The mining industry is risky enough in itself without incurring the worry of a lawsuit.

MR. COSTE:—I fully endorse Mr. Willmott's remarks. Our worst troubles are undoubtedly the uncertainties of the law, accentuated by orders in council. But Major Leckie to my mind goes rather too far when he says that title should be unalterable, even by the Legislature. That is an impossibility, since the Legislature has always power to amend the law.

Major Leckie:—When we receive a deed from the Crown it should be couched in clear and distinct terms and should be inviolable. If I secure such a title, it should not be within the power of even Parliament to take it from me.

Dr. Miller:—In presenting this matter I did not intend to go into details but to enunciate broad principles which might apply to the various provinces and to the Dominion. It has been argued that when a man stakes out a piece of ground he should be allowed to hold it as long as he works there. But the answer to that is that the miners at Cobalt in the early days asked for inspection. The later arrivals felt that the whole of the promising area had been blanketed. They complained that there had been blanketing, and asked the government to insist upon discovery. They feared that without this, large corporations might hire men for the purpose of holding vacant ground and thus blanket the whole country.

Major Leckie has also referred to the fact that patents should not be cancelled. That seems to me pretty strong, as under such circumstances, the Crown would not have the power to cancel patents granted in cases when fraudulent representation could be proved.

Mr. Fox:—We had that argument with the Ontario Department, and our answer was that if the mining officer took the same care before the title was issued as he did afterwards there would be no chance of fraud. Once then a title is issued it should be always inviolable. As long as this uncertainty prevails it will be difficult to interest capital in the Province.

Col. Hay:—With regard to inspection, the Government was simply misled by the demands of a howling mob at Cobalt in the summer of 1905, who found that the most desirable lots had been taken up by earlier arrivals. The result of the Inspection Law was that men, while working on what they thought were their own locations by priority of discovery, found stakes were being planted all over their properties, and every stake meant a lawsuit. I always opposed inspection as long as working conditions were complied with, and am glad to hear that it is being done away with in the township of Coleman. If a miner applies for ground that has not already been taken up, it should be his subject to reasonable conditions of work.

Dr. Miller:—The government must consider the prospector as well as the capitalist. It has been said that men who ask for inspection in Cobalt were only the late arrivals. But the chairman of the meeting referred to was Marty Wright, who made the second important discovery iu 1904, and a number os the "old timers" were also present.

COL. HAY:—Marty Wright accompanied me on a deputation to Toronto to oppose that same inspection.

The following resolution was then moved by Mr. A. B. Willmott and seconded by Mr. J. M. Clark:—

WHEREAS, in view of the increasing importance of mines and mineral lands subject to the jurisdiction of the Dominion Parliament, be it therefore resolved, that the Canadian Mining Institute in annual meeting assembled, do hereby memorialize the Dominion Government to appoint a Royal Commission to secure evidence concerning the requirements of the mining industry in this regard and to draft mining laws to be submitted for the consideration of the Dominion Government.

"AND as an argument in support of the appointment of such a Royal Commission, it be urged, that when a statute to be enacted by the Dominion Parliament declares with clearness, conciseness and certainty the laws relating to mines and mining under Federal control, such a statute would, as far as local conditions permit, be followed by the various Provincial Governments, thus, ensuring as far as practicable, a uniform system of mining laws throughout the whole Dominion."

MR. CLARK:—In seconding that resolution I wish to emphasize the necessity of making the mining law clear, concise and certain. If we had such law a great many of the difficulties we now have to face would be eliminated.

MR. COSTE:—This resolution now before the Institute is a most important one. Our worst troubles are undoubtedly the uncertainties of the mining law, complicated by the practice of passing Orders in Council. By this practice the law as it stands is not stable, since at any time entirely new regulations may come into force by Orders of Council. Especially is this the case in respect to Dominion lands at the present time. The Dominion lands in Saskatchewan, Alberta, Manitoba and the Yukon have always been governed, so far as mining is concerned, by departmental regulations approved by Order in Council, and sometimes not even by that, but simply by regulations of the Minister of the Interior without the sanction of the Council. I had a personal experience of such a case in connection with the development of oil prospects in the North-West. That system is totally wrong. We are supposed to be a democracy under parliamentary government, but in all mining affairs we are absolutely in the hands of the Governor-in-Council, or of the Minister of the Interior independent of the Conucil. For instance, when we made application for these petroleum lands, we were told we were the first applicants and having made the necessary deposit, were entitled to the property; but should get the homesteader to sign a lease under the form prescribed by the Department, which lease stipulates that a royalty should be paid to the homesteader, while the Order in Council states that the royalty is payable to the government. We refused to pay this double royalty, and as a result the development of that property has been delayed during the past nine months. If the request in this memorial is accepted by the Dominion Government and the Hon. the Minister of Mines, is, I understand favourable thereto, all these points may be settled and a proper mining law passed. It would then be possible to carry on operations under reasonably favourable conditions in respect to title.

The resolution was adopted unanimously.

The following paper was then read: "THE MOOSE MOUNTAIN IRON ORE DEPOSIT," by N. E. Leech, Sudbury, Ont.

ELECTION OF OFFICERS.

MR. HOBART, on behalf of the scrutineers, then presented their report on the ballots for the election of officers. He stated that 316 ballots had been cast, by far the largest number in the history of the Institute. Of these 24 had been rejected for various causes.

The election resulted as follows:—

President—Dr. Willet G. Miller, Toronto, Ont.

Vice-Presidents—

Mr. W. Fleet Robertson, Victoria, B.C.

Mr. Geo. E. Drummond, Montreal, Que.

Secretary—Mr. H. Mortimer-Lamb, Montreal, Que.

Treasurer—Mr. J. Stevenson Brown, Montreal, Que.

Council—

Mr. Charles Fergie, Glace Bay, N.S.

Mr. J. E. Hardman, Montreal, Que.

Mr. R. H. Stewart, Rossland, B.C.
Mr. Arthur A. Cole, Cobalt, Ont.
Mr. Wm. M. Brewer, Victoria, B.C.
Mr. A. J. McNab, Trail, B.C.
Mr. J. B. Tyrrell, Toronto, Ont.
Mr. H. A. Drury, Montreal, Que.
Mr. R. T. Hopper, Montreal, Que.
Mr. O. B. Smith, Phœnix, B.C.
Mr. R. W. Robb, Amherst, N.S.
Mr. F. C. Parsons, Londonderry, N.S.

After a hearty vote of thanks had been accorded the scrutineers, the President, Mr. Keffer, invited the president-elect, Dr. Miller, to address the meeting.

DR. MILLER:—Gentlemen, I wish to sincerely thank the members of the Institute for this honour. All I can say is that I shall try to do everything in my power to promote the welfare of this Institute and of the mining industries of the Dominion during my term of office. (Applause.)

MR. COSTE:—I would remind the assembly that according to our constitution we must now proceed to the election of another vice-president to fill the vacancy created by Dr. Miller's election. I have therefore much pleasure in proposing the name of Dr. Barlow.

This was seconded by Mr. Hedley and carried unanimously.

THE SECRETARY:—Before we adjourn I think that a very hearty vote of thanks is due to the local committee to whose efforts we may largely attribute the success of this meeting. The chairman of that committee, our friend Dr. Barlow, has been most assiduous, and we owe him in particular an expression of grateful acknowledgement.

The vote of thanks was carried unanimously and the proceedings then terminated amid cheers for the retiring president, Mr. Keffer.

ANNUAL DINNER.

The Annual Banquet of the Institute was held in the large dining-room of the Russell Hotel, at 8 p.m., on Friday evening, and proved to be a most enjoyable affair. Among the guests of the evening were the Hon. William Templeman, Minister of Mines, Mr. T. Luginmara, Japanese Consul General, the Hon. Senator Bostock, Mr. Duncan Ross, M.P., Mr. A. C. Boyce, M.P., Mr. Cockshutt, M.P., Mr. McDonald, M.P., Dr. J. Bonar, Deputy Master of the Royal Mint; Dr. R. M. Coulter, Deputy Postmaster General; Dr. Eugene Haanel, Director of the Mines Branch, Federal Department of Mines; and Mr. R. W. Brock, Acting Director of the Geological Survey. Letters of regret at inability to attend were received from the Premier, Sir Wilfrid Laurier, the Hon. Mr. Pugsley, the Hon. Clifford Sifton and others to whom invitations had been issued.

Covers were laid for a hundred and twenty, and an excellent menu was provided. The retiring President, Mr. Keffer, presided, and had on his right the Hon. the Minister of Mines, and on his left, the President-elect, Dr. Miller. Col. A. M. Hay, of Toronto, acted as toast-master.

The formal toasts of "The King" and the "President of the United States" having been received with musical honours, the toast-master proposed the toast of the "Dominion and Provincial Governments."

THE HON. WILLIAM TEMPLEMAN upon rising to respond to the toast was received with loud cheers. He said:—

"On behalf of the numerous governments you have just toasted so heartily I beg to return their several and collective thanks. But for a few minutes, I would prefer to speak to you of the great mining industry whose interests you have so much at heart, rather than of these governments and of their merits.

"I notice on the back of your menu cards a ladder dating from 1877 to 1907 showing the growth of the mineral output of Canada. As I remember it 20 years ago there was little, if any, successful quartz mining in Canada. Perhaps I am putting the date too recently, but 25 years ago British Columbia, from which province I come, had no quartz mining at all, and the entire mineral industry of our province has developed since that time. When I resided in Ontario some thirty years ago, we had then a few small lode mines in operation, but they were relatively unimportant.

"Your statistics show that in 1877 Canada produced minerals to the value of approximately $11,000,000. In 1897 you produced $28,000,000, while last year your products amounted to no less than $87,000,000. Thus the ratio of increase during the past decade as compared with previous years is very great indeed, and there is every reason to believe that during the next ten years this ratio will be still greater; and with the improvement in transportation facilities, you should ere long be making an annual production not far short of $250,000,000.

"A few years ago we boasted that British Columbia was the foremost mining province of the Dominion, but I am now told that Ontario is leading British Columbia by four or five million dollars, in consequence of the development of the rich Cobalt mines. We, in British Columbia, are glad to see this development in Ontario, but we intend to run her a close race, knowing as we do the great mineral resources of our own province.

"It is 34 years ago since I left Ontario for British Columbia, and up to 20 years ago there was no quartz mining there. Last year from quartz mining alone, British Columbia's production represented $17,000,000 or $18,000,000.

"Seventeen years ago there was not a smelter in British Columbia. To-day, we are the smelting province of Canada, with eight large smelters handling millions of tons of ore every year.

"Again in the east, in Nova Scotia and Quebec, there is great mining activity, and it is most gratifying to know that in Canada we have so vast an area of mineral bearing country, which should in a few years make the Dominion one of the world's great mining countries.

"I recently read that in the United States the economic value of the various minerals produced amounted to no less than $2,000,000,000 a year. We have as great and probably as rich an area in Canada, and the time should not be so far distant when our mineral production will equal that of the United States. There is no industry the government can better afford to assist by the establishment of a special department and by the aid that such a special department can give, than the mining industry of this country. There is nothing the government can do of greater benefit to the country than to encourage the development of our mineral resources. (Loud applause).

"The Department of Mines is still young. It was only organized a year ago. We do not claim that our organization is yet complete, but we hope to branch out, and by additions to the staff and by extending our investigations, to render a valuable service to the mining interests of the country. Already I think you will admit, the Mining Department has been of considerable service. (Applause). It was constituted for the benefit of the mining industry, just as the agricultural department was for the benefit of farming, and in my opinion great things will be accomplished by it in the years to come. As to the Minister of Mines I can promise you, that in so far as he has it in his power, he intends to do everything that seems advisable for the permanent benefit of this great industry. (Loud applause).

HON. MR. BOSTOCK, of Ducks, B.C., in responding for the Senate, applauded the action of the government in constituting the Department of Mines.

MR. DUNCAN ROSS, M.P. for Yale-Cariboo, B.C., responding for the House of Commons, said: As a representative of a mining district I am very glad of this opportunity to meet the representatives of the mining industry of the Dominion. I represent a district which has possibly the biggest smelter on this continent, grinding out 3,500 tons of ore a day; and coming from such a country I naturally feel at home with you. I regret that the exigencies of political life prevented my attending all your meetings, but I was with you this afternoon to hear Prof. Miller, of Toronto, telling you something about what perfect mining laws ought to be. The thought occurred to me at that time that the mining men were the real pioneers, the path finders of any new country. You can not show me a section of Canada or the United States that was not originally discovered by the prospector, with his pack on his back, who went out and found things. Then later came the fruit growers, the agriculturists, and lastly the professional men who live on the farmers and mining men. (Laughter).

"The thought occurred to me that the fundamental principle in mining is that the man who discovers things should have what he discovers. (Applause). And I am bound to say, that the most perfect mining laws in the world are those of British Columbia, where they allow a man to plant his stakes and get possession of what he stakes out. In the older settled portions of this country every man has an indefeasible right to the title of his property and you cannot disturb it. With regard to the unsettled lands the policy I believe in is to encourage men to go there and find things, and give them what they discover so they can hold it against all comers.

"That is our British Columbia practice. We allow a man to plant his stakes, but fine him for holding it against everybody else by saying he must do assessment work or pay $100 a year. And after he gets the crown grant he must pay so much a year for holding the land against everybody else. That is the true basic principle which should prevail in every country and province in respect of its mining laws. Further I think that principle should obtain in respect of coal and timber. In the Mackenzie basin we have some of the most valuable timber properties in the world as well as some of the richest mineral areas in Canada. It is all owned by the Dominion Government, and I would encourage people to go into this unknown land and discover things by giving them everything they find. We shall not give breadth as well as length to Canada by figuring our wealth in undeveloped resources. Our strength is in the people who exploit things, and I would give them every opportunity to do that." (Applause).

MR. COCKSHUTT, M.P. for Brant, the next speaker, strongly endorsed Mr. Ross' argument that the prospector should be entitled to his discoveries. Although not a mining man he considered that there must be money in mining because he had put a good deal into it and could not get it out. (Laughter).

Referring to the Ontario mining laws the speaker said:—"I do not like the idea of putting a royalty upon the output of the mines. (Loud Applause.) I think that when men have set their ingenuity to work and have gone over the face of the earth staking out claims that may or may not be good, and that when finally they strike one that is good, it is not fair for the government to step in and demand ten or twenty per cent. in royalties. Although I am a strong supporter of the Whitney government I do not think this taxation of the output of the mines is a fair proposition. (Loud Applause.) The business is risky enough in any case, and to my thinking any man who has the snap to put his time, energy, ingenuity and money in it is entitled to all he can get."

MR. EDWIN HARKIN then sang "The Trumpeter" in excellent style.

MR. MCDONALD, M. P. of Pictou, Nova Scotia, responding for that province, said:—

"We have heard a good deal about British Columbia, but I represent a province which leads them all so far as mining is concerned. Not only have we lead, copper, zinc and gold, but we have what none of the other provinces have, we have iron and coal. In fact I was one of the counsel in the coal and steel dispute, and perhaps that is why I am so strong for the mining industry. (Laughter.)

"I come from the province which is the parent of the Canadian mining industry, and my own constituency of Pictou saw the first coal dug, and there also the first railway on this continent was built. Since then Nova Scotia has maintained her position as the leading coal mining province of the Dominion. We do not make so much out of our gold mines, which are low grade ores, and we find ourselves unable to float such huge companies as British Columbia has done, and that is one thing I hope British Columbia will teach us—how to earn an honest dollar by capitalizing a hole in the ground. (Laughter.)

"There are millions of miles of undiscovered mineral lands in our great northland, and the young men I see here to-night will not merely reap a personal reward from their devotion to their profession, but will render a much nobler service to Canada in increasing her wealth and power. I recognize in you, men who are doing that for Canada in your own profession which none else can do, and we look to you to develop and people Canada so that in the years to come she may take that place in the mineral world which awaits her in every other industrial direction. (Applause.)

MR. OBALSKI, superintend of mines, Quebec, briefly responded on behalf of Hon. Charles Devlin, Minister of Mines of that Province.

On rising to respond for Ontario, Dr. Miller, was received with loud and prolonged applause.

He said:—"I may say on behalf of the Legislature of Ontario that I am sure its members appreciate very highly the work of the Canadian Mining Institute, and recognizes its educational value, and we may look to assistance from the Ontario Government.

"As a member of the Institute I desire to add, and in this I think I voice your views, that we appreciate very highly the interest taken by Hon. Mr. Templeman, in the mining industry. We all consider him our very good friend, and one of the first appointments he has made, that of Mr. Brock, as Acting Director of the Survey, met very strongly with our approval.

"So far as the Ontario Legislature is concerned I believe I am safe in asserting that it may be depended on to encourage the Institute and its work at all times." (Applause.)

The toast of "The Mining Industry" was then proposed and enthusiastically received, all joining in the chorus of the time honoured anthem, "Drill, Ye Terriers, Drill."

MR. EUGENE HAANEL, Director of the Mines Branch responding to the toast, said:—It is very important that we should secure capital for the development of our mineral resources. This can be done in part by publishing monographs dealing with the important economic minerals of Canada, from the mining, engineering and investor's standpoint. This work has been commenced, and we have issued several such monographs upon mica, asbestos, graphite, etc., and another is ready for press on the chrome iron ores. The difficulty we experience in the Department is in securing experts to write these monographs, since industrial pressure is so great that the best men are not available for the Government service.

Our provinces labour under somewhat peculiar difficulties. When I first came to assume the duties of the Superintendent of Mines, my attention was arrested by the large amount of iron in the crude and manufactured state imported into Canada. Iron is the foundation of all industry, and a country which has to import its iron, either in the raw or manufactured state, is severely handicapped. In the middle provinces we have the iron ore deposits, but no metallurgical fuel, and it occurred to me that some other process than the blast furnace process might be made available for the extraction of the metal from the ores. The central provinces are richly endowed in the possession of numerous water powers, which might be made available for conversion into heat for smelting operations.

To gain all needed information as to what had been done in this direction in Europe, the Government appointed a Commission to investigate the subject. Since the publication of the report of this commission, some 17 electric steel furnaces have been set up in Europe, and on account of the economic success of the electric process in producing an excellent quality of steel it is gradually displacing the crucible process.

Regarding production of pig-iron by the electric process, it may be stated that the experiments at Sault Ste. Marie, conducted under Government auspices, have established the metallurgy of the process and the further important discovery has been made, that by the electro-thermic process, sulphur up to two and more per cent. may be eliminated without making a basic slag, a fact which will make many ore deposits which cannot be handled by blast furnaces commercially available. The furnace employed in the experiments at Sault Ste. Marie was provided with a central electrode, which prevented the mechanical charging of the furnace and permitted the escape, without utilization, of the carbon monoxide resulting from the chemical action within the furnace. What is now needed, is the invention of a commercial furnace, permitting the use of labour-saving machinery and the utilization of the carbon monoxide evolved. Improvement in these directions is now being prosecuted at Welland, Ontario, where an experimental electric furnace has been set up by the Electro-Metals Company.

The experiments made at Sault Ste. Marie have been watched with intense interest by the Swedish iron masters, and no sooner had our report been issued than 200,000 kronor were subscribed by the iron masters for further experiments in Sweden to solve the problem presented in the construction of an economical, commercial electric furnace.

The next important and very grave question for the central provinces is the securing of an adequate supply of fuel. Although we have no coal in these provinces, they are, however, richly provided with extensive peat bogs. The utilization of this low grade fuel has been recognized as an important problem and much money has been spent in this country in experimentation to render peat a marketable fuel. Many of the failures are due to the fact that this experimentation has been undertaken without a proper knowledge of what has already been done in this direction in countries which have employed peat as a fuel for many years. To furnish this necessary information, an expert was sent by the Department to Europe to examine into the peat and lignite industry and report upon the same. This report will soon be ready for distribution.

During the summer, the Department has undertaken in the interest of the peat industry the investigation of the various accessible peat bogs, and reports will be issued of their extent, depth, best method of draining, quality of peat therein contained, and the best methods adapted to their exploitation. When this has been done, one of the most rational methods of utilizing our peat bogs will consist in setting up gas producers for power purposes upon the peat bogs and utilizing the energy in a similar manner as that furnished by water powers.

The solution of these two problems for the middle provinces, that of the iron industry and the utilization of peat, will render us independent to a great extent of outside sources for these two necessities.

As regards the future prospects of the mineral industry of Canada, we have every reason for optimism. In the exploitation of the resources of the country to the south of us it is now recognized that it has been extravagant and accompanied by waste, and a note of warning is being sounded throughout the country by an intelligent press. The time will come, and is regarded to be not far distant, when their ore deposits will be worked out, and they will look with longing eyes to Canada with its magnificent resources for the supply of that necessary metal, iron, without which modern civilization cannot be maintained. I hope the lesson thus taught us by our neighbours early in the history of our development will render us more prudent regarding the exploitation and utilization of our resources. Especially would I plead for such action as would prevent our iron ores from passing out of our country. Our country is extensive in area, has a brilliant future before it, and for its development we shall need every ounce of iron ore with which it is endowed.

MR. R. W. BROCK, Acting Director of the Geological Survey, in a brief speech, expressed the desire of the members of the Mines Department to serve the mining industries of the country.

MR. A. B. WILMOTT, of Sault Ste. Marie, also responded to the toast. He referred to the immensity of the "claim" that Canada had staked out for herself on this continent. "As to discoveries," he continued, "I would point out that the Cordillera region is divided into three sections. There are 1,500 miles in Mexico, rich in silver; 1,500 in the United States, with gold and silver. We have 1,500 miles in Canada, and know that along the boundary and to the extreme north it has proved very rich, and we may justly infer that our fifteen hundred miles is as rich as either of the others. Then we have the Sudbury district, the greatest nickel camp in the world, and Cobalt; while in Quebec we have corundum, asbestos and many other valuable minerals, while on our eastern and western coasts we have abundant coal. To the north again we have gold areas of which practically nothing is yet known. That north region is bound to become a valuable asset to Canada. These are merely a few of the reasons I have for feeling confident that our great Canadian claim will 'pan out' well." (Applause).

MR. LOUIS PRATT responded on behalf of the mining industry of British Columbia.

"The Retiring President" was then proposed by Mr. J. E. Hardman of Montreal, who said:—"It gives me very great pleasure to propose this toast, both as an old member of this Institute, and as an old friend of many of your past presidents. The position of president of this Institute is by no means a sinecure, especially when, like your immediate past president, he resides in British Columbia, and requires to travel across the continent to attend a meeting. In proposing this toast I crave permission to tell you something about Mr. Keffer which you may not know. Going to British Columbia in 1896, when there was one log cabin in Greenwood, he began his work on the "Mother Lode," unassisted, without any large capital. He developed that property from a prospect to what it is now, the second largest producing mine in British Columbia. He was undoubtedly the pioneer of the Boundary country of British Columbia, and as the pioneer engineer of the Boundary country he has steadily upheld a standard of moral integrity amongst his people. It is to his credit that during the time he was general manager of that company there was no dissension and no strike amongst his employees, and this I conceive to be as bright a crown as a man can wear. It is needless to say that he has most worthily maintained the dignity of the Institute during his term of office as President.

MR. KEFFER, on rising to reply, was greeted with loud cheers. In a few well chosen words he returned thanks, and added that he would continue to take a warm interest in the Institute, and would promote its welfare by every means in his power.

"Our Guests" was responded to by Messrs. Sakemure, Acting Consul General for Japan; Dr. J. Bonar, Dr. W. Campbell, Mr. Turriff, and Dr. R. M. Coulter, Deputy Postmaster General; and "The Press," by Mr. Frederick Hobart, Mr. Farr and Mr. J. C. Murray.

WESTERN BRANCH MEETINGS.

Reported by E. Jacobs, Secretary.

The proposal to form a western Branch of the Institute was taken up with enthusiasm by a number of members resident in the Province, conspicuous among them, Mr. Frederic Keffer, of Greenwood, engineer in charge of the several mines of the British Columbia Copper Company, who in March of 1907 was elected president of the Institute for the year 1907–8, and Mr. A. B. W. Hodges, of Grand Forks, general superintendent of the mines and smelters of the Granby Consolidated Mining, Smelting and Power Company. The movement received a decided stimulus as the direct outcome of the visit to the West last autumn of Mr. H. Mortimer-Lamb, of Montreal, secretary of the Institute, who stirred up general interest in the proposal to organize a Western Branch. The result of the efforts of these several gentlemen and of other members who heartily supported them, was seen in the successful organization of the branch at Nelson on Wednesday, January 15, on which day and that following a satisfactory and successful meeting of members was held.

PROCEEDINGS ON THE FIRST DAY.

The Court Room at Nelson having been kindly placed at their disposal, the members first met there on Wednesday morning.

Mr. Frederic Keffer, as president, made an address in which he stated the object of the meeting, which was primarily the formation of a Western Branch of the Institute.

It was then moved by Mr. S. S. Fowler, and seconded by Mr. C. P. Hill, that "we now constitute ourselves a Western Branch of the Canadian Mining Institute." This was carried unanimously.

The next order of business was the election of permanent officers, with the following result: President, Mr. A. B. W. Hodges; secretary, Mr. E. Jacobs; Executive Council: Messrs. P. S. Couldrey, R. H. Stewart, L. Hill, O. E. S. Whiteside, W. M. Brewer, J. C. Haas, E. C. Musgrave, J. McEvoy and S. G. Blaylock, and the western members of the Council of the Institute, ex-officio.

While the scrutineers were examining the ballot papers, Mr.

E. Jacobs stated that the provincial mineralogist had requested him to express his regret that his official duties just now prevented him from leaving Victoria, so that he was unable to attend the meeting. He also apologized for the unavoidable absence of Mr. John Hopp, of Cariboo, who had intended being present, but had been prevented by business engagements.

After announcement of the result of the ballot, the president of the branch, Mr. A. B. W. Hodges, took the chair and in his opening address thanked his fellow members for the honour they had done him. He said: "I have belonged to the Institute many years, but have been so busy that I have never had time to attend a meeting in the East. When the Council of the Institute suggested this plan, I was heartily in favour of a branch out here, and I know all the gentlemen present are interested enough to endorse my sentiments. But an endeavour should be made to increase the membership as soon as possible. It will require hearty co-operation to make a success of this branch. The whole reason of the formation of the Western Branch is that the busy members out West cannot attend the meetings of the Institute held in the East.

"I think we should have a committee of three appointed to look into the by-laws of the Canadian Mining Institute and report to-morrow on such changes as they shall consider it advisable to make. I appoint on that committee, Messrs. S. S. Fowler, L. Hill and J. C. Haas."

Mr. E. Jacobs, the newly elected secretary, thanked the members for his election, and went on to say that there were already nearly 150 western members of the Institute, including those resident in Alberta, British Columbia, Yukon Territory, and the State of Washington, and he thought it probable that within a year there would be a membership of at least 200. He then pointed out that the Government of the Province was paying a great deal of attention to agriculture, but not so much to mining. The new branch of the Institute might induce it to make a difference in this regard.

The president next stated that it was not the intention that afternoon to proceed with the reading of technical papers, but rather to have an informal discussion as to the best method of carrying on the newly formed branch of the Institute.

Mr. F. Keffer thought it would be well to have small local branches of the Institute in the different mining centres, to meet every month or so.

Mr. S. S. Fowler thought that there would be hardly a sufficient membership present in any one of these centres, with the possible exception of the Boundary, to make such meetings interesting. He was of opinion that there should be quarterly or semi-annual meetings. This suggestion led to some discussion, and finally the general opinion seemed to be that the meetings of the Western Branch of the Institute should be held thrice yearly.

Mr. Keffer agreed with Mr. Fowler that the oftener meetings could be held the better the members could get together.

Mr. J. C. Haas suggested the reading of papers at such meetings, but thought the procedure of the meetings should be, as far as possible, informal.

Mr. T. Kiddie agreed as to the non-formality of the meetings, and thought that meetings three times a year would be ample.

Mr. E. Jacobs called attention to the fact that the annual meeting of the Institute would be held this year in Ottawa, opening on March 4, and that it would be in order for the Western Branch to prepare for that annual meeting anything that the West particularly thought desirable for discussion. He next read, for the information of the meeting, the by-laws of the Institute as to membership and associate membership. Continuing, he remarked: "In view of the fact that a Dominion Department of Mines had been organized, it would be politic for the meeting to pass a resolution congratulating the Dominion Government upon its establishment, and expressing appreciation of the useful work done in the West by the Geological Survey Department and, as well, with reference to the exhaustive labours of the Zinc Commission, and the work of Mr. R. R. Hedley in gathering for the Department of Mines, for publication, statistics and other data relative to the mining and smelting industries of the West." Further, he called attention to a statement published in the press to the effect that the Canadian branch of the Royal Mint would not be able to use for coinage purposes metals smelted in Canada until after these shall have been further refined. He thought the Institute should call attention to the fact that such a statement is quite erroneous, since at the refinery at Trail, owned and operated by the Consolidated Mining and Smelting Company of Canada, the silver produced is of fineness averaging over .999 and the gold about .995.

The secretary was requested to prepare resolutions along the lines sugested, for consideration the following day.

Mr. Fowler, on behalf of the Nelson members, invited the visiting members together with their lady friends to be present at a complimentary dance arranged to take place at the Hume hotel that night.

At five o'clock adjournment was made until the following morning at 11 o'clock.

PROCEEDINGS ON SECOND DAY.

The first business taken up on Thursday morning was the consideration of the following two resolutions, which were unanimously adopted:

Proposed by Mr. E. Jacobs and seconded by Mr. T. Kiddie: "That the Western Branch of the Canadian Mining Institute hereby expresses its satisfaction at the establishment of a Dominion Department of Mines, with its 'Geological' and 'Mines' branches, under the control of a minister of mines and directed by his several chief officials, the deputy minister of mines, director of the Geological Branch and director of the Mines Branch respectively. It also expresses its appreciation of the valuable work heretofore done in western Canada by the Geological Survey, particularly in the Crow's Nest Pass coal fields, and later in Kootenay, Boundary, Similkameen and Skeena districts, and the comparatively large amount of geological and topographical work done in Yukon Territory. Further it places on record its recognition of the systematic and thorough work of the Zinc Commission and that of the more recent efforts of the Mines Branch to collect and compile for publication statistics and other useful information concerning, the mining and smelting industries of Western Canada. Finally, it notes with satisfaction the considerable increase in the amount placed by the Dominion Government on the estimates for the ensuing fiscal year for the purposes of continuing and extending the valuable work of the respective branches of the Department of Mines, and it respectfully commends to the favourable consideration of the hon. the minister of mines and his chief officials the great need existing for field work operations in Western Canada on an adequate scale, so that the development of the enormous mineral resources of this very important part of the Dominion may be further encouraged and facilitated."

It was further resolved that the secretary forward copies of the foregoing resolution to the right hon. the prime minister, the hon. the minister of mines, the deputy minister of mines and the directors of the Geological and Mines branches respectively.

Proposed by Mr. S. S. Fowler and seconded by Mr. Frederic Keffer: "That, in the opinion of the Western Branch of the Canadian Mining Institute, the mining industry of British Columbia has attained to such comparatively large proportions in regard to annual total value of its mineral products, and gives such promise of continued steady increase in activity and productive results as to call for larger annual appropriations for the practical purposes of the Provincial Bureau of Mines, so that the examination of mining districts and the dissemination of useful information relative to their mineral resources, may be on a scale more in keeping with the fast growing importance of the mining industry than has been reasonably practicable during recent years. It is therefore respectfully urged that, while much good work has already been done, the great benefit the adequate development of the mining industry will be to the Province at large, as well as to the districts more directly interested, be fully recognized, and that the Provincial Government make more liberal provision for the work of the Bureau of Mines, so that this serviceable department may be enabled to considerably extend its effective work, thereby ensuring that the mining industry shall enjoy the benefit of similar liberal treatment by the Government as has been, and is being, given to the agricultural and fruit-growing industries of the Province."

The secretary was directed to send copies of this resolution to the hon. the premier and the officials of the Provincial Bureau of Mines

The committee on by-laws, appointed the previous day, made a verbal report to the effect that the by-laws of the parent Institute must govern the conduct of this branch, though such modification as shall be considered necessary may be recommended by the local council to the council of the Canadian Mining Institute.

Mr. S. S. Fowler here extended to the members, on behalf of that company, a cordial invitation to visit the reduction works of the Canada Zinc Company now in course of construction within a short distance of the city. The invitation was accepted with thanks.

This completed the general business of the morning. Mr. W. A. Davidson, engineer of the West Canadian Collieries, Limited, Blairmore, Alberta, read some notes on the "Utilization of Waste at Lille Colliery, and how it is accomplished." An interesting discussion followed, which occupied the attention of the meeting until the session was adjourned for luncheon.

At two o'clock some 20 members left by electric car for the Canada Zinc Company's works, over which they were shown by the resident officials. Upon return to the city the afternoon session was opened at half-past three o'clock. The several papers read and discussed were as follows: "Notes on Cost of Diamond Drilling in the Boundary District," by Frederic Keffer; "Handling 3,000 Tons of Ore Per Day at the Granby Mines and Smelter," by A. B. W. Hodges; "Mineral Production of British Columbia in 1907," by E. Jacobs.

Other papers were read by title.

This concluded the business, whereupon hearty votes of thanks were tendered to Messrs. Keffer and Hodges for having been largely instrumental in bringing about the holding of the meeting and the resultant organization of the new branch; to the committee of Nelson members of the Institute, particularly Messrs. Campbell and Fowler, for having made arrangements for the convention, carrying out of the local arrangements for holding the meeting, and for the entertainment and hospitality provided for the enjoyment of the visiting members and the ladies accompanying some of them; to the Canada Zinc Company for the opportunity to inspect its works, and to the *Daily News* and *Canadian* newspapers for the publicity they have given the proceedings.

In conclusion it may be said that the meeting was decidedly successful, both in point of attendance and as regards its representative nature. Nine signed applications for membership were received and others were promised. The attendance of members was as follows: W. B. Bishop, A. B. W. Hodges, C. T. Mitchell and W. St. John Miller, Grand Forks; F. Keffer and C. Varcoe, Greenwood; C. Rundberg, Phœnix; W. E. Zwicky, Kaslo; A. W. Davis, Sandon; Jas. Buchanan, Trail; E. C. Brown-Cave, Vancouver; E. Jacobs, Victoria; W. A. Davidson, Blairmore, and C. P. Hill, Frank, Alta.; J. C. Haas, Spokane; T. Kiddie, Northport, Wash. The Nelson members in attendance were: G. H. Barnhart, S. G. Blaylock, J. J. Campbell, S. S. Fowler, A. C. Garde, A. H. Gracey, Leslie Hill, B. A. Isaac, A. L. McKillop, G. A. Revell and E. W. Widdowson. The non-members present were: A. D. Wheeler, Ainsworth; J. A. Whittier, Kaslo; L. Pratt, Sandon; F. W. Guernsey, Trail; Thos. Brown, L. Crawford, Frank Fletcher, E. F. Miltenberger, A. Bruce Ritchie and C. H. Rowlands, Nelson.

WESTERN BRANCH, ROSSLAND MEETING.

Reported by E. Jacobs, Secretary.

The Western Branch of the Canadian Mining Institute held its second general meeting at Rossland on Thursday, May 14.

Mr. A. B. W. Hodges, of Grand Forks, general superintendent of the Granby Mining, Smelting and Power Company, Limited, was in the chair.

The following members were present: From Nelson: S. S. Fowler and C. H. Rowlands. Grand Forks: W. B. Bishop, A. B. W. Hodges, Frank E. Lathe, W. St. John Miller and C. T. Mitchell. Phœnix: C. M. Campbell. Trail: F. W. Guernsey and J. M. Turnbull. Vancouver: J. West Collis. Victoria: E. Jacobs. Northport, Wash.: Thos. Kiddie. Rossland: D. J. Browne, T. W. Cavers, H. H. Claudet, P. S. Couldrey, Graham Cruickshank, Geo. W. Dunn, A. G. Larson, A. J. McMillan, M. E. Purcell, J. M. Sands, R. H. Stewart and C. Varcoe. Dr. J. Bonsall Porter, professor of mining at McGill University, and Mr. John A. Dresser, instructor in geology, both members of the Institute, who were in the Kootenay with the McGill summer mining school, also attended. The visitors at the meeting included J. A. Macdonald, M.P.P. for Rossland; A. B. Mackenzie, secretary of the Associated Boards of Trade; J. S. C. Fraser, manager of the Bank of Montreal, Rossland; W. S. Rugh, office manager of the Le Roi Mining Company, Limited; H. P. Dickinson, district representative of the Giant Powder Company; K. C. Allen, J. C. Fuller and F. S. Peters.

The secretary read an account of the proceedings at the Nelson meeting last January, and this was taken as the minutes of that meeting, and on resolution was so adopted.

The chairman then asked Mr. J. A. Macdonald, member for the Rossland district in the Provincial Legislature, who was present by invitation, to address the meeting.

Mr. Macdonald said that the citizens of Rossland had been honoured by having the second meeting of the Western Branch of the Canadian Mining Institute convened in their city. He thanked the Branch for the honour done him in inviting him to be present and to address the meeting. He knew the work the branch was doing was entirely one of unselfishness—to give others the benefit of the experience each had obtained in his own sphere. In mining there was no selfish competition, each mine owner being glad to see his neighbour prosper and none succeed at the expense of others. This spirit had been carried into the work of the Canadian Mining Institute, and was being used for the purpose of disseminating the knowledge individual members had gained, thus exemplifying the unselfishness of their motives.

Mr. A. J. McMillan, managing director of the Le Roi Mining Company, was next called upon. He expressed pleasure at seeing members of the Canadian Mining Institute meeting in Rossland, and hoped the proceedings would be found profitable to those taking part in them. The visitors would be given opportunity to go through the large mines of the camp. Those in charge of the mines had not lost faith in them—they believed there still remained large bodies of good ore, and although there were still difficulties to be met, these would doubtless be overcome as others had been in the past.

The chairman then announced that an intimation had been received from the secretary of the Institute, in Montreal, that several British and foreign institutes connected with engineering, mining and metallurgy had been invited to join the Canadian Mining Institute in an excursion through the mining sections of the Dominion next September, and that it was proposed to visit the chief mining camps of British Columbia. The members of the Western Branch would be expected to unite in entertaining the visitors, and he asked that as many as possible would join in the excursion when the party should come west and proceed to Victoria, where a formal meeting of the Institute would be held. He understood the Provincial Government had already been informed that it would be asked to make an appropriation towards the cost of entertaining the visitors. He hoped Mr. Macdonald would endeavour to help them to secure some such assistance from the Government.

Mr. Macdonald enquired whether the Canadian Mining Institute received a grant from the Provincial Government. He thought that if application for it were made the Legislature would support a grant to assist in carrying the useful work of the Institute.

The secretary said that so far as he knew no financial assistance had yet been given the Institute by the Government of British Columbia. The statement of the treasurer of the Institute, presented at the annual meeting in Ottawa in March, shows that the Dominion Government gives an annual grant of $3,000 and the Ontario Government one of $1,500, and he understood that the Dominion Government had been asked to increase its yearly grant to $5,000. As a matter of fact there had been no official recognition by the Government of British Columbia of the existence of the Institute. The Dominion Government and the Provinces of Quebec and Ontario had all been officially represented at the annual meetings of the Institute, and had supplied information relative to their mineral production, but British Columbia had had only the benefit of the attendance at the annual meetings of two or three members from the Province, and such information concerning mineral production as he, the speaker, had supplied for submission to the meetings of 1907 and 1908 respectively.

Mr. McMillan suggested that the Institute should apply to the Provincial Government for a grant, which should not be less than the amount received from Ontario.

Mr. Macdonald did not anticipate that the Institute would have any difficulty in obtaining a grant from the Provincial Government if the proper information concerning the work and position of the Institute were supplied. The Province had been fairly liberal in giving aid to the agricultural and fruit-growing industries, so he thought the mining industry would be similarly assisted if the necessary representations were made.

The secretary mentioned that the total value of the mineral production of the Province in 1907 was not far from $26,000,000, which was as large as or larger than that of the combined value of two or three others of the chief industries of British Columbia. It was true the Province had the benefit of the work of the provincial mineralogist and the provincial assayer, but in his opinion, the mining industry did not receive from the Provincial Government adequate aid or recognition. It was gratifying to find the

Dominion department of mines doing so much work in the West, and he had received assurances from the minister of mines, and the directors of the geological survey and mines branches, respectively, that their work in the West would be continued on at least as large a scale as during the past few years.

The secretary here mentioned, as good news, to those interested in the zinc mining industry, that the appeal to the United States courts, against the decision of the General Board of Appraisers in favour of admitting zinc ores into the United States duty free, had not been successful, the court ruling that no duty is legally chargeable upon them, except as to their lead contents.

The chairman expressed his pleasure that the question of applying to the Provincial Government for aid to the Institute had been brought up, and that Mr. Macdonald had been present and heard the views expressed in this connection. Bearing in mind the relative importance of the several industries and the value of their products, he thought the mining industry should receive from the Government twice the amount of the assistance given to any one of the others.

An adjournment to the afternoon was here made.

AFTERNOON SESSION.

The business was resumed at 2.30 o'clock p.m., and the following resolutions were unanimously adopted after a brief debate:—

Proposed by Mr. P. S. Couldrey, seconded by Mr. Thomas Kiddie, "that in order to make the council of this branch more fully representative, the number of elected members thereof be increased from nine to twelve, in addition to the president and secretary."

Proposed by Mr. R. H. Stewart, seconded by Mr. F. W. Guernsey, "that Messrs. R. W. Coulthard, Fernie, and John L. Retallack, Kaslo, be and hereby are elected members of the council."

The secretary reported that "the council recommends that a committee be appointed to request the Provincial Government to make an appropriation towards the expense of suitably entertaining the British and foreign and other visitors who will next September visit British Columbia as guests of the Canadian Mining Institute, such committee to consist of Messrs. A. B. W. Hodges, W. H. Aldridge and S. S. Fowler, with power to add to their number."

Dr. J. Bonsall Porter, who is senior vice-president of the Canadian Mining Institute, at the request of the chairman, gave some information as to who were these invited guests, who include a number of eminent members of British and foreign societies, and the scheme of the proposed excursion.

On motion of Mr. A. J. McMillan, seconded by Mr. M. E. Purcell, the recommendation of the council was adopted.

Proposed by Mr. S. S. Fowler, seconded by Mr. J. West Collis, "that a committee of five be appointed by the president to make suggestions to the council of the Institute in connection with the itinerary in western Canada of the British and foreign visitors next September." Carried unanimously.

The reading and discussion of papers was then proceeded with.

Mr. E. Jacobs read some brief notes on a "Matte Separating Forehearth" in use at the Tyee Copper Company's smelter at Ladysmith, Vancouver Island. He said that Mr. W. J. Watson, manager of the smelter, had informed him that so far as he knew, he, Mr. Watson, was the first to use this particular adaptation of the old Orford settler to a water-jacketted receiver, and that during the two years it has been in use the matte compartment has only frozen up three or four times, and then on account of the high zinc contents of the matte. The settler has more than paid for itself by reason of the slag made being cleaner. Among other advantages which this arrangement of the settler affords are the following: The wear and tear of the matte pots is reduced by the stream of matte not striking the side of the pot as it does in the ordinary tapping methods; tapping clay is saved; the danger of men being burned when tapping slag is obviated; the services of a tapper are dispensed with and a consequent economy is effected in not having to pay this extra man's wages.

The notes were discussed by Mr. Thomas Kiddie, who was familiar with the conditions under which Mr. Watson had worked, and by Messrs. Guernsey and Hodges.

Mr. H. H. Claudet contributed a "Few Notes on the Elmore Vacuum Process of Ore Concentration." The discussion that followed was participated in by Messrs. Porter, S. S. Fowler, F. W. Guernsey, A. B. W. Hodges, Thos. Kiddie and J. M. Turnbull. Samples of several concentration products were passed around for inspection.

Mr. C. M. Campbell's paper on "Granby Mining Methods" was a clear and comprehensive description of the methods followed by the Granby Company at its big copper mines at Phœnix. A number of excellent drawings and large photographs illustrated the text of the paper, which was generally commended as being a distinctly creditable production. As the time was short, discussion was brief.

The chairman here announced that he had been requested by Mr. Frederic Keffer, engineer in charge of the mines of the British Columbia Copper Company in the Boundary, and who was last year's president of the Institute, to present to Mr. Frank E. Lathe the president's gold medal for the best paper submitted by a student member last year. Mr. Lathe, who is now with the Granby Company, was then at McGill University.

Mr. Lathe was heartily applauded as he went forward to receive the medal, in addition to which he had already received from the Institute a cash prize of $25.

The secretary then read some notes he had made on "Ore Hoisting Appliances at the Tyee Copper Company's Smelter," when visiting those works a fortnight ago. In particular he described a trolley designed by Mr. W. J. Watson and found to work effectively in connection with hoisting ore from vessels into the bunkers on the wharf. Illustrative photographs were shown.

On the request of the chairman Dr. Porter briefly outlined the work in progress in McGill laboratories to test the coals in Canada. These tests are being made under the auspices of the Dominion Government.

On motion of Mr. S. S. Fowler, seconded by Mr. M. E. Purcell, the president and secretary were appointed to urge upon the Dominion Department of Mines the desirability of completing as soon as possible Mr. R. W. Brock's full report on his structural survey of Rossland camp, with maps, the necessity of having these made available being pressing.

Votes of thanks to the local committee for its services in providing for the entertainment of the visitors; to the district press for the publicity given the meeting, and to local officials for the use of the court room, were passed, and the meeting then adjourned.

SMOKER AT THE ROSSLAND CLUB.

A most enjoyable smoker was tendered the visitors at the Rossland Club in the evening. The chairman of the club, Mr. J. S. C. Fraser, presided over the proceedings and he and Mr. J. A. Macdonald, M.P.P., cordially welcomed the visitors, on whose behalf Mr. Hodges responded. Speeches were also made by Mr. A. J. McMillan, Dr. J. B. Porter, Mr. A. S. Goodeve, Mr. P. S. Couldrey, Mr. S. S. Fowler, Mr. M. E. Purcell, Mr. Thos. Kiddie, Mr. F. W. Guernsey, and others.

In the course of the evening an excellent programme of vocal and instrumental music was rendered.

The next day was spent in inspecting the Le Roi, Le Roi No. 2, and Centre Star mines, under the escort of the various mine officials. Most of the visitors left for home by the evening train.

The committee on entertainment consisted of Messrs. A. G. Larson, J. S. C. Fraser, R. H. Stewart, W. S. Rugh, P. E. Couldrey, Graham Cruickshank and H. P. Dickinson.

COBALT BRANCH

Reported by G. R. HARDY, Secretary.

A regular meeting of the Cobalt Branch was held Friday, December 20, 1907.

Present:—A. A Cole, E. L. Fraleck, Capt. Leckie, C. Campbell, H. J. Deyell, R. W. Brigstock, Carl Reinhardt, W. H. Prest and G. D. Hardy.

Mr. Cole occupied the chair and after a few preliminary remarks, called upon Capt. Leckie, who read an interesting paper entitled, "The Mispickel Deposits at Arsenic Lake." Capt. Leckie showed some good specimens of mispickel, also maps showing the location of the deposits. A brief discussion followed the reading of the paper.

The meeting closed with a vote of thanks to Capt. Leckie, proposed by Mr. Brigstock and seconded by Mr. Fraleck.

A meeting of the Branch was also held during the month of May, when interesting papers were presented by respectively Mr. E. L. Fraleck, on "Early Mining Endeavour in the Province of Ontario," and by Mr. G. H. Sancton on "Methods of Concentration at Cobalt," which was productive of a lengthy discussion.

MONTREAL BRANCH MEETING.

On Tuesday evening, March 31st, the members of the Montreal Branch entertained at dinner at the Engineers' Club, Montreal, the President of the Institute, Dr. Willet G. Miller, Provincial Geologist of Ontario, and Mr. R. W. Brock, the Acting Director of the Geological Survey of Canada. Mr. Geo. E. Drummond, Chairman of the Branch, presided, and was ably supported by the vice-chairman, Mr. John E. Hardman. The toast of the evening, "Our Guests," was proposed by Mr. Drummond and Mr. Hardman. Both speakers paid a warm tribute to the magnificent work accomplished by Dr. Miller in the field of economic geology in Ontario, and added that the Institute had every reason to be proud of having this year as its presiding officer, a man of such sterling worth and high professional standing. Mr. Hardman referring to Mr. Brock's recent appointment to be Acting Director of the Geological Survey, remarked that the selection of that gentleman to fill this important post was an eminently judicious one. Mr. Brock, the speaker added, enjoyed the confidence and esteem of the mining communities of Canada, and had established for himself an enviable reputation as a geologist, more especially in connection with his valuable work at Rossland and in other British Columbian districts. Other toasts given were: "The Manufacturing Interests," responded to by Messrs. T. J. Drummond, MacDougall and Peacock; "Financial Institutions," responded to by Mr. Hal Brown; "The Western Branch of the C.M.I.," responded to by Mr. R. R. Hedley; "The Mining Industry of Australia," responded to by Mr. Marshall; "McGill University," responded to by Dr. F. D. Adams; "The Secretary of the Institute," and "The Chairman of the Montreal Branch." During the evening Mr. Strangways sang several songs, while Mr. Stevenson Brown recited one of the late Dr. Drummond's poems in a very acceptable manner. The Dinner was pronounced a great success and was most thoroughly enjoyed by all present.

McGILL MINING SOCIETY.

(Reported by H. H. YUILL, Secretary)

A meeting of the Society was held in the Lecture Hall in the Mining Building of the University, on March 15th, to elect officers for the coming year. The results of the elections were as follows:—

Honorary President:—Dr. J. B. Porter.

President:—H. H. Yuill.

Vice-President:—H. B. Gillis.

Secretary-Treasurer:—J. Penney.

Second year Representative:—C. Fortier.

The retiring President, Mr. C. V. Brennan thanked the members for the support he had been accorded during his term of office.

PAPERS

THE IRON ORES OF CANADA.

By C. K. LEITH, University of Wisconsin, Madison, Wis.

(Ottawa Meeting, March, 1908.)

I hasten to disclaim intention of attempting a comprehensive discussion of all known Canadian iron ore deposits. While I have seen most of the principal deposits in Canada and Newfoundland, and others have been examined by associates and assistants, I cannot claim to have sufficiently detailed knowledge of a considerable part of them to warrant detail discussion. Attention will be called rather to certain general features of comparison of Canadian ores with the several types of deposits of the United States which have been more fully exploited and studied, and thus view the Canadian iron ore situation with a perspective not otherwise easily gotten. For the purposes of this discussion, the Newfoundland ores are included with the Canadian ores, because they are controlled, mined and largely used by Canadian inteiests. So far as is necessary, information will be drawn from the various careful descriptions of Canadian ores published by the Dominion and Provincial Geological Surveys or Mining Bureaus.

The classification of iron ore deposits we shall use is partly a new one based upon recent detailed studies of the Lake Superior ores and ores of the western United States.

All metallic ores are derived ultimately from the interior of the earth, whence they are delivered by igneous eruptions near or to the surface, there to undergo various distributions and concentrations under the influence of meteoric waters and gases. The variations in composition, shape, and commeicial availability of an ore are controlled by variations of conditions under which the ores have reached the surface and have been distributed. The variations have developed the following types of North American iron ore deposits:—

(1) *Magmatic segregation type.*—Ores brought to the outer part of the earth in molten magmas but retained in them during

crystallization, with the result that the ores form part of the rock itself, just as do the feldspar and other minerals. Such are the titaniferous magnetites, containing refractory silicates, and frequently sulphur and phosphorus, in deleterious quantites. While known in enormous quantities over North America—in Canada principally along the Lower St. Lawrence river, and in the Chaffey and Matthews mines of Lower Ontario—smelting is not beyond the experimental stage and they are nowhere used at a profit.

(2) *Pegmatite type*.—Ores which are carried to or near the surface in magmas and are extruded from them, in the manner of pegmatite dikes, after the remainder of the magma has been partially cooled and crystallized. They are deposited from essentially aqueous solutions mixed in varying proportions with solutions of quartz and the silicates. To this class belong some, and perhaps all, of the magnetite deposits along the contacts of limestone and igneous rocks constituting the greater part of the iron ores of the western United States, and most of the magnetite ores of Vancouver and Texada Islands and elsewhere in British Columbia. The assignment of the British Columbia magnetites to this type is based on a personal comparison of them with ores in southern Utah believed to be of this type, the origin of which is discussed in some detail by Mr. Harder and myself, in Bulletin No. 338 of the United States Geological Survey. The essential features of these deposits are their highly crystalline, magnetic character, their content of garnet, amphibole and other silicates, local abundance of sulphides and of apatite. The area of these deposits at the surface varies up to about 0.2 of a square mile. They are easily located by their outcrops or by the fragments strewn down the slopes, but it is not so easy to determine the shape and extent of the deposits when found, because of their extremely irregular association with wall rock. It is not safe to assume that they extend a foot beyond the zone of direct observation. Their vertical dimensions and shape and their mineralogical composition at depth are relatively unknown. Mining operations in the west on this class of deposits have not been extensive enough to determine these facts, such deposits having been mined principally in but few localities, at Texada Island, at Fierro, New Mexico, and in the Monterey and Durango deposits of Mexico. In the United States and

Mexico certain similar deposits, but not all, have been found to take on pyrites and garnet with depth.

A small amount of ore has been mined from Texada Island. The better ore averages about 55% iron content, and from this down; much of it is below Bessemer limit in phosphorus, and sulphur is in amounts requiring roasting. Garnet and amphibole are both abundant, locally requiring hand sort'ng. Silica varies, inversely as the iron, up to about 11 per cent. All of the ore contains a small amount of copper, locally as much as 4 per cent. The shapes of the deposits are extremely irregular. Seldom do the widths exceed 100 feet. In depth they are best shown by a tunnel 300 feet below the surface which discloses ore with essentially the same width and composition as at the surface.

The ores on the west coast of Vancouver Island have had only a little development work done on them. They likewise vary widely in iron content; phosphorus is low, sulphur is usually high, silica varies up to about 26 per cent.

Making due allowances for lack of development and possible shallowness and change of character with depth, it is still certain that there is a large known tonnage available in British Columbia, which will be used when West Coast demands warrant the establishment of a local steel industry, instead of the importation of finished products from the east. There are indications that this time may not be far distant. While suffering somewhat from their composition, they are easily and cheaply mined, and being located directly upon the coast, will have the cheapest transportation. So far as the ores have thus far been used, it has been in Washington, and the recent rapid development of the northwestern United States suggests that their further immediate use will be in Washington, notwithstanding duty, at least until such time as sufficiently large ore reserves in this part of the United States become developed or until the population of British Columbia requires a steel industry of its own.

To the pegmatite type are provisionally assigned the ores of the Attikokan and Hutton districts, of Ontario, where the magnetites have the mineralogical and chemical constituents of this class and show such intimate relations with greenstones as to suggest a direct derivation from them. They lack the bedded structures, characteristic of ores of class (3) to be described, though in the Hutton district the bedded iron formation rocks are also present. The extremely irregular association of the ore with greenstone makes it difficult to outline the deposit even a few feet in advance of exploration. The Attikokan deposits are high in sulphur, 2 to 5 per cent., requiring roasting. At Hutton the sulphur is low so far as explorations yet go, and phosphorus runs about 1 per cent.

To this class of ores also may belong at least a part of the magnetites in the pre-Cambrian Grenville series of New Jersey (*a*), some of the magnetites of the Adirondacks of New York (*b*), some of the magnetites in the Grenville series of southeastern Ontario (*c*), and the magnetites of Cornwall, Pa. (*d*), and Cranberry, N.C. (*e*).

These deposits have essential features in common and mineralogical and chemical similarities to the western ores of this class. It may be that part of the Ontario Grenville ores belong rather with the following class (3), suggested not only by their characteristics, but by Dr. Miller's recent correlation of certain associated rocks with the Keewatin series of the Lake Superior region, which contains ores belonging to class (3).

The Grenville ores of lower Ontario are interbanded lenses of magnetite, gneisses and amphibolites, closely associated with, and partly in direct contact with, crystalline limestones of the same series. The ores vary from lean unworkable magnetite gneiss, carrying a small percentage of magnetite ribs as compared with gneissic ribs, to deposits of nearly pure magnetite. The iron formation bands are lens shaped and discontinuous. Their greatest width is probably less than 150 feet and usually under 50 feet, and their greatest length perhaps 1,500 feet. They have been mined to a depth of 350 feet, but most of the workings are less than 100 feet. The better grade ores average much the same in iron as the better grade western magnetites of this class, that is about 55 per cent. and from this down. Phosphorus is usually

(*a*) Spencer, A. C. Genesis of the magnetite deposits in Sussex county, N.J. Min. Mag., vol. 10, 1904, pp. 377–381.

(*b*) Kemp, J. F. The geology of the magnetites near Port Henry, N.Y., and especially those of Mineville. Trans. Am. Inst. Min. Engs., vol. 27, 1898, pp. 146–203.

(*c*) Brock, R. W. Personal communication.

(*d*) Kemp, J. F. The ore deposits of the United States and Canada. New York, 3d ed., 1900, pp. 175–179.

(*e*) Keith, Arthur. Iron ore deposits of the Cranberry district, North Carolina-Tennessee. Bull. U.S. Geol. Survey No. 213, 1902, pp. 243–246.

below the Bessemer limit, adding much to the availability of the ores. Sulphur is usually too high to allow the ore to be used without roasting, seldom running less than .05 per cent. though by hand cobbing the sulphur content may be kept down somewhere near this limit. Concentration of certain of the leaner grade ores is likely to be commercially feasible in the future, though this is yet a mooted question, especially with reference to the satisfactory elimination of sulphur. In a few places titanium is present.

Hematite has been mined at Wallbridge, Dalhousie and McNab in eastern Ontario in similar geological relationships. According to Willmott, (*a*) there is reason for believing that they are oxidized portions of iron pyrites bodies lying below.

A deposit of magnetite not far from Bathurst, New Brunswick, seems from its available description (*b*) to belong with this class of pegmatite ores, but I do not have sufficient information to discuss it.

(3) *Lake Superior sedimentary type.*—Ores brought to the surface by igneous rocks and contributed either directly by hot magmatic waters to the ocean or later brought by surface waters under weathering to the ocean or other body of water, or by both; from the ocean deposited as a chemical sediment in ordinary succession of sedimentary rocks; and, still later, under conditions of weathering, local enrichment to ore by percolating surface waters. To this class belong most of the producing iron ores of the Lake Superior region, those of the Michipicoten district of Canada, and most of the non-producing banded iron formation belts of Ontario and eastern Canada. The Lake Superior ores constitute the world's largest reserve of high grade hematite, more or less hydrated, much of it of Bessemer grade, and little of it high either in phosphorus or sulphur.

The ores of this class differ in origin from those of the preceding classes in that the iron, instead of being directly deposited near igneous rocks as ore, is distributed by the aqueous sedimentation and deposited with a large amount of interlayered silica in

(*a*) Willmott, A. B. The Iron ores of Ontario. Jour. Canadian Min. Inst., vol. XI, 1908.

(*b*) Hardman, John E. A new iron ore field in eastern Canada. Jour. Canadian Mining Institute, vol. XI., 1908.

banded "iron formation," containing about 25 per cent. of iron, too poor to be used directly as ore, and requiring that the silica be locally taken out before they are of value. This ore may or may not show close areal association with the parent igneous rocks. It is obvious that gradation phases are to be expected between groups (2) and (3), and that many ore deposits can with difficulty be assigned definitely to one or to the other.

It has long been known that the lake Superior ores were concentrates in certain sedimentary iron formations. It was believed that these sedimentary iron formations were derived from the weathering of basic shores containing much basic igneous rock usually called "greenstone." As a result of further study it has been found necessary to conclude that the iron formations have not only been derived from greenstone by weathering, but have actually been contributed by greenstone magmas directly to the water in magmatic solution and that there are all intermediate stages between the two processes. It begins also to appear that the iron, copper, nickel and silver ores of the Lake Superior and Lake Huron districts are related in a great metallographic province in which the characteristics and distribution of the different ores are initially controlled by igneous rocks.

This conclusion has an essential bearing on exploration, for if the iron is specifically related to certain greenstones, just as the Sudbury ores are to the norite, then it follows that its distribution may be somewhat freakish, as it is in any ores related to igneous activity, as for instance, the gold ores of the west, and that it cannot be concluded from similarity in succession or structure that iron ores should necessarily be found in a distant district, though the redistribution as sedimentary rocks which the iron ores alone have undergone has greatly increased their area and the chances of finding them.

As first deposited the iron formation consisted essentially of chemically precipitated iron carbonate or ferrous silicate (greenalite) with some ferric oxide, all minutely interlayered with chert. When these were exposed to weathering, the ferrous compounds, the siderite and greenalite, oxidized to hematite and limonite, essentially in situ, although some of it was simultaneously carried and redeposited. The result was ferruginous chert called taconite or jasper, averaging less than 30 per cent. of iron.

The concentration of the iron to 50 per cent. and over has been accomplished principally by the leaching of silica bands from the ferruginous chert and jasper. Infiltration of iron has been on a smaller and more variable scale. The leaching of the silica develops pore space, and allows the iron layers to slump, thereby enriching the formation sufficiently to constitute an ore.

It has been found, further, that during this leaching of silica the character of the iron bands has not essentially changed and therefore that the nature of the ore deposits is determined largely by the character of the ferruginous chert. The phosphorus is in the iron bands, rather than in the chert, and therefore the leaching of the chert tends to raise the percentage of phosphorus in the ore, but there has been also later introduction of phosphorus, making the phosphorus content of the ore considerably higher than that of the parent rock.

For flat-lying formation such as the Mesabi from 4 to 8 per cent. of the surface of the formation and less than 2 per cent. of the volume of the part of the formation lying vertically below this exposed surface have been altered to ore. For steep dipping formations like the Gogebic, about the same percentage of the volume has been altered to a depth of 2,000 feet.

I have discussed the Lake Superior ores only so far as necessary to bring out certain essential features of this class of ores in Canada and their bearing upon availability. There are many iron formation belts of this class, but they have been found to have undergone local enrichments to important ore deposits only in the Michipicoten district, and to some extent in the Animikie district.

In the Michipicoten district the ores are principally non-Bessemer and in portions of the deposits high in sulphur. Their occurrence beneath the peculiar Boyer Lake basin with walls of chert, tuff and carbonate, is well described by Coleman and Willmott. (*a*)

In the Animikie district the iron formation is an eastward continuation of the Mesabi iron formation, but it is less than 200 feet thick, as compared with 700 to 1,000 feet in the Mesabi, and has undergone enrichment only in thin layers interbedded with

(*a*) Coleman, A. P., and Willmott, A. B. The Michipicoten iron region. 11th Report of the Ontario Bureau of Mines, 1902, pp. 168–169.

cherts and along a few fault planes. The thickness of the ore beds that may be mined will depend on how low a grade can be used and the success of hand sorting in keeping the ore up to this grade. Under any conditions much rock must be handled. On the other hand, the ores have great horizontal extent, are near the surface, are red hematite, low in phosphorus, with low sulphur, and practically on the shore of Lake Superior, justifying the hope that they may be used.

Two significant questions remain to be solved in connection with the lean iron formation of the Lake Superior type so widely distributed in Ontario and elsewhere in Canada: (1st) Is their apparent lack of second concentration a real one; and (2nd) if so, what has caused it? On the assumption that the apparent lack of concentration is a real one, Van Hise has suggested that perhaps a part of the enriched portions has been removed by deep glacial erosion. Another alternative is that the structural conditions have not favored abundant flow of surface waters necessary for the leaching of the silica. A third possibility here most favored, is that the original texture of the iron formations or proportions of the original constituents have been somewhat different from those of the Lake Superior region, and that they have not allowed access to the waters necessary to leach the silica. The formations are principally Keewatin and in general are more dense, crystalline and magnetic than the Huronian iron formations of the Lake Superior region. Some of these differences are doubtless due to secondary alterations, but it is not easy to account for all of the differences in this way. Another possible reason for deficiency of ore in the Ontario iron formations is that their yet known area is so small, as compared with that in the Lake Superior region, that even if the same percentage of the formation were concentrated to ore, the total amount of ore to be discovered would not be large. The Keewatin formations of the Lake Superior region occupy only about 9 per cent. of the area of all the iron formations, and have produced only 7 per cent. of all the ore mined to date (*a*). There may be unfavorable significance, therefore, as noted by Willmott, in the fact that the Canadian formations thus far discovered are largely Keewatin.

(*a*) Iron Ores of Ontario, cit.

All these explanations and possibly others may apply. On the other hand, much more exploration is necessary to show that there really has not been concentration of large ore deposits in the known Canadian iron formations. The fact is again cited, that, in the producing Lake Superior districts, the proportion of ore, even under most favorable conditions, constitutes less than 8 per cent. of the surface of the iron formation and usually much less, and in volume it constitutes less than 2 per cent. Only rarely have the ores been discovered at the surface. Underground exploration through drift and rock has been necessary. In but few localities in Canada has there been adequate search for these localized concentrations within the iron formations. This fact is sometimes lost sight of because of marked tendency to use the term "iron ore" for the banded, unconcentrated "iron formation," and to speak of such formation as "lean, banded ore." In the Lake Superior region "iron formations" and "iron ores" are discriminated. It is not impossible that mechanical concentration of the iron formation may result in the production of ore, but it is unnecessary to argue the commercial advantage of finding some part of the iron formation in which nature herself has done the concentrating.

(4). *Clinton sedimentary type.*—Sedimentary ores deposited in oceans from weathering of the land areas in which the iron is either disseminated in igneous rocks or has undergone some of the concentrations outlined in (1), (2) and (3). To this class belong the "flax seed" ores of the Clinton and other beds of the Appalachians and Wisconsin, the ores of the Torbrook and Nictaux areas of Nova Scotia, and those of Belle Isle in Newfoundland. They have now been discovered in Missouri. (*a*) They are believed to differ in origin essentially from those of the preceding classes in that they are immediately derived by weathering processes, that they were deposited in the ocean as iron oxide rather than as ferrous salts, and that they have undergone no further concentration, being mined essentially in the condition in which they were deposited. There has long been some doubt as to whether or not these ores might not represent two concentrations, but work in the south-eastern United States by Eckel, Burchard and others,

(*a*) Buckley, E. R., State Geologist of Missouri. Personal communication (*a*) for the U. S. Geological Survey, and our own observations in Wisconsin, seem to show one concentration.

On Belle Isle the ores are beds dipping about 9° to the northwest, in two main seams. The lower or Dominion seam averages about 10 feet in thickness, though variable, and extends across the island for about 3 miles along the strike and down the dip for perhaps half a mile, covering an area of 818 acres, although not productive for this entire area. The upper seam occupies an area about 1 by ⅓ mile (240 acres) averaging 7 feet in thickness and is not all productive. The mining has been largely open pit, but is becoming more largely underground as the ore is followed down the dip. They are now being followed under the ocean by drifting. Much of the upper bed averages about 52 per cent. in iron, and the lower bed about 50 per cent. Recent shipments are reported to be under 50 per cent. Phosphorus averages 1 per cent. The ores are adapted to basic Bessemer or open hearth treatment, and for the former receive a bonus for high phosphorus from some European consumers.

In the Torbrook and Nictaux areas the ores are of similar kind, but the beds differ from those of Belle Isle in being thinner and inclined, requiring deep mining and handling of waste rock.

Ores of this kind occupy a definite stratigraphic position, are easily explored for, and so far as their future in Canada is concerned, they have already been pretty well discounted.

(5). *Carbonate ores*, derived from weathering of rocks, transported and deposited with organic reducing material in bogs; now found in thin beds usually associated with coal seams or carbonaceous shales. These have been extensively mined in the coal bearing and adjacent areas of the eastern United States, but not in Canada. Their present production in the United States is almost nil. Wheie exposed to weathering they alter to limonite or brown ores, considered under the following heading. Iron carbonates constitute minor phases of class (3).

(6). *Brown or hydrated ores*, developed either from the weathering of iron carbonates mentioned in the preceding head-

(*a*) Eckel, E. C. The Clinion ore red ores of northern Alamba. Bull. U.S. Geol. Survey No. 285, 1906, pp. 172–179.

Burchard, E. F. Clinton ores of Birmingham District, Ala. Bull. U.S. Geol. Survey No. 315, 1907, pt. I, pp. 130–151.

ing, or of limestones containing carbonate or other iron minerals, or by replacement of limestones or by deposition in glacial drift, or by log deposition, or by some combination of them. The few limonites in class (3) are not here included. Being often residual products of weathering, they are characteristically mixed with other residual products of weathering, particularly clay. To use these ores it is necessary to wash out the other residual products, a process which nature neglected to attend to. The ores are characteristically hydrous and high in phosphorus, but when washed aie found highly suitable for open hearth furnace practice.

The bog ores of Quebec presumably belong to this class.

Related to classes (5) and (6) are the Londonderry ores of Nova Scotia, consisting of carbonates of iron, calcium and magnesium, showing more or less alteration to limonite in irregular vein-like masses, in slate and quartzite. These ores are low grade, fairly high in phosphorus, manganese and silica, and are extremely irregular in their shape and distribution. Their origin is in doubt.

(7). *Magnetic sands.*—Magnetic sands are developed from the erosion of classes of (1), (2) and (3). As exposed along the lower St. Lawrence river they seem to be principally from classes (1) and (2), and are therefore high in titanium. They form beds from ½ inch to 2 feet in thickness, with wide extent. Their availability is still in doubt.

Commercial importance of the several classes of ores. The proportions of the several classes of ores mined in the United States, Canada, and Newfoundland, for 1906, appear in the subjoined table. Where the origin of the deposits is in doubt, the classification of their production is in doubt but the production from such types is too small to introduce any essential error into the figures given.

PRODUCTION OF DIFFERENT CLASSES OF IRON ORES IN 1906 IN TERMS OF PERCENTAGE OF TOTAL PRODUCTION.

		U.S.	Canada and Newfoundland.
Class 1.	Magmatic segregation (magnetite)	.00	0
Class 2.	Pegmatite type (magnetite)	5.2	12.29
Class 3.	Lake Superior sedimentary type (hematite)	80.	
Class 4.	Clinton sedimentary type (hematite).......	8.	78.34
Class 5.	Carbonate type	1.	8.51
Class 6.	Brown ore type (limonite)................	5.8	

The dominances of class (3) (Lake Superior ores) in the United States production shows how desirable it is to have the ores go through nature's concentrating mill. These are the only ores which have undergone second local enrichments. That the less desirable grades of ore should compete at all with the Lake Superior grades is due largely to lower freights between ores and furnaces, between fuel and fluxing materials and furnaces, and between furnaces and consuming centres. Iron ores differ from most other metallic ores in that their great bulk, as compared with their value, required cheap transportation, which operate to develop certain low grade deposits well situated in this regard at the expense of better grade ores.

Turning to the Canadian production, it appears from the table that the proportions of different classes of ores mined are quite different from those of the United States, and that a far larger proportion of Canadian ores is being drawn from less desirable classes. The class which produces 86 per cent. of the United States production produces only 12.29 per cent. of the Canadian production.

It appears, therefore, that in order to compete with the United States on equal terms so far as grades of ore are concerned, Canadian ores of the Lake Superior type must be more largely developed. The proportions and amounts of ores of the Lake Superior type now mined in Canada are not far different from those of the United States fifty years ago, before the advent of high grade Lake Superior ores had revolutionized the industry. It is not meant to imply that Canada is fifty years behind the times in this regard, but rather to call attention to its latent possibilities for the future and probable direction of development. It does not follow that the production of ores other than of the Lake Superior class may not also increase, because of low freights or artificial aids in the way of tariff or for other reasons.

Similar conclusions seem to follow from a consideration of ore reserves. I fully realize the uncertain nature of estimates of undeveloped deposits and the wide variety of figures that may be gotten by conscientious observers with different points of view or different methods, but certain essential features of our knowledge concerning reserves are fairly well established and a brief summary of them will help to bring the Canadian iron ore situation somewhat more definitely before us.

The titaniferous ores of class (1) not being mined, there is no point in attempting estimates, indeed, they are not sufficiently well developed to warrant estimates.

The British Columbia magnetites of class (2) have been subject to a wide range of estimates depending upon how low a grade of ore is included, upon the depth arbitrarily assigned and upon the extent to which isolated portions of deposits are assumed to be continuous. Using only the extents and depths known, the tonnage of ore of commercial grade may be measured in a few tens of millions.

The difficulty of estimating the Attikokan and Hutton ore of class (2) is due to their mixture of greenstone, making it impossible to predict in advance of exploration the extent of the deposits. In both districts the explorations show at least several millions of tons.

For the Lake Superior ores of type (3) in the Michipicoten district, Coleman and Willmott have estimated a reserve of possibly two millions of tons. Some of this reserve is of doubtful value because of high content of sulphur. In the Animikie district the tonnage is problematic because of conditions described for that district, but at best the ore to be recovered is not in large amount. The reports of hundreds of millions of tons of ore of the Lake Superior type in various parts of Canada so frequently seen in print are without foundation except as they cover commercially non-available lean iron formation rather than ores. Even under the best conditions but a small fraction of the iron of these formations is likely to be in ore of commercial grade.

The Grenville ores of lower Ontario show wide variations of estimates depending upon the factors chosen. The known dimensions of commercial grades indicate not more than a very few millions of tons.

I have little knowledge on which to base an estimate of the Londonderry carbonate and limonite ores, but no one claims these deposits to be of the first magnitude.

The ores of the Clinton type of Newfoundland (class 3) are sharply delimited on Belle Isle and the reserve tonnage carefully estimated. The doubtful features are the amount of ore below present commercial grade and the amount of available ore in the beds known to extend under the ocean. The ore on the island alone has been estimated at about thirty millions of tons. The amount available beneath the ocean is now being demonstrated by drifting and may be several times this figure. The reserve is large because the ores make up the entire beds, rather than concentrations within the beds.

The similar beds of Nova Scotia are so thin that only a part of them can be counted as commercially available. A commercial estimate has been four million tons to level of 700 feet on the principal group of properties.

It appears in general, then, that the proportion of reserve of Canadian ore of the Lake Superior type to the total reserves is probably not greater than the proportion of their annual production to total annual production. It is not held for a moment that the tonnage of some of these deposits to be ultimately developed may not be considerably larger than here indicated, but whether they be increased or decreased, it will be because of introducing factors of depth or grade partly common to all of them. This is not likely to change their proportion sufficiently to obscure the fact that the most desirable ores of the Lake Superior type of class (3) are not yet developed in large enough tonnage to insure the future competition of Canadian iron ores with those of the United States on an equal basis. In competition with the great reserves of high grade ores of the Lake Superior region the principal Canadian reserves thus far developed suffer handicaps in grade and in content of deleterious constituents. These handicaps are and will be overcome to a certain extent by bounties or locally by favorable conditions of transportation, but that they exist is shown by the extremely vigorous search for iron ore of the Lake Superior type by Canadian mining interests, by the importation of Lake Superior ore to the amount of 4 /5 of the ore used in Ontario, and by the recent increase in proportion of ore imported to home production, due to Canadian demand for finished products having gone ahead of the production from Canadian ores.

That ores of the Lake Superior type are in larger quantities in Canada than are now known seems likely, in view of the position of the Lake Superior region as a mere southern fringe of the great Canadian area of the pre-Cambrian rocks. Their discovery will require closer search than has been previously made in any but isolated localities, for it is not only necessary to find the iron formation, but to find the small fraction of this formation which happens to have been concentrated. The vast area, the difficulties of travel, and the drift covering, requiring drilling, all combine to make the task a difficult one and partly explain why the search is not farther advanced. On the other hand, exploration may never develop abundant ores of the Lake Superior type for geological reasons discussed under class 3.

THE IRON ORES OF ONTARIO*.

(By A. B. Willmott, Sault Ste. Marie, Ont.)

(Ottawa Meeting, 1908.)

This article, like many of its predecessors, must be a record of what we are going to do in the development of the iron ore resources of Ontario, rather than of what we have accomplished. It will be a statement of the opportunities open for the iron-ore miner, rather than a statement of results attained. The production of iron ore in Ontario has been as follows:—

	Tons.	Value.
1869–1896	582,542	$1,445,225
1897	2,770	4,996
1898	27,409	48,875
1899	16,911	30,951
1900	90,302	111,805
1901	273,538	174,428
1902	359,288	518,445
1903	208,154	450,099
1904	53,253	108,068
1905	211,597	227,909
1906	128,049	301,032
1907	200,185	471,127
	2,153,998	$3,892,960

CHARACTER OF ORES.

Hematite.—We have in Ontario all the usual varieties of merchantable iron ore. Of the total production by far the larger amount, namely, about one and a half million tons has been of hematite ore. So far as this has come from the Helen Mine there

Note by the Author:—

*This paper is written at the request of our energetic secretary who thought that a compilation of our present knowledge of the iron ores of Ontario would be of value in view of the proposed visit of the members of the British Iron and Steel Institute. This must be my apology for burdening the already large literature on the subject with still another paper.

has been mixed with the pure hematite a certain amount of limonite and goethite which would make the product of that mine strictly classed as brown hematite. An average analysis of 20,000 tons of the earliest shipments from the Helen, runs as follows:—

Moisture at 212° F.	6.610	per cent.
Iron	58.70	"
Silica	5.660	"
Alumina	0.730	"
Lime (CaO)	0.210	"
Magnesia (MgO)	trace	
Phosphorus	0.114	"
Sulphur	0.047	"
Organic matter and combined water	9.670	"
Insoluble	6.040	"

The average cargo analysis for 1901 was 58.709% iron, and for 1907 just a shade better, showing that this property has maintained its grade as depth has been attained. Ores similar to the Helen have been discovered and explored at several other points, as Steep Rock, Frances, and Josephine, but as yet there has been no production. From a number of properties in eastern Ontario, of which the Wallbridge, Dalhousie and McNab are the chief, about 150,000 tons of hematite have been produced. These ores have been good in their iron, phosphorus and sulphur contents, and carried small percentages of lime which was an additional advantage. All these eastern deposits have so far proved small and there is reason for believing that some of them, if not all, are oxidised portions of iron pyrites beds lying below. From the Stobie Mine in Aberdeen township, a few small cargoes of specular hematite of good quality were shipped some years ago. Similar specular hematites occur in the quartzites of the Lower Huronian at a number of points, as at Killarney, Algoma Mills, and around Echo Lake. In Aberdeen township a vein of high grade hematite occurs at the contact of a quartzite and slate conglomerate, and has been traced by pits at intervals for over a mile.

Analysis shows as as follows:—

Iron	65.60%
Managanese	.10
Silica	1.73
Alumina	1.31
Lime	.39
Magnesia	trace
Phosphorus	0.045
Sulphur	.005

A somewhat slaty hematite occurs on the Williams property a few miles north of Sault Ste. Marie, Ont. A silicious hematite, but otherwise of excellent quality, occurs in the flat lying Upper Huronian at Loon Lake east of Port Arthur.

MAGNETITE.—Of the total production of the province about 600,000 tons have been of magnetite. For the most part these ores have been high in iron, low in phosphorus, high in sulphur, and with titanium absent. The average of ten samples of Belmont ore taken by Prof. Miller, runs:—

Iron	60.02%
Phosphorus	.015

A shipment of 800 tons from the same mine averaged:—

Iron	57.38%
Phosphorus	.01
Sulphur	.08

A shipment of 8,514 tons of Farnum ore ran iron 54.05, phosphorus .018, and sulphur .059, titanium nil. A pile of 7,000 tons of ore from the Wilbur Mine averaged 57% iron, and under .01 phosphorus. Thirty-seven determinations for phosphorus made by Ingall on magnetites from the vicinity of the Kingston and Pembroke Railway ran from a trace to .17, averaging .022.

From the northern part of the province magnetites have been mined this past year, and will be shipped in an increasing amount next year. Atikokan ore from mining locations E. 10 and 11, has been smelted this season in the furnace of the Atikokan Iron Company, at Port Arthur. Surface samples from this property run, iron 66.5, silica 3.2, phosphorus .015, and sulphur .01, according to sampling and analysis by Hille (1). An average of seven samples of the best ore from a number of diamond drill cores is given by Hille as iron 59.3, Phosphorus .069, sulphur 1.09, and this probably fairly represents the ore when below the zone of oxidation. The ore is being roasted by blast furnace gas before being smelted, and is giving excellent results in the manufacture of foundry pig.

(1) Jour. Can. Min. Inst. 9–1906.

A property a short distance to the west has been explored this past year by the United States Steel Corporation, and purchased by them. Surface samples show magnetite running from 53% to 67% in iron, .007 to .058 in phosphorus, and .07 to .5 in sulphur.

Another property which will this year begin shipping magnetite is the Moose Mountain lying north of Sudbury, of which the guaranteed analysis is, iron 55.5, phosphorus .10, and sulphur .011.

TITANIFEROUS MAGNETITE.—There are throughout Ontario a number of considerable ore bodies of titaniferous magnetite, such as the old Chaffey Mine, and the Matthews Mine on the Rideau Canal, from which several thousand tons were shipped years ago. Near Gooderham, Ont., is a similar deposit, in connection with a large gabbro intrusive. Near Chapleau, Ont., a magnetite deposit carries 10% titanium. The Orton Mine in Hastings county, an undeveloped prospect, carries from 1% to 3% titanium. In twenty-five samples of magnetites taken by Ingalls along the Kingston and Pembroke Railway, titanium was absent in 13, and 12 went between 1.03% and 16.45%. Numerous other occurrences are known, but in practically every case titanium is absent from the magnetites and hematites of Ontario except where the deposit is connected with basic eruptives.

LIMONITE.—Bog ore occurs at many points throughout the province as deposits resulting from the leaching of the glacial drift. There are also numerous deposits resulting from the weathering of iron pyrites, and some from the weathering of iron carbonate.

Back as far as 1813 small quantities of bog ore from Norfolk County were smelted in a small furnace at Normandale. In more recent years bog ores from Oxford county and vicinity have been smelted in small quantity at Hamilton. As already mentioned a percentage of limonite is mixed with the Helen ore, which has been classed as a hematite. Bog ores resulting from the oxidation of pyrites occur at Paint Lake in western Michipicoten, Goudreau Lake near Missanabie, and in the vicinity of the Josephine. Similar ore is seen near some pyrites deposits near Steep Rock Lake, and also in Parkin township north of Sudbury. Eleven cars of limonite, from what afterwards became the Bannockburn Pyrites Mine, were smelted at Hamilton. The better class of such ores run from 50% to 55% in iron, and under .5% in sulphur. On the Mattagami River, there is a limonite deposit resulting from the oxidation of iron carbonate occurring in the Devonian limestone. This ore runs from 48% to 57% in iron, and about .1 in sulphur, and from .1 to .2% in phosphorus. Similar ore is found at a number of points in the valley of the Moose River, and its branches, originating in a similar way.

SIDERITE.—In connection with a number of hematite deposits in Ontario, quantities of siderite are found which may yet become of commercial value. On the hill back of the Helen Mine, there are exposed siderite lenses aggregating a width of 136 feet, and averaging 34.94% in iron, and 7.7% insoluble. A picked specimen yielded:—

Insoluble	4.38%
Carbonate of iron	78.57
Carbonate of magnesia	12.84
Carbonate of lime	4.09
Alumina	trace
Total	99.88
Metallic iron	37.71%

Ore of this character in considerable amount is found at the Josephine, at Steep Rock Lake, and at other points throughout the province. It is almost always contaminated with sulphur up to 1% or 2%, and but for this might be considered a fair ore of iron. It is low in phosphorus, and on roasting would yield a product running 50% in iron, and the roasting would eliminate the sulphur. The magnesia and lime present would serve as useful fluxes.

In the vicinity of Port Arthur in the Animikie formation are considerable bands of siderite somewhat lower in iron content, and correspondingly higher in silica. The bands correspond to the taconite of the Mesabi range, though they are higher in carbonate of iron. One deposit north of Port Arthur is said to be 500 feet long by 100 feet wide, by 12 feet deep, and to average 33 per cent. iron. On the Opazatika River, and on other tributaries of the Moose, iron bearing limestones are found. These carbonates are probably too low in iron ever to be of direct value as an iron ore; possibly, however, bodies of hematite may yet be found in their vicinity. (1)

(1) Bur. of Mines, Vol. 13, pages 150–152.

MAGNETIC SANDS.—At many points in the province iron sands are being, or have been, concentrated by the waters of the Great Lakes. Such a deposit is found in the vicinity of Peninsula Harbour on the north shore of Lake Superior. On the north shore of Lake Erie a small amount of such sands was smelted in the funace at Normandale nearly 100 years ago. It is improbable that these sands can be made of commercial value at the present time.

GEOLOGICAL CLASSIFICATION OF ORES.

The geological formations occurring in Ontario, beginning at the most recent, are as follows:—

Cenozoic	Pleistocene
Paleozoic	Devonian Upper Silurian Lower Silurian Cambrian
Pre-Cambrian or Archean	Keweenawan or Nipigon Animikie or Upper Huronian Middle Huronian Lower Huronian (Laurentian Eruptives) Keewatin

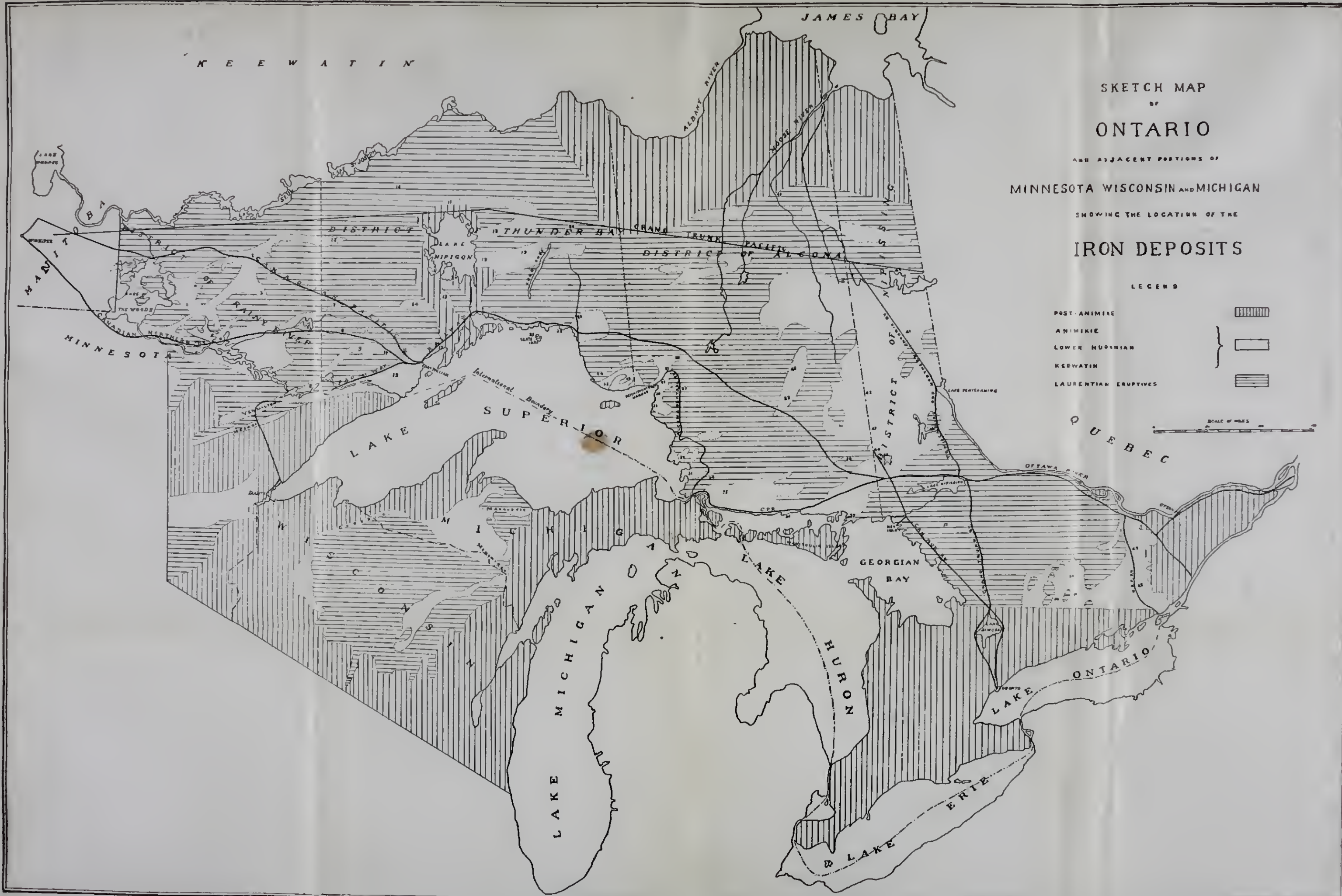
In this classification the recommendations of the International Committee on the succession in Lake Superior region have been followed (1). The Laurentian granites, etc., which used to be considered the base of the geological column are now recognised as eruptives, always later than the Keewatin, and very frequently later than the Middle Huronian. In the eastern section of the province, the international committee recommended the following succession from below, Laurentian, Grenville, but Miller has shown (Bur. of Mines, Vol. 16, page 221) that rocks undoubtedly Keewatin occur in that section of the province, and that the Grenville is really an upper portion of the Keewatin. Miller further finds an

(1) Journal of Geology, 1905, or Bur. of Mines, Vol. 14, page 269.

overlying formation carrying pebbles of the Grenville, which he considers Huronian. His classification corresponds closely with that adopted for the Lake Superior region, and permits an orderly arrangement of many facts, which did not fit with the previous classification.

In the Pleistocene we have only the insignificant deposits of bog iron. In the Devonian there are some siderite deposits now altering to limonite in the valley of the Moose River, which are as yet unknown, and so far of no commercial value. The Clinton formation of the Upper Silurian is in Ontario commercially barren, although a small deposit has been found near Cabot Head. The base of the Medina of the Upper Silurian is marked by red ocherous clays, which are, however, of no value. At the base of the Potsdam of the Cambrian, there are some deposits of impure hematite, such as that at Dog Lake, north of Kingston. At the base of the Keweenawan again, there are some ocherous clays which in places almost approach iron ores, but are so far of no commercial value. In the Animikie there are possibilities of commercial ores. This formation is the one which on the United States side of Lake Superior carries the Mesabi, Gogebic and Menominee iron ranges. It is found in Ontario in the triangular area between the Port Arthur, Duluth, and Western Railway, Lake Superior, and the American boundary. At numerous points in this area indications of ore have been found, and large ore bodies have been developed at Loon Lake. In the vicinity of Sudbury is another Animikie area, but so far as known carrying no iron deposits. Except these two areas, and a few other very small areas the Animikie is unknown in Ontario. North of the province on the eastern shores of James Bay, rocks apparently of the Animikie series are found on the Nastapooka Islands. Here very considerable bodies of iron ore have been found, and when transportation difficulties are removed these ores will undoubtedly come on the market.

The Lower Huronian formation is widely distributed throughout Ontario, the typical region being that north of Lake Huron. It should be noted that all the older geological maps and reports by Canadian Geologists, use the term Upper Huronian for what is now called Lower Huronian, and similarly Lower Huronian was used in the older reports for what is now termed Keewatin.



SKETCH MAP
OF
ONTARIO
AND ADJACENT PORTIONS OF
MINNESOTA WISCONSIN AND MICHIGAN
SHOWING THE LOCATION OF THE
IRON DEPOSITS
LEGEND
POST-ANIMIKIE
ANIMIKIE
LOWER HURONIAN
KEEWATIN
LAURENTIAN ERUPTIVES
JAMES BAY
KEEWATIN
DISTRICT OF THUNDER BAY
DISTRICT OF ALGOMA
GRAND TRUNK PACIFIC
LAKE NIPIGON
DISTRICT OF RAINY RIVER
LAKE OF THE WOODS
CANADIAN NORTHERN
MINNESOTA
LAKE SUPERIOR
International Boundary
MICHIGAN
WISCONSIN
LAKE MICHIGAN
LAKE HURON
GEORGIAN BAY
LAKE ONTARIO
LAKE ERIE
QUEBEC
OTTAWA RIVER
DISTRICT OF NIPISSING
ALBANY RIVER
MOOSE RIVER
C.P.R.

On the accompanying map the areas of Keewatin and Lower Huronian are outlined with as great accuracy as our present knowledge of the unsettled regions of Ontario will permit. It has not proved possible to show them separately on a small scale map even when the information was at hand to do so. So far little iron ore of commercial value has been found in the Lower Huronian areas. In Deroche township north of Sault Ste. Marie, some prospecting has been done with fair results. In Long and Rutherford townships, deposits of specular hematite have been found in small quantities. In Aberdeen township a more promising prospect occurs. All of these deposits are associated with quartzite or slate. The banded jasper and hematite of the Marquette range is for the most part absent in the typical Lower Huronian area. In Harrow township the typical iron formation does, however, occur in the Lower Huronian, and at two other points iron carbonate has been found.

In the Keewatin the most promising iron deposits of Ontario are found. This formation is very widely distributed and in practically every place where Keewatin or Huronian are marked on the various geological maps, bands of sedimentary iron formation can be found. These may be small in extent, representing only the last remnants of a large area, or they may be long and narrow belts. Usually the bands are only a few hundred feet wide; almost always less than half a mile. Most frequently there are a series of lenses ranged in a row or occasionally in a few parallel rows. At times the iron belt extends for many miles enclosed on either side by green schists. The Nipigon-Long Lake belt is almost continuous for 70 miles.

The ores associated with the basic intrusives may occur in different periods, but seem to be all pre-Cambrian.

The iron ranges on the American side of Lake Superior show a close similarity geologically to those in Ontario. As seen on the map the various producing ranges occur in the Keewatin, Huronian, and Animikie series of the Archean. These formations occur as narrow belts between the eruptive granites, just as in Ontario. The characteristic association of banded jasper with ore is true on both sides of the lake. In the following table the total production of the different ranges is given.

Range.	Year opened.	Total Tons	Shipments per cent.
Marquette	1855	84,849,280	22.3
Menominee	1877	63,806,652	16.7
Gogebic	1884	54,023,478	14.2
Vermilion	1884	26,785,950	7.0
Mesabi	1892	150,198,054	39.4
Ontario	1900	1,400,000	.4
		381,063,414	100.0

The Ontario production is made up mainly of shipments from the Helen Mine on the Michipicoten Range, and the McKellar property on the Atikokan. Both of these properties are in the Keewatin formation, as also are the mines in the Vermilion. The mines of the Menominee, Gogebic and Mesabi are all in the Animikie, and most of the Marquette production comes from the Lower Huronian, although a portion of it is at the base of the Animikie, practically at the contact with the Lower Huronian. Assuming that the whole of the Marquette production is from the Lower Huronian, one finds that of the total production of iron ore from around Lake Superior, 70.3% has been produced from the Animikie, 22.3 from the Lower Huronian, and 7.4 from the Keewatin.

COMPARISON WITH SCANDINAVIAN ORES.

In the transactions of the American Institute, 1907, a classification of the Scandinavian Iron Ores is given by Prof. Sjorgen. Considering the similarity between the general geological conditions of Scandinavia and northern Ontario, a comparison is of interest.

1. Ores of the Archean Crystalline Schists.
    - A. Apatite Ores.
    - B. Mixed Hematite and Magnetite.
    - C. Quartz Banded Ores.
    - D. Skarn Ores.
    - E. Limestone Ores.
2. Ores of the Porphyries.
3. Magmatic Segregations in Basic Eruptives.
4. Iron Ores of Metamorphosed Cambro-Silurian Schists.
5. Contact Deposits in the Christiana Region.
6. Lake and Bog Ores.

Of these groups numbers 2, 4 and 5 are not found in Ontario. While eruptive porphyries occur, so far we have no iron ores associated with them. In Ontario there are no metamorphosed Cambro-Silurian Schists, nor eruptives of the post-Silurian age, so that groups 4 and 5 are impossible. The other groups 1, 3 and 6 are found in Ontario, and closely resemble the corresponding deposits in Scandinavia. The Apatite ores of group 1, resemble closely the ore mined in the Lake Champlain region of New York State, which again is closely paralleled by some deposits in eastern Ontario. The mixed hematite and magnetite deposits free from banded material are not common in Ontario, but the deposit north of Cartier would seem to resemble corresponding deposits in Scandinavia. The quartz banded ores are extremely common in Ontario, more so than in Scandinavia. Typical occurrences are those of the Mattawin, Michipicoten and Temagami ranges. The Skarn ores and Limestone ores of groups D. and E. can be paralleled from some of the minor deposits in eastern Ontario. Magmatic segregations in basic eruptive rocks, group 3, are very common in Ontario, and titaniferous as in Scandinavia. The Lake and bog ores of the two countries are naturally similar.

GENESIS OF IRON ORES.

As previously stated the majority of the Ontario ores occur in the Keewatin formation. At the base of this series is a mass of greenstone frequently ellipsoidally parted, which is the oldest known rock of the Lake Superior area. Overlying this are various green schists, and towards the top of the series the iron formation proper. This consists of ferruginous cherts more or less banded with hematite and magnetite, iron carbonate and iron pyrites. Carbonated schists frequently border the iron formation. Originally these belts seem to have been a chemical sediment, but are now found in nearly every case closely folded, and standing nearly vertical. Transverse folding has been a very common occurrence, and the anticlines have been frequently eroded until the formation has been cut off into separate lenses, varying from a few feet to a few miles in length. In most cases the width of the formation is a few hundred feet, and occasionally up to half a mile. Folded with the iron formation there is usually a bed of green schists which forms an impervious layer at the bottom of the basin. The American geologists who have closely studied the Vermilion and other south shore ranges are of the opinion that the ores associated with these ranges have resulted from descending water concentrating the leaner ores from above, in the bottoms of these basins. Iron carbonate is supposed to have been the most frequent source of the ore, but both iron silicate and iron pyrites have also contributed. Probably in our Ontario ranges iron pyrites is a larger contributor than in the ranges to the south, as it occurs much more frequently in the iron ranges to the north of Superior than to the south. In some few cases the original deposits in connection with the formation seem to have been rich enough to make an iron ore without further concentration. In other cases there are lean silicious magnetites up to 40 and 45%, which can hardly be classed as commercial ore bodies, and which might well represent original deposits without secondary concentration. In these the silicious bands are absent, the silica being more evenly distributed through the whole mass. Another class of ore bodies includes those which are regularly banded, consisting of either hematite or magnetite, alternating in narrow bands from ⅛ in. to 2 in. in width, with bands of quartz which may be white chert, or red or black jasper. It is with the more granular cherts that the hematite ore bodies so far discovered have been found.

SPECIAL DESCRIPTIONS.

An attempt has been made to show on the map the principal areas in which iron ores have been found, and to add here a very brief description concerning them. It is probable that in every area shown on the map as containing Keewatin rocks, the iron formation will be found when search is made. In the following descriptions the numbers after the names refer to the corresponding numbers on the map.

The Dryden and Wabigoon area (1) shows a number of bands of lean silicious magnetite with assays running in the vicinity of 40% iron. Kaiarskons Lake deposits (2) of silicious magnetite with some higher grade lenses have been slightly explored. Parallel to it is a belt of iron pyrite characteristic of the Keewatin ranges. At Bending Lake (3) a number of locations have been taken up on a silicious magnetite somewhat similar to the two previous ones. In Watten and Halkirk townships on Rainy Lake (4) a band of the iron formation has been found, containing magnetite and particularly rich in sulphides. It is traceable at intervals for some miles either way, and is really part of one belt extending from Fort Frances up the valleys of the Seine and Atikokan as far as Magnetic Lake, a distance of slightly over 100 miles. At Steep Rock Lake (5) the formation has been considerably bent. Diamond drilling on the eastern arm of Steep Rock Lake, and also on Strawhat Lake has disclosed fair bodies of hematite ore. In these cases, as in several others in Ontario, bodies of iron pyrites are found in close contact with, but not contaminating, the hematite ore. Considerable bodies of siderite also occur. Through the valley of the Atikokan (6) are a number of deposits of magnetite standing out as low hills in the valley, and accompanied by various green schists. These magnetites are low in phosphorus, but high in sulphur. The deposit of McKellars is now being worked by the Atikokan Furnace Company, and a property a short distance west of this, after careful exploration, has been bought the past year by the United States Steel Corporation. On Fire Steel River (7) bands of pyrites are known which represent the iron formation in that belt of Keewatin. On Hunters Island (8) there are several parallel belts of the iron formation which may represent a folding of the Keewatin, but possibly as suggested by Leith some of the belts are Huronian. The Hunters Island range is in line with the Vermilion, and distant from the closest part of it about 20 miles. There has been little exploration beyond surface work, but it is reported that the little drilling done was fairly successful. At Greenwater Lake (9) is a continuation of the Vermilion-Hunters Island belt, and this continues to the east through the Mattawin area (10) and Conmee and Ware townships (11). These last three occurrences are all similar in character, showing banded jaspers with magnetite and hematite. Picked samples from the surface of locations on the Mattawin yielded 58% to 68% iron, .013 to .056 phosphorus, .054 to .164 sulphur, and titanium nil. The amount of ore in this belt is very considerable, but so far the limited exploration which has been done has not revealed any large concentrations. The ore is favourably situated for transportation, and could be quarried from hillsides. Until, however, the higher grade ores are mined out, it is questionable whether these surface deposits running 40% in iron can be economically concentrated. There is, however, a probability that bodies naturally concentrated may be found if properly sought. The Animikie formation (12) occupies a considerable area round Lake Superior, and at many points within it carbonate of iron running 20% to 25% is found.

At Loon Lake and vicinity, 25 miles east of Port Arthur, considerable exploration work has been done resulting in the finding of several beds of excellent hematite ore, narrow, however, in width, and separated from each other by lean material. This ore where pure is high in iron and low in phosphorus and sulphur, and carrying a little lime, is altogether an excellent furnace ore. The costs of mining and concentration are, however, problematical, and no company has yet attempted to operate commercially. Altogether there is a big tonnage of ore which will undoubtedly be valuable before long. It is only four miles from Lake Superior, and is traversed by the main line of the Canadian Pacific Railway. A second series of beds lie above those already mentioned, which contain even larger quantities of iron. This is, however, only about 35% ore, and high in phosphorus and sulphur. On Black Sturgeon River (13) are some deposits of hematite in the Keewatin of a promising character. At Little Pike Lake (14) specular hematite interbanded with a gray slate occurs on a number of locations taken up some years ago, but on which no work has been done. At Savant Lake (15) the usual iron range rocks of the Keewatin occur, and search may result in the finding of merchantable ore. On Whitearth Lake (16) iron range rocks are reported. At Cariboo Lake (17) lean silicious magnetite is found over a large area, also at Mud River, somewhat to the east. In the valley of the Red Paint (18) the Keewatin formation is traceable for some miles, and some diamond drilling was in progress last year. The Nipigon-Long Lake (19) belt is 70 miles long and almost continuous. At the Nipigon end three parallel belts are found, the centre hematite, and the north and south magnetite. A little drilling has been done but not enough to determine definitely. At Little Pine Lake (20) a similar formation occurs, and also on the Slate Islands (21). On Lake Superior at the mouth of the Little Pic (22), locations were taken up years ago for a magnetite associated with a basic eruptive.

The ore is lean and probably useless. Ten miles up the Pic River (23) are some magnetite locations showing iron ore carrying about 45% and contaminated with a little sulphur. At Otter Cove (24), in a small fragment of the Keewatin, a lean magnetite occurs. At many points throughout the Keewatin belt of the western part of Michipicoten (25) the usual iron range rocks are found. Towards Lake Superior these occurrences are silicious magnetites; further north they are banded cherts with hematite and magnetite. At the Frances diamond drilling as shown towards the bottom of one of these basins, considerable hematite of good quality. In central Michipicoten we have characteristic banded cherts and hematite at a number of points. At the Helen Mine (26) is the largest ore body yet exploited in the province, which has yielded about one and a third million tons of ore, to the end of 1907. Associated with this ore, as is so often the case, are deposits of pure pyrites. At the Josephine (27) drilling has shown considerable ore, under the waters of Parks Lake. The iron range is traceable both east and west from the lake, and theory indicated that where the iron-bearing rocks had been broken down and eroded so as to form a lake basin, a deposit of ore might be sought, and this was done successfully. Further to the north (28) the range is so rich in sulphur, that it has become of value as a source of iron pyrites, iron oxide except as a gossan being practically absent. At Michipicoten south, lean magnetites are found at several points as at Anjigomi (29) and Bridget Lake (30). At Cape Choye (31) and eastward, an unimportant belt of Keewatin occurs, carrying lean hematite and magnetite. At Batchawana (32) banded jasper and hematite occur a few miles from Lake Superior, and six miles further back several deposits of lean magnetite. At Goulais Bay (33) a belt of the Keewatin formation runs east and west for several miles, and is enclosed by rocks of the Lower Huronian. The brilliant jasper conglomerates which occupy miles of the Lower Huronian have always proved extremely interesting, and until the discovery of this Goulais belt, no source of the jasper pebbles was apparent. The probability is, that this is only a small part of one of several buried ranges. In Deroche and adjoining townships there are several occurrences of hematite associated with quartzite and slate. Some of these lenses are good ore, but no large bodies have yet been found, though further development is warranted.

From Aberdeen township (35) several small vessel loads of good hematite were shipped years ago. In the northern part of the township a promising prospect of hematite is being developed, which occurs at the contact of the slate and quartzite. In the townships of Long (36) and Rutherford (37) occurrences of high grade specular hematite in the quartzite have been explored, but the deposits have proved small. North of Cartier (38) a deposit of hematite and magnetite is of considerable promise. At Woman River (39) and north of Flying Post (40) belts of banded jasper and hematite are found continuous for some distance, and of considerable width. At the Grand Falls on the Mattagami (41) carbonate of iron and the resulting limonite are found. Further exploration of these and similar deposits occurring in the Devonian may show ores of value as soon as transportation has been provided. At Shining Tree Lake (42) and Burwash Lake (43) the usual banded ores are found. At Moose Mountain (44) is a large deposit of magnetite, which seems to be an original deposit, and not a secondary concentration from the usual leaner ores. This property is now connected with the Georgian Bay at Key Inlet by railway, and shipments will begin on a large scale next season. To the north and west banded iron continues, and is found on the Wahnapitae (45) to the south east. Around Temagami Lake (46) are several belts of the usual iron range rocks making altogether a good many miles in length. On the Caldwell-Mulock property a little diamond drilling has been done, but with this exception these ranges are as yet unexplored. In Boston township (47) lean magnetite has been found, and a little exploration work has so far failed to locate commercial ore bodies. At Lake Abitibi (48) the usual iron range rocks occur. Along the Kingston and Pembroke Railway in Eastern Ontario are numerous deposits of magnetite which have been worked in a small way in years gone by.

Similar occurrences are found in Hastings and adjoining counties (50). In both these districts the magnetites are fairly high in iron, low in phosphorus, and apt to be contaminated with sulphur. In the Parry Sound district (51) there are several occurrences of magnetite, associated with limestone. This area has not yet been mapped so that an outline of the Keewatin and Huronian cannot be given.

CONCLUSIONS.

There is no other area in the world equal to the Lake Superior region as a producer of high grade iron ore. The only competitor is the Minette region of Germany, France and Belgium, which is being rapidly left behind. The following table shows the great increase in production which has yearly taken place on the American side of Lake Superior.

PRODUCTION OF IRON ORE FROM LAKE SUPERIOR.

1891	7,621,465	long tons.
1892	9,564,388	"
1893	6,594,620	"
1894	7,682,548	"
1895	10,268,978	"
1896	10,566,359	"
1897	12,205,522	"
1898	13,779,308	"
1899	17,802,955	"
1900	19,121,393	"
1901	20,593,537	"
1902	27,571,121	"
1903	24,281,575	"
1904	21,726,590	"
1905	34,241,498	"
1906	38,393,495	"
1907	41,817,385	"

But even the immense resources of the American side of Lake Superior will reach an end. The serious drain on this supply is well shown in the following quotation from Van Hise, one of the best authorities on Lake Superior iron mines.

"The total product of the Lake Superior region since mining "began in 1850 to 1899 inclusive is 171,418,984 long tons. The "amount mined in the decade between 1891 and 1900 inclusive is "114,017,546 long tons, or 66.5 per cent. or nearly seven tenths of "the total amount mined. The product for the year 1900 surpasses "that of any previous year, and is one ninth of the aggregate of "this and all preceding years. It is certain that the product of "the current decade will far surpass that of the last decade."

It is most striking that the production for 1907 is also one ninth of the aggregate of this and all preceding years.

This season as a result of the investigation by the Tax Commission of Minnesota, it has been determined that the Minnesota deposits of ore approximate 1,170,000,000 tons. The total tonnage for the Lake Superior district of the United States, including undeveloped lands amounts to 2,000,000,000. This, on the basis of last year's consumption will last fifty years, but as is shown in the preceding table, consumption is advancing with rapid bounds. Already lower grade ores are being marketed than a few years ago was thought possible. In 1907 the standard for iron ore was reduced from 56.7 to 55, and this will undoubtedly continue as iron ore becomes scarcer. Moreover three quarters of the ore reserves of Minnesota are in the hands of one company. As the scarcity develops on the southern side, the search for ore among the iron formations in Ontario must correspondingly increase. As shown on the map the same geological formations are found throughout northern Ontario, as in Minnesota, Wisconsin and Michigan. One mine in Ontario has already produced one and a third million tons of ore, and two other properties have begun shipment. It will be extremely strange if the banded jasper and hematites found for so many hundred miles throughout northern Ontario are not in places associated with iron ore, as they are on the south side of Lake Superior. When these surface indications on the Canadian side are followed up as they have been on the United States side, similar ore bodies will undoubtedly be found. The amount spent on exploration on the Vermilion range alone, between Tower and Section 30, a distance of say thirty miles, probably surpasses all the money spent in actual exploration of the hundreds of miles of similar ranges in northern Ontario. Not only must part of the future demands of the United States be met from Ontario, but the Ontario demand itself must also be provided for. As shown in the accompanying table we only furnished last year % of the ore required for our Ontario furnaces. Indeed from 1901 and onward the per cent. of Ontario ore used in our furnaces has steadily decreased.

CONSUMPTION OF IRON ORE IN ONTARIO.

	1901	1902	1903	1904	1905	1906	1907
Ontario ore smelt'd	109,109	92,883	48,092	50,423	61,960	101,569	120,177
Foreign ore smelt'd	85,401	94,079	103,137	173,182	383,459	396,463	388,727
Ratio Ontario ore to total	56%	50%	32%	23%	14%	20%	23.6%
Pig made.	......	......	......	127,845	256,704	275,558	..,....

As stated in the beginning of this paper the record of the production of iron ores in Ontario is rather one of opportunity than of achievement.

It has been suggested by several competent geologists that the only reason that can be suggested why the iron formations of Ontario should not overlie ore bodies as they do south of the international line would be the greater glacial erosion to the north. This reason does not appeal to me so forcibly as to some. It is generally accepted that the iron ore bodies of Lake Superior have been concentrated in underlying impervious basins by descending waters. The upper portions of the formations are left that much poorer, and it is these that have for the most part suffered erosion. In the "old ranges" of the south shore ore is being mined to a depth of 2,000 feet, and little of it came from near the surface. Even if it be granted that glacial erosion was carried deeper in Ontario (and this might be successfully disputed) unless it cut nearly to the bottoms of the basins the ore deposits would be only slightly affected. Severe erosion of this kind would have left only shallow and isolated patches of the iron formations instead of the hundreds of miles which are found in Ontario. Moreover, drilling has already established at several points that the formation is at least 500 to 1,000 feet deep. These considerations do not apply to the flat lying Animikie, where a few hundred feet of erosion would cut to the bottom of the basins.

To my mind the most striking differences between the United States and Canadian occurrences are (1) the relative greater abundance of the Keewatin iron formation in Ontario as compared with those of Lower Huronian and Animikie age, and (2) the more frequent occurrence in Ontario of iron pyrite with the ferruginous cherts, etc., of the iron ranges. Apparently iron pyrites and iron carbonate were somewhat equally deposited in the iron formations of Keewatin times, and iron carbonate predominated in Lower Huronian and Animikie times.

DISCUSSION.

MR. F. HILLE:—I am sorry Mr. Willmott did not lay more stress upon the Mattawin Iron Range, which, in my opinion, contains the greatest iron ore deposits in Canada of which we have knowledge. To give you an idea about some of these deposits I might mention only a few: one is over 700 feet wide by 3,400 feet long; another, over 1,000 feet wide by nearly two miles in length; and there are many others. We have drilled into these deposits over a thousand feet, of course not reached the bottom, and if we go by our geological survey, they may be over 10,000 feet deep. We can trace these deposits from 20 miles west of Port Arthur to the Vermillion range in Minnesota, thus you have an idea of the vast extent of this range. The ore is not of high grade, but it can be concentrated very cheaply into a high grade Bessemer ore with hardly any phosphor and sulphur.

Mr. Willmott spoke about assets of the Province of Ontario, not in the eastern deposits, but in the Mattawin range lies the greatest asset the province possesses. In a few weeks "the Mines Branch" will publish my report on part of this range from which you may learn more about it.

MR. DIXON CRAIG:—A few words with regard to the commercial aspect of this matter may be of interest. Prof. Willmott spoke of a mine in Ontario which produces some ore and two others which have begun shipping. The reason that these latter two are shipping is that this ore is low in phosphorus, or is a Bessemer ore, the supply of which in the Cleveland market to-day is practically nil. This is a great advantage to the ore as well as the local conditions, and although the Bessemer process is on the decline it will last for ten or fifteen years yet, so there will be a continued demand for this ore, and it can possibly be shipped to the U.S. and pay duty and still make a fair profit. The Canada Iron Furnace Company is using it at Midland with good results.

The reason for the small amount of exploratory work done in Canada is that under present conditions, with the keen competition in our markets from the United Kingdom and United States, we have not been able to make any of the large accretions of capital necessary to carry on this work. But to my mind the eastern Ontario magnetites offer a very promising field for prospectors.

THE IRON AND STEEL INDUSTRY OF THE PROVINCE OF ONTARIO, CANADA.

By Jas. Grannis Parmelee, Sault Ste. Marie, Ont.

(Ottawa Meeting, 1908.)

To describe the general process of manufacture of iron and steel and the interesting details showing the capacity and general lay-out of the different plants throughout the province of Ontario, would consume too much time in the reading and too much space in publishing, and in consequence no attempt will here be made to more than touch on the various subjects, and if we are successful in our efforts, to give a brief outline of the more important plants in the province.

In point of tonnage and amount of capital invested, the largest single plant is that owned by the Lake Superior Corporation, which is operated under the name of The Algoma Steel Co., Limited. The plant, which is located on the St. Mary's River a short distance above the rapids, was built in 1901 and commenced operations in the spring of 1902. A dock 2,250 feet long is built along the river at which the ore vessels are tied up and unloaded by means of two bridges to the piles immediately behind the dock. The ore is brought from the Lake Superior ranges to the plant. The Corporation also owns the Helen mine, located about one hundred and thirty miles north of Sault Ste. Marie, but only a small percentage of the ore is used at the plant, as it is too high in phosphorus for use in the Bessemer process. This ore, however, is sold to other consumers, and exchanged for Lake Superior ores.

The two ore bridges for unloading vessels and transferring ore to the ore pile were designed by the Wellman-Seaver-Morgan Co. Each bridge has a span of 295 feet, and a height at the inner end of 84 feet and a height at the water end of 50 feet. The motive power for operating the bucket and for moving the bridge is furnished by two 130-h.p. 500-volt motors, which are installed in a house in the supporting legs at the water end. These motors are geared to counter shafting driving three winding drums through a train of gears and clutches, which are thrown in or out according to the motion desired. The handling capacity of the automatic buckets on the bridge is 70 tons per hour each.

The storage bin system is located 340 feet from the edge of the dock and is built of brick and steel, the total height being 40 feet. The ore is carried in steel bins of the Berquist type, of which there are eight, with a combined capacity of 3,000 tons, and when unloaded is either carried full length of the ore bridge to the bins, or, if the bins are full, it is dumped on the ore pile, and afterwards reloaded into the bins as required. Each bin is provided with four chutes and the necessary gates for controlling the removal of the ore. These chutes are located on the side of the bin away from the water end and deliver the ore into round buckets for the skip hoist used for charging the blast furnace. These buckets are placed on flat scale cars, which run on a track along the face of the bins and are operated by an electric motor, the current being supplied to it by a trolley. The bucket can thus be run under any desired bin for charging. A steel trestle 1,400 feet long and 40 feet high runs along the inner edge of the ore pile and on the centre line of the bins, which connects with the main line of the Algoma Central railway and with the yards of the Canadian Pacific railway, from which points the cars of raw material are switched to the required position for dumping directly into the bins.

Adjoining the ore bins there is a coke bin provided with 16 chutes, through which the blast furnace hoist bucket is loaded.

The skip hoists to the blast furnaces are operated by 135-h.p. motors driving a four foot winding drum through double reduction gearing. The motors are controlled by means of Otis magnet regulators, which are installed in the houses located at ends of the ore bins.

The blast furnaces are two in number and are on line parallel with the dock. No. 1 stack is 70 feet high, furnace bosh 17 feet and an 11-foot hearth, capacity 250 tons per day. The corresponding figures for No. 2 are: stack 80 feet high, bosh 17 feet, and hearth 10 feet 8 inches; capacity, 250 tons per day. Both are operating with coke for fuel. The general plan contemplates the addition of two 400-ton furnaces, the trestle and bin system of which are already in place. In the same line with the blast furnaces, and between them, there are seven fire-brick stoves 20 feet in diameter and 70 feet high. A steel stack 150 feet high at the rear of the stoves removes the waste gases after their passage through the stoves. The furnaces are provided with adequate dust catchers from which the dust is dropped direct into standard steel hopper cars. Beside each furnace, and with its axis in the same straight line joining the furnaces, are two cast houses of steel and corrugated iron structure, into which the iron may be run and made into pigs necessary, or into 20-ton ladles mounted on a standard gauge railway truck, which convey it to the steel plant mixer or to the pig casting machine.

These furnaces are being operated on a mixture of ore, a large percentage of which is obtained in the States, Ontario Bessemer ores not yet being mined in sufficient quantities to meet the present requirements. Coke is obtained in the Pocahontas fields in West Virginia and transported entirely by rail. No deposits of limestone have yet been located on the Canadian side, and the supply of this material is also obtained near by in the state of Michigan. The air blast for the blast furnaces is supplied by four blowing engines located in an engine house parallel with the blast furnaces. The engines are of the Steeple Corliss type and were built by the Mesta Machine Co. The steam cylinders are 72 inches by 60 inches. The engines run at about 40 revolutions per minute and are capable of blowing thirty pounds pressure. Each engine has a fly-wheel 24 feet in diameter. One engine is provided with a gear wheel on the main shaft, enabling it to drive two 225 kilowatt electric generators, which are used to supply current to the entire plant in case of emergency as a balance to the primary system, which is generated by water power, and for supplying power when water wheels become choked with slush and needle ice. The generators may also be run as motors, if desired, making this unit a very ingenious and interesting machine. The generator switches may be opened and the machine run simply as a steam driven blowing engine, similar to the other three engines in the building; or the steam may be shut off and the generators used as motors, thus making the machine a motor driven blowing engine. The air cylinders may be put out of service and the machine becomes a steam driven electric generating unit, or with the air cylinders at a combination electric generating unit and blowing machine. Is has been used in all four capacities.

Steam is furnished for operating the blowing engines by a battery of twelve Cadall vertical water tube boilers, each 250 h.p. The boilers are arranged in batteries of two, three, three and four respectively.

The boiler house is built of steel and is erected in a line with the engine house and about 50 feet distant. Each boiler is provided with a 36-inch stack 40 feet high.

The iron is delivered from the blast furnace into the 20-ton ladles, as noted above, and is conveyed by them to a steel and corrugated iron building about 800 feet distant from the furnaces, where is installed a three-strand Heyl & Patterson pig casting machine. The machine is fed directly from the 20-ton ladles brought from the blast furnaces, these ladles being picked up by a 40-ton travelling crane fitted with an auxiliary hoist and carried over the receiving end of the pig machine, and poured by appropriate mechanism. The pig machine is driven by a 30-h.p. 220-volt motor, located in a house near the delivery end of the machine.

The results obtained from the above described blast furnaces since the end of the last fiscal year, June 30th, 1907, are interesting records of good blast furnace practice (as the following table of average daily tonnage shows), especially when taking into consideration that during the period from July 22nd, 1907, to September 2nd, 1907 (41 days), No. 1 furnace was out of blast while the work of relining and remodelling was under construction.

NO. 1 BLAST FURNACE.

1907—July.	Average tonnage of pig iron per day......	128 G.T.
Aug.	Relining and remodelling................	
Sept.	Average tonnage of pig iron per day	204 G.T.
Oct.	" " "	221 "
Nov.	" " "	240 "
Dec.	" " "	245 "

NO. 2 BLAST FURNACE.

1907—July.	Average tonnage of pig iron per day......	249 G.T.
Aug.	" " "	224 "
Sept.	" " "	236 "
Oct.	" " "	258 "
Nov.	" " "	258 "
Dec.	" " "	212 "

From the *Canadian Manufacturer.*
The Radnor Forges at Radnor, Que.—The oldest Iron Furnace in Canada.

Dock, Ore Bridges, Stock Bins, Blast Furnaces and Stoves.—The Algoma Steel Co., Ltd., Sault Ste. Marie, Ont.

The open hearth steel department consists of two 35-ton furnaces of the Wellman-Seaver-Morgan stationary type contained in a substantial steel and corrugated iron building conveniently located for additional units to be added from time to time as the market for this product may demand, at minimum cost. The foundations for a third furnace are already in place.

The furnaces are served on the charging side by a Wellman-Seaver-Morgan low type charging machine handling stock by the box system, and on the pouring side by an electric overhead travelling crane constructed by the Morgan Engineering Co. The gas producers are eight in number and are of the hand-poked water-sealed circular type. The furnaces are being operated at present on basic linings and produce steel from pig iron made from basic ores mined in the province.

The steel rail and finishing mills are installed in a series of buildings adjoining each other and extending practically in a straight line. These buildings are constructed mostly with red sandstone with steel and corrugated iron roofs. At the end nearest the blast furnaces, however, is a building constructed of steel and corrugated iron, in which is installed a 150-ton mixer for handling molten iron direct from the blast furnaces. This mixer is served by a 40-ton electric travelling crane built by the Whiting Foundry and Equipment Co., for lifting the ladles which are brought from the blast furnaces on a standard gauge railroad track running into the building alongside the mixer.

Adjacent to the mixer building is the cupola building, containing four cupolas used for melting pig iron for the converters, and also three furnishing spiegeleisen for the same.

The cupolas for melting the iron are 8 feet in diameter and have a capacity of about 25 tons per hour. The three spiegel cupolas are each 5 feet 6 inches in diameter. A pair of Otis electric elevators serve to convey the charge of coke and iron to the charging floor of the cupola house.

The melted iron from the cupolas is tapped out on a level with the charging floor of the converters into ladles, which are either charged into the mixer by the mixer crane or taken directly to the converters by an electric trolley car system operating on a narrow gauge track between the mixer, cupolas and converters on this level.

The Bessemer converters are two in number, each of four tons capacity, and are mounted on a platform which is on a level with the lower floor on the cupola house. The blast is furnished at pressure of about 18 pounds by two blowing engines located in a separate building. The converters pour into a ladle mounted on a hydraulic jib crane which swings over the ingot moulds, which stand on cars. These ingot moulds after being filled are conveyed to the stripper, and when stripped, the ingots are placed in two four-hole gas fired soaking pits located near the Bessemer in the same building. Each hole in the soaking pit has a capacity of four ingots.

In this same building is the 32″ blooming mill. The ingots are withdrawn from the soaking pit by means of an automatic electric overhead travelling crane and delivered direct to the table of the blooming mill, the rolls of which are driven by a pair of reversing Southwark engines 28 by 48 inches. The tables are driven by electric motors and are operated from a pulpit above the rolls, from which point the engines, table and manipulator are controlled.

The ingots are bloomed down to 8 inches by 8 inches and carried along the table to a bloom shear and cut into blooms of proper length.

The reheating furnaces are located in a building at right angles to the end of the blooming mill and contain three horizontal furnaces of the regenerative type. These furnaces are operated by producer gas supplied from the producers above mentioned. The furnaces are served by two bloom charging cranes supplied by the Wellman-Seaver-Morgan Co., which deliver the bloom to the furnaces and, when heated, withdraw it and deposit it on the table of the rail mill.

The rail mill building is parallel to the steel mill and joins the building containing the reheating furnaces. It contains two sets of roughing rolls and one set of finishing rolls, which are all three-high and are coupled together and driven by a condensing Porter-Allen 40 x 48 engine. The piece receives four passes in first set of rolls, four in the second set and three in the finishing set. The train is served on the front side by two electrically operated travelling tables equipped with tilting motors, and on the back side by three stationary tilting tables designed and furnished by the Wellman-Seaver-Morgan Co.

After passing through the finishing rolls the rail is conveyed about 75 feet to the hot saw and sawed to standard lengths. After being sawed the rails are stamped and cambered, and then run onto the hot beds; these beds, of which there are two, each 140 feet long, are located in a stone building adjoining at right angles with the rail mill.

The finishing mill adjoins the hot beds and is parallel to the rail mill. Along one side of the building is a roller table for conveying the rails to any desired set of straightening and drilling machines. The rails are delivered on skidways alongside the machine and the burr occasioned by the hot saw is chipped from them by a man at each end of the rail, when they are straightened in the presses, then pass on to the drilling machines. There are four straightening presses and eight drill presses, each one independently motor driven. After drilling the rails are loaded directly on cars for shipment.

The above described rail mill is capable of rolling rails from 25 lbs. up to and including 100 lbs. per yard, but rolling has been confined to 60, 70, 80, 85 and 100 lb. sections, being the greatest in demand. Capacity, 225,000 tons annually.

The power plant for the steel mill is located about 75 feet to the west of the steel mill. In this building are located the boilers which supply steam to the engines in the mill, the blowing engines for the converters, the blowers for the cupolas and the pumps for furnishing water to the boilers, the gas producers which furnish gas for the soaking pits and reheating furnaces, and for operating hydraulic machinery around the plant. The boilers are arranged in two batteries each containing eight Stirling boilers of 250 h.p. each. The two batteries of boilers are separated by a room containing the gas producers. The boilers are hand fired. The gas producers are three in number and are of the Frazer-Talbot mechanical type.

PRODUCTIONS—FISCAL YEAR ENDING JUNE 30TH, 1907—OF THE ABOVE DESCRIBED PLANT.

Blast Furnace No. 1	Blast Fur. No. 2	Rail Mill	Open hearth
59,568 G. T.	68,874 G. T.	178,624 G. T.	*6,896 G.T.

* Only in operation May and June, 1907.

The Hamilton Steel and Iron Company, Limited.

The Hamilton Steel and Iron Company, Limited, is located at Hamilton, Wentworth county, Ontario, and its development is covered in the brief historical review in this paper. The present plant consists of two blast furnaces, four open hearth furnaces and sundry finishing departments.

"A" furnace stack is 80 feet high, bosh 16 feet, capacity 200 tons per day. "B" furnace stack is 80 feet high, bosh 20 feet, capacity 300 tons per day; both are operated with coke for fuel. Stack "B" is a new furnace and was blown on November 8, 1907; it embodies all modern improvements in the way of devices for the saving of labor and in handling of ore, pig iron, etc. Ore used: Lake Superior hematite, Ontario hematite and magnetic. The two 15-ton open hearth furnaces have been enlarged and two 30-ton furnaces have been added. Through careful management this company has been enabled, during the last few years, to steadily increase the capacity of the plant.

The plant as it stands to-day has an annual productive capacity of about 180,000 gross tons pig iron, 100,000 net tons of steel ingots and 90,000 to 100,000 gross tons of rolled iron and steel bars, besides washers, forgings, steam and electric railway car axles and track spikes.

Canada Iron Furnace Company, Limited.

The "Canada Iron Furnace Co., Limited," with offices in the Canada Life Building, Montreal, Que., operate a number of plants, namely, Radnor, Three Rivers, Lac-a-la-Tortue, Grandes Piles, Lac aux Sables, Lac Pierre, Ste. Thecle, all of which are in the province of Quebec, and Midland in Ontario.

Plant No. 1 is situated at Midland, Simcoe county, Ont., and consists of one blast furnace together with the necessary boilers, engines and stoves. Stack is 65 feet high, bosh 13 feet; daily capacity of furnace 120 tons, product being foundry, malleable Bessemer and Bessemer iron—foundry and malleable Bessemer being used for castings and Bessemer for steel rails. Fuel is Connellsville coke ; 30% of the ore charged is Canadian, the balance being that of the Lake Superior region.

Three hundred and twenty-five men are employed, wages paid annually being about $118,300.00.

The above furnace was built in 1900 and was blown in December 4th of the same year. Stoves are three in number of the two-pass fire-brick type. Iron produced, 1906, 36,187 tons.

DESERONTO IRON COMPANY LIMITED.

The "Deseronto Iron Co., Limited," situated at Deseronto, Hastings county, Ontario, have a blast furnace of about 50 gross tons capacity, built in 1898, and has been in successful operation since January 25th, 1899, using charcoal as a fuel, the product being sold for malleable castings, car wheels and grey castings.

Recently the furnace has been remodelled, and coke is now used exclusively for fuel. The present amount of ore used daily is 61 tons, of which 52 tons are imported, the product being malleable, Bessemer and foundry pig iron, and is sold principally for malleable and grey castings.

In remodelling the furnace the size of the bosh has been enlarged from 9 ft. 6 in. to 10 ft. 6 in., the productive capacity increasing considerably, as the following figures show:—In 1903, before the improvements were made and the change of fuel had taken place, the year's production was $8911\frac{1995}{2240}$ tons; for the year 1906 the corresponding figures are $8876\frac{885}{2240}$ tons. Considering that the plant is equipped with iron pipe stoves only, and that the furnace was only in blast for eight months out of the twelve of 1906, I do not consider the output a small one. It is evident that coke to-day is pre-eminently the blast furnace fuel of Ontario.

THE ONTARIO IRON AND STEEL COMPANY, LIMITED.

The Ontario Iron and Steel Co., Limited, have recently completed works at Welland, Ontario, where they have installed equipment of which the works proper consist in general of two open hearth basic furnaces, one in the foundry department, with a capacity of 20 tons, the other being of 25 tons capacity, situated in the ingot foundry; the melting capacity of the two furnaces is about 80 tons per day, part of the product being used for steel castings.

The finishing department consists of one 22″ mill and one 12″ mill capable of rolling small rails, angles, bars and skelps for pipe.

The power for these mills and various appliances throughout plant is supplied by electric current from Niagara Falls. The Company own and operate natural gas wells near Port Colbourne, and pipe the gas to their plant, where it is used exclusively for fuel.

At present only the steel foundry is in operation, but it is expected that the rolling mills will be rolling very soon.

THE CRAMP STEEL COMPANY, LIMITED.

The Cramp Steel Co., Limited, later the "Northern Iron and Steel Co.," through financial difficulties has never been fully in operation. Works were built in Collingwood, Simcoe county, Ontario, for the manufacture of basic open hearth steel and rolled iron and steel.

The plant consists of an open hearth department equipped with two 15-gross ton Siemens furnaces and rolling mills, with trains of rolls for the production of plates, merchant bar iron and shafting.

The Company proposed erecting two blast furnaces with daily capacity of 250 gross tons each, using Canadian hematite and magnetic ores, product to be basic pig iron, but this department was never constructed. The future of the departments completed is uncertain, owing to the financial difficulties as above stated.

Atikokan Iron Company, Limited.

The Atikokan Iron Co., Limited, is situated at Port Arthur, Thunder Bay district, Ontario. A blast furnace of 100 tons capacity, together with the necessary stoves, boilers, shipping docks, etc., comprise the equipment.

About 160 tons of ore is used daily (all Canadian) and is brought from the Company's own mines a short distance back of Port Arthur (on the Nipigon river).

The furnace proper has a 74′ 3″ stack, bosh 14′, coke is used for fuel; product, foundry iron. 150 men are employed in the several departments.

This furnace was in blast but a short time, making 7,532 tons of iron, when the management deemed it advisable, owing to prevailing conditions. to discontinue operations until the coming spring.

All the above mentioned industries of this province are conducted in their respective lines by the ordinary accepted modern processes of manufacture. In addition, however, some original research has been carried on in the treatment of various ores, and among these the electro-thermic process for the manufacture of pig iron from iron ores, although at present not a serious competitor to the ordinary blast furnace, has a right to be considered an important factor in the future manufacture of iron and steel.

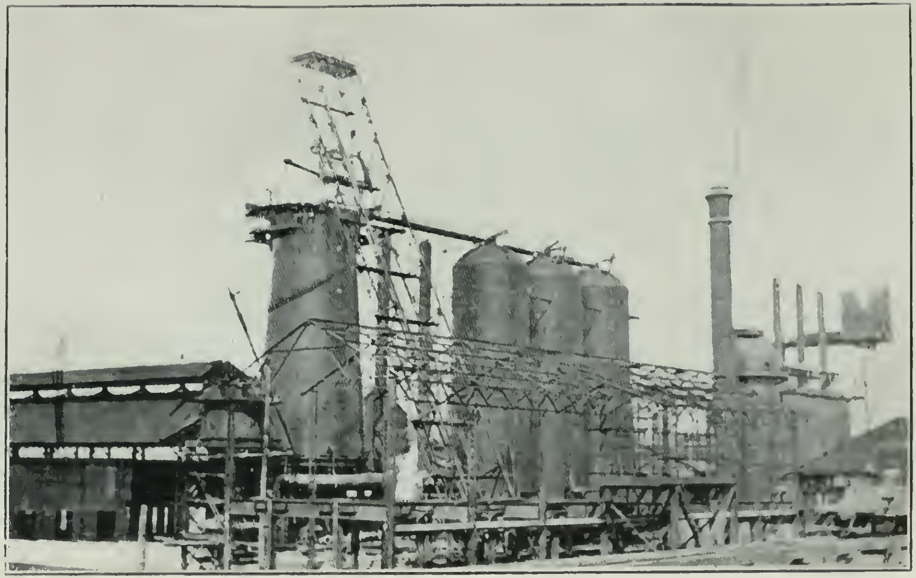
In 1898 experiments were carried on in Ontario by Mr. Ernst A. Sjostedt, Chief Metallurgist of the Lake Superior Power Company, in desulphurizing a certain grade of the Company's nickeliferous pyrrhotite from the Sudbury district, with the object of utilizing its sulphur contents for the production of a suitable sulphur dioxide ($S\ O_2$) gas in a contemplated sulphite pulp industry, and its iron and nickel contents for the manufacture of ferro-nickel in the ordinary blast furnace and open hearth steel practice from dead roasted "cinders." These first experiments did not prove altogether satisfactory, the product containing some 7% sulphur, but realizing that if a high temperature could be attained, sufficient to melt and keep fluid the refractory mixture, the sulphur could be fluxed off with lime or similar strong base;

his attention was taken to the electric energy for the required source of heat. Electrical experiments were then carried out (first on a very small crucible scale), the result of which was the construction of an electric furnace, using the Company's electric power plant for energy. The results obtained were, I believe, satisfactory and proved the possibility of converting a partially roasted pyrrhotite into a sulphur free alloy. Later in the winter of 1905–6 an experimental Government plant was installed, supervised by Dr. Eugene Haanel, Supt. of Mines, for the manufacture of pig iron from iron ores. This plant was subsequently purchased by the L. S. Corporation, when about 150 tons of ferronickel was produced from the Lake Superior Company's briquetted roasted pyrrhotite. These experiments not only verified Mr. Sjostedt's previous results, but were made on a scale sufficiently large to encourage the belief that even in a small furnace ferronickel alloy could be profitably produced.

If electric power at (a reasonable charge of) say $15.00 per h.p. annum, could be furnished from some established power plant, it is reasonable to believe that the electric-thermic process of smelting iron ores could be carried on profitably and successfully with a furnace similar in size to a small charcoal blast furnace, which would at present seem sufficiently large for such a purpose, and furnaces of this description would give Ontario a chance to develop its smaller ore deposits, especially in the county of Hastings and in the immediate vicinity of Ottawa.

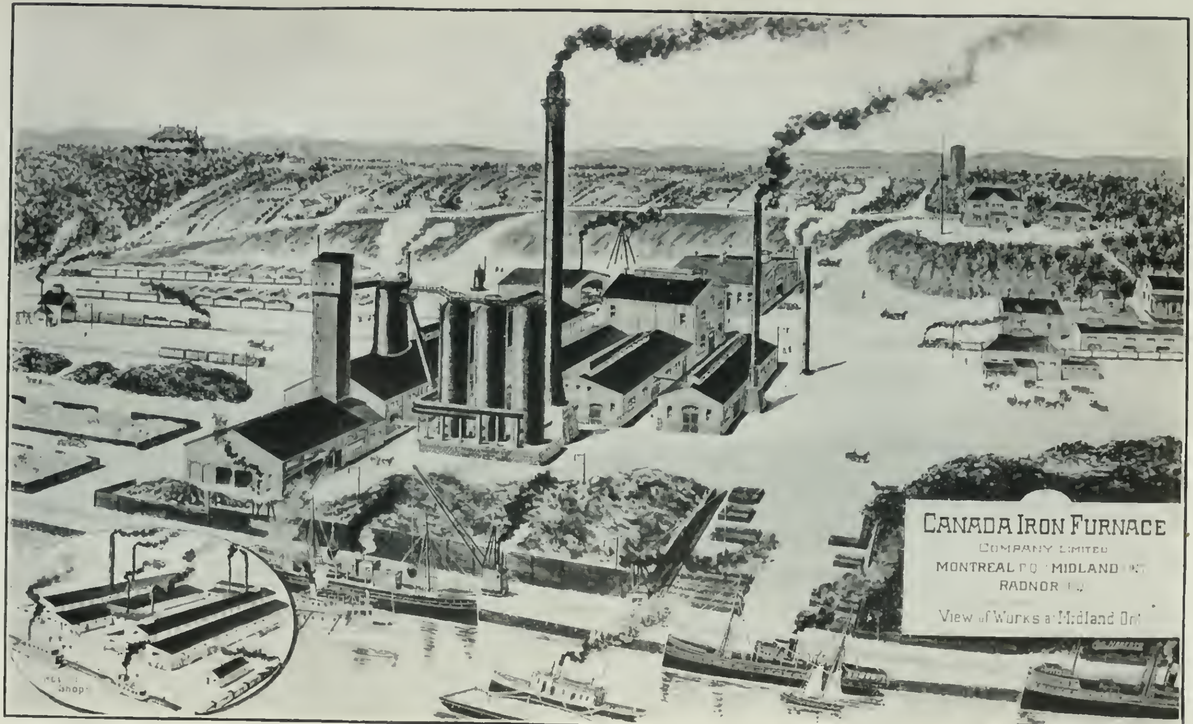
In attempting a comparison between the electro-thermic process and the present blast furnace practice in the reduction of iron ores, it will be well, I think, to narrow the same down to that of a charcoal furnace and an electric furnace of similar capacity, both corresponding to a 3,000 h.p. electric smelting plant, which at present would seem sufficiently large for such a purpose.

The average output per 1,000 h.p. day, as given in Dr. Haanel's preliminary report, is about 10 short tons, which equals about 9 gross (pig iron) tons. Although such a production no doubt can be obtained and possibly will be exceeded on a large scale, we will, for the sake of reasonable safety, make a reduction from this amount of about 20% and thus base our estimates on a daily output of only 7 gross tons per 1,000 h.p. day, or an annual production of about 7,500 gross tons.



From the *Canadian Manufacturer.*

Hamilton Steel and Iron Company's New Furnace in course of construction.


CANADA IRON FURNACE
COMPANY LIMITED
MONTREAL · MIDLAND
RADNOR
View of Works at Midland Ont
Shop

Deseronto Iron Company, Limited.

Deseronto Iron Company, Limited. (Showing stock bins.)

TABLE SHOWING BLAST FURNACE PLANTS IN ONTARIO.

Name of Company	Height of stack	Size of bosh	Fuel used	Daily furnace capacity	Ore used daily. Can'd'n	Ore used daily. Foreign	Product	Disposition of product sold or used
The Algoma Steel Co., Ltd. No. 1	70′	17′	Coke	250	25%	75%	Mostly Bessemer (little Basic)	Used steel rails
The Algoma Steel Co., Ltd. No. 2	80′	17′	Coke	250	25%	75%	Mostly Bessemer	Used steel rails
Hamilton Steel and Iron Co., Ltd., "A"	73′	16′	Coke	200	39%	61%	Basic, Foundry and Malleable	Both sold & used
Hamilton Steel and Iron Co., Ltd., "B"	80′	20′	Coke	300	23%	77%	Basic Foundry and Malleable	Both sold & used
Canada Iron Fce. Co. Ltd.	65′	13′	Coke	120	30%	70%	Foundry Malleable & Bessemer	Castings and Steel rails
Deseronto Iron Co., Ltd.	61′	10′ 6″	Coke	50	14%	86%	Malleable Bessemer Foundry Pig	Malleable Castings and grey Castings.
Atikokan Iron Co., Ltd.	74′ 3″	14′	Coke	100	100%	—	Foundry Pig	Castings, etc.

Roughly speaking, the cost of an electric smelting plant and charcoal blast furnace plant of the same capacity would involve the following expenditure—exclusive of site, mining privileges and hardwood land:—

	Electric Furnace	Charcoal Furnace
Furnace Plant	$35,000	$100,000
Electrode Plant	6,000	——
Charcoal Kiln Plant	15,000	30,000
Sundries, say	19,000	20,000
	$75,000	$150,000

For the complete equipment of an electro-thermic smelting plant it may also be necessary to invest in separate power and electric installation, which in the present case probably would involve an additional expenditure of some $200,000, but we will in the present case assume that electricity will be furnished for some established power plant, and allow for the same the reasonable charge of $15.00 per h.p. annum.

The cost of charcoal will be, in both cases, estimated at 6.5c. per bushel, limestone at $1.50 per ton, and the ore for blast furnace practice at $2.50, and that intended for electric smelting (being supposedly of an inferior quality, not suitable for ordinary blast furnace practice) at $1.50 per ton. We will also assume labor cost at the two furnaces to be the same (say $2.00 per ton), as also all incidental expenses.

We thus obtain the following cost items for the production of one gross ton of pig iron :—

	Electric Furnace	Charcoal Furnace
2 tons of iron at $2.50	——	$ 5.00
2 " " $1.50	$ 3.00	——
110 bush. charcoal at 6.5 cents	——	7.15
56 bush. charcoal at 6.5 cents	3.64	——
Electrodes, say 20 at 2.5 cents	.45	——
Limestone, say	.50	.25
Electric Power at $15	6.00	——
Furnace Labor	2.00	2.00
Office Expenses	1.00	1.00
Incidentals, say	.41	.60
	17.00	16.00
Add for Amortization at 10 %	1.00	2.00
	$18.00	$18.00

The above estimates are considered very conservative, and the manufacturing cost will be reduced in larger plants. There are exceptional cases where the cost of raw material and power differ radically from that given in the above tables and where, therefore, the totals will be entirely changed, but the above will serve as a conservative estimate for plants of the assumed capacity, according to the present day's knowledge.

The quality of the product from the electric furnace would compare favorably with, and in most cases would excel, that of the best charcoal iron made (owing to the possibility of a perfect elimination of sulphur and the great homogenity of the electric furnace product).

(I am indebted to Mr. Ernst A. Sjostedt, Chief Metallurgist of the Lake Superior Corporation, for the above figures).

To encourage this process the Government has authorized the payment of the following bounties on the undermentioned articles when manufactured in Canada for consumption therein, viz.:—

(a) On pig iron manufactured from Canadian ore by the process of electric smelting during the calendar years:—

1909.......	$2.10 per ton	1910......	$2.10 per ton
1911.......	1.70 " "	1912....	0.90 " "

(b) On steel manufactured by electric process direct from Canadian ore, and on steel manufactured by electric process from pig iron smelted in Canada by electricity from Canadian ore during the calendar year:—

1909.......	$1.65 per ton	1910.....	$1.65 per ton
1911.......	1.05 " "	1912......	0.60 " "

The historical review of iron making in Ontario dates back to the year 1800, when the first furnace in the province was constructed at the falls of the Gananoque river, but owing to inferior ores and the high cost of assembling materials, the furnace was only kept in blast two years. Not until twenty years later was a furnace constructed and successfully operated for a number of years. This furnace was built at Charlotteville township, Norfolk county, using bog ore from the immediate vicinity. However, the supply of ore became exhausted, and in 1854 the management erected another furnace in Houghton township, which was in blast but a short time when it was deemed advisable, owing to the prevailing conditions, to discontinue operations.

In 1820 a furnace was established at Marmora, but was also unsuccessful. Then, in 1831, a furnace was started using bog ores of Colchester and Gosfield townships, but after five or six years of operation it was closed down on account of financial difficulties. In 1836 a furnace was built in Madoc, being in operation some eight or nine years. Following these many attempts to start furnaces and smelt iron in the province, without satisfactory results ever being arrived at, a mill was erected at Hamilton in 1864 for the purpose of re-rolling iron rails. This mill was in operation until 1871, when, in consequence of the introduction of steel rails, the re-rolling of iron rails was abandoned, the mill remaining idle until 1879, when, under the name of The Ontario Rolling Mills Company, it was started as a merchant bar mill. Some years later the Hamilton Iron Forging Company started a plant and small rolling mill on the premises adjoining the Ontario Rolling Mill Company's works, but in 1890 the Ontario Rolling Mill Company bought them out. Then in 1896 the Hamilton Blast Furnace Co. blew in a furnace, and in the spring of 1899 this Company amalgamated with the Ontario Rolling Mill Company, under the name of the Hamilton Steel and Iron Co., Limited, their equipment consisting of one blast furnace, with a capacity of 150 tons per day, two mills with five trains of rolls (14 inch neck, 9 and 10 inch guide, 20 inch bar and 20 inch plate), two bushelling furnaces, four double puddling furnaces and nine coal heating furnaces, also a forge plant with four steam hammers with necessary lathes for rough turning forgings.

An analysis of this industry in the province would disclose the permanent foundation upon which it is being established. Foremost, of course, stands out the large deposits of rich ore that exist in Eastern Ontario, whose presence has been known for years. These deposits are being supplemented from time to time by such discoveries as that of the Helen mine at Michipicoten, yielding 1,000 tons of rich basic ore per day, with a tonnage that will not be exhausted for years. The "Moose Mountain" mine, which is located about 30 miles north of Sudbury in Hutton township, is perhaps the largest and best iron ore deposit in the province. (The first development of this mine brought to light a bonded hematite basic ore, but recently, through diamond drilling, a Bessemer ore has been produced.) And the mines of the Central Ontario range, Hastings county, operated by such companies as the "Wilbur Iron Ore Company," The Mineral Range Iron Mining Company, and the "Belmont."

The consumption of iron and steel in all its various forms is increasing with giant strides, caused primarily by the rapid development of the province and the Dominion at large. To satisfy this growing demand new plants are being built and new products manufactured whenever the market for such product justifies.

Under this state of facts the past two years have witnessed the establishment of two new blast furnaces, one at Port Arthur and the other at Hamilton, making a total of seven in the province, six of which have been built in recent years. At Welland, The Ontario Smelting Co. have completed a new plant consisting of two open hearth furnaces and a rolling mill, and at the works of The Algoma Steel Co., Limited, two new open hearth furnaces have been installed and an increase has been made in the productive capacity of No. 1 blast furnace.

The Canada Iron Furnace Co., Limited, whose principal office is at Montreal, have preliminary plans for a new blast furnace, steel works and rolling mill to be built on its property at Midland; four open hearth furnaces have also been planned; and the company operating the Moose Mountain mine are negotiating with the Toronto authorities for the establishment of a furnace plant at Ashbridge bay, which is believed will have a capacity of 1,400 tons of ore daily, to be followed by the establishment of plants for manufacturing pig iron into various finished products. A steel plant, rolling mill, car shops and finishing mills.

Particularly important in the increasing use of iron and steel is the constantly growing demand for foundry, railroad and building purposes. There is a large market in Canada for structural steel, but at present this product comes from Belgium and the United States. And while there is a growing demand for it, the material required is purchased elsewhere, being cut here to suit local requirements. Although this class of work is essentially an American production, the time has come when our engineers should be familiar with it, and a modern plant well managed, with low fixed charges, situated advantageously, and controlling its own raw material, would have nothing to fear in the future.

Further, the construction of railroad and trolley systems are, comparatively speaking, still in their infancy, and the amount of steel necessary for this construction will add largely to the requirements. But at present our rail mills can look after the work to be done as far as rail requirements go, for the mills of the Algoma Steel Co., Limited, and those of the Dominion Iron and Steel Company produce ample tonnage to provide for present needs, these mills having a total capacity of over 400,000 tons a year. The demand for rails last year, the largest in the history of Canadian rail requirements, amounts to about 300,000 tons. Previous years the demand was considerably under the above figure, but there is room for development in structural steel, and manufacturers should be induced to take up this line. The demand for this material in the past few years has been a most striking development in the industry. Among the varied new uses for steel, the rod mill has its share and the wire nail industry is a large one in itself, but more remarkable is the increase in the wire fence requirements. This industry in the United States is nearly nine times as large as it was six years ago, their production being something like three hundred and seventy-five thousand tons.

These industries are practically new to us and are full of rich opportunities. No other industry across the border has paid such lavish awards to men who have possessed the genius of organization, and now that Canada is turning the corner in the matter of iron and steel development it is to be hoped that other companies will be formed to follow the example of some of our larger concerns, and go even further into the manufacture of the finished product. The province already includes a great number of establishments from the mills of the Algoma Steel Co., Limited, as above mentioned, upon which millions of dollars have been expended, to the little foundry of the small towns, or even to the smithy's forge at the cross roads.

A steel industry is a benefit to a country in many ways. It is the foundation of larger communities which increase and influence the general prosperity of all other industries. It contributes to the payment of taxes. It supplies an enormous amount of freight to the railroads, the receipts from a plant being many times as much as though the same amount of material were imported and further lowers the cost of transportation by their adding to the amount of tonnage handled. No country can prosper without an iron industry of some description, whether it be an iron producing country itself, with mines and furnaces, or not. If it does not possess iron in accessible form itself, or if it has not the energy to develop its own iron, it is under the necessity of importing iron from other countries, either as pig iron for manufacture, or the finished product, or both. Another argument advanced in favor of iron and steel development in the Dominion is the bounty offered by the Dominion Government. An act respecting bounties on iron and steel made in Canada, having been assented to and renewed April 27, '07, from which the following has been copied:—

(a) In respect of pig iron manufactured from ore, on the proportion from Canadian ore produced during the calendar year:—

1907.......$2.10 per ton	1908.....$2.10 per ton.
1909....... 1.70 " "	1910..... 0.90 " "

(b) In respect of pig iron manufactured from ore, on the proportion from foreign ore produced during the calendar year:—

1907.......$1.10 per ton	1908.....$1.10 per ton
1909....... 0.70 " "	1910..... 0.40 " "

(c) On puddled iron bars manufactured from pig iron made in Canada during the calendar year:—

1907.......$1.65 per ton	1908.....$1.65 per ton
1909....... 1.05 " "	1910..... 0.60 " "

(d) In respect of rolled round wire rods not over three-eighths of an inch in diameter, manufactured in Canada from steel produced in Canada from ingredients of which not less than 50 per cent. of the weight thereof consists of pig iron made in Canada, when sold to wire manufacturers for use, or when used in making wire in their own factories in Canada —on such wire rods made after the thirty-first day of December, one thousand nine hundred and six, six dollars ($6.00) per ton.

(e) In respect of steel manufactured from ingredients of which not less than fifty per cent. of the weight thereof consists of pig iron made in Canada—on such steel made during the calendar year:—

1907.......	$1.65 per ton	1908.....	$1.65 per ton
1909.......	1.05 " "	1910.....	0.60 " "

The character of the finished product of the several industries has reached a high and very satisfactory standard, and in the product of the greatest tonnage has perhaps excelled that of other districts. The matter of section and specification in this particular product is now in the transition stage, and as soon as a decision is reached all the requirements will be met and this high standard maintained. All products in the regular course of business must pass inspection by a third party, who is the agent of the purchaser for this purpose, and whose judgment is final as between the parties.

This matter has until recently been in the hands of foreign "Bureaus of Inspection," but recently a bureau fully equipped to handle all branches of the service has been established at Toronto, so that at the present moment every step in the process from producing the raw ores to the final acceptance of the finished material, can be carried on within the province.

From the *Canadian Manufacturer.*

The Atikokan Iron Company's Roasting Kilns.—The furnace is in the background.

From the *Canadian Manufacturer.*

Atikokan Iron Company's Power House and Blast Furnace.

TABLE SHOWING ADVANCEMENT MADE IN THE SEVERAL IMPORTANT INDUSTRIES IN THE PROVINCE COMPARING 1903 WITH 1906.

Name of Company	Men employed in		Wages paid in		Iron produced in		Steel produced in	
	1903	1906	1903	1906	1903	1906	1903	1906
The Algoma Steel Co., Ltd.	—	1,106	——	816,179.07	—	138,593	——	201,577 Bess.
The Hamilton Steel and Iron Co., Ltd.	290	360	149,000.00	256,140.00	46,175	69,694	15,227 O.H.Basic	49,905 O.H.Basic
Canada Iron Furnace Co. L'd	300	325	110,650.00	118,300.00	33,871	36,187		
Deseronto Iron Company..	45	45	24,683.76	18,984.72	8,911	8,876		

ONTARIO IRON AND STEEL PRODUCTION.

The production of Pig Iron and Steel in the Ontario Mills during the calendar year 1907 as follows:—

Name of Company	PIG IRON Tons	STEEL Tons
Hamilton Steel & Iron Co., Limited	79,817	61,893
Canada Iron Furnace Co. (Midland)	27,153	
The Algoma Steel Co., Limited	142,054	229,514
Deseronto Iron Company	3,510	
Atikokan Iron Company	8,195	
*Lake Superior Iron & Steel Co., Ltd.		3,466
Ontario Iron & Steel Company		152
Total	260,729	295,025

* Same as Algoma Steel Co's open-hearth Department.

THE MOOSE MOUNTAIN IRON RANGE, WITH SPECIAL REFERENCE TO THE PROPERTIES OF MOOSE MOUNTAIN, LIMITED.

By Norman L. Leach, Sudbury, Ontario.

(Ottawa Meeting, March, 1908.)

The conformation of the Moose Mountain Iron Range has been traced in a general manner and found to extend in a northwesterly direction from the northwest shore of Lake Wahnapitae, in the district of Nipissing, to Onaping Lake, in the district of Algoma, a distance of approximately thirty-five miles.

Twenty-five miles due north of Sudbury, in the township of Hutton, are situated the properties of the Moose Mountain, Limited. The existence of iron ore in this township has been known in a general way for years. During the gold excitement of the "nineties," prospectors travelling the West Branch of the Vermilion River, in search of the yellow metal, portaged across a ridge of the "No. 2" deposit at a point known as the "Iron Dam," the wearing away of the moss on the portage having exposed the ore in several places.

In 1901 and 1902 Sudbury prospectors, through Mr. Chase S. Osborne, of Sault Ste. Marie, Michigan, succeeded in interesting Mr. John W. Gates, of New York, and associates, in the property. Enough exploratory work was then done to prove its value and negotiations commenced with the object of securing rail connections with the Georgian Bay.

Messrs. Mackenzie & Mann, appreciating the possibilities of the ore tonnage as a source of revenue for their railroads, became interested in the property, and as a result, a branch of their Canadian Northern Ontario Ry., from Toronto to Sudbury, has been built from Sudbury north to the mines, a distance of 35 miles. A six mile spur from the main line, a few miles south of the

French River, has been constructed to the Georgian Bay at a point known as Key Inlet, and is the final link connecting the mines with the Great Lakes, making a rail haul for the ore of about eighty miles, or about the same as the average haul of the three iron-ore-carrying roads of Minnesota.

Ore docks for the transhipment of the ore are now under construction by the Mackenzie & Mann interests at the "Key." A splendid natural harbour has been secured there with twenty-four feet of water alongside the ore docks, more than enough to float the largest vessels on the Great Lakes; and the "Key" as a shipping point by water is 500 miles nearer any of the iron ore receiving ports, as compared with shipments from the head of Lake Superior. This will be a considerable factor in the securing of favourable lake freight rates.

The docks are of unique construction, and will be unlike any on the Great Lakes for the handling of iron ore. The ore from the mines, loaded in hopper-bottomed cars, is dumped from a trestle to a stock-pile ground beneath. Under this stock-pile ground, in line with the centre line of the trestle, is a tunnel through which a forty-two inch belt will convey the ore to a similar belt at the water's edge, which in turn conveys and elevates the ore to the dock trestle sixty feet above the water level. It is then tripped off the belt, weighed by an automatic device, and dumps into pockets from which it will be spouted into the hold of the vessels alongside the dock. It is expected that these belts will have a capacity of eight hundred tons of ore per hour.

Development work at the properties of the Moose Mountain, Limited, has proven the existence of several large deposits of merchantable ore, principally magnetite, and a small amount of hematite. The ores occur in the following rocks of the Keewatin age. Those in close proximity to the ore bodies consist principally of diorite, diabase, hornblende-schist, hornblende-gneiss, all of which may be collectively referred to as greenstone. In a few instances granite comes into contact with the ores. Numerous exposures of magnetic ores are to be found. Where weathered the ore presents grey, dark green and black appearances, and glaciated surfaces have the lustre of metallic iron. When crushed for shipment the ores have a steel grey appearance. These ores can be delivered to any blast furnaces in Canada or the United States, tributary to the Great Lakes, and the product from the Moose Mountain mines will be disposed of in the above markets.

The present guaranteed analysis on ore sales is:—

Iron	55.50
Phosphorus	.10
Silica	13.29
Manganese	.02
Alumina	1.21
Lime	3.60
Magnesia	3.15
Sulphur	.011
Titanium	none
Moisture	1.00

So far actual mining operations have been confined to the "No. 1," or original "Moose Mountain" deposit. The surface of the ore body at this point is approximately 140 feet above the level of the railroad loading tracks. The ore is won by under hand stoping, from an open face of from 60 to 70 feet in height, trammed out to a large chute discharging thirty feet below the level of the bottom of the present stope into a No. 8 Austin gyratory crusher, which reduces it to a maximum size of five to six inches diameter. Leaving the number eight crusher, the ore passes through a revolving screen 48″ by 12′ with ¼ inch perforations, the rejections going direct to the foot of the elevator pit, and the balance to a No. 5 Austin gyratory crusher discharging into the 14″ by 30″ buckets of a fifty-two foot centre belt elevator, which elevates the ore into the loading bins, whence it discharges through hoppers into the railroad cars.

A 16″ by 42″ Jenckes Corliss engine, to drive the crushing plant, and two 150 h.p. return tubular boilers, constitute the present power plant, the machine drills having been operated by steam up to the present time.

Very little systematic exploration work has been done upon the Moose Mountain Range as yet, and when it is remembered that upon all of the older iron ranges of the Lake Superior country millions of dollars have been, and are still being, spent in the systematic search for new ore bodies—and that all of these iron ranges show more ore in sight to-day than they ever did—it seems a reasonable possibility that careful explorations in the future will reveal still other bodies of high grade merchantable ore in the Moose Mountain District.

NOTES ON EARLY MINING ENDEAVOUR IN ONTARIO.

By E. L. Fraleck.

(Cobalt Branch Meeting, May, 1908.)

The mining and smelting of iron ore in Ontario was commenced as early as 1800. In this year a furnace was erected in the northern part of the township of Lansdowne, in the County of Leeds, at the falls of the Gananoque river, by a syndicate composed of E. Freeman Jones, Daniel Sherwood, Samuel Barlow, and Wallace Sutherland. The place on this account was called Furnace Falls, but is now known as the village of Lyndhurst. This furnace, however, was only operated for two years, the suspension of operation being attributed to the inferior quality of the ore, which, too, required to be transported a considerable distance from lot 25, in the 10th concession of the township of Bastard.

The next attempt was made in 1813 by John Mason, an Englishman, who commenced the erection of a furnace on the shore of Lake Erie, in the township of Charlotteville, with the object of treating bog ores from the County of Norfolk. The plant was a very crude affair, and after running a short time the inner lining gave way, and the enterprise was abandoned. The following extracts from letters written by John Mason to Robert Gourlay in 1817 will give us an idea of his difficulties. "I want five or six pieces of cast iron 30 cwt. These will come to an enormous expense. I intended to ask Government to give, or lend me, six disabled cannon for this. I asked Government to pay the passage of five or six families from England to work in the furnace. This could not be granted, therefore I would not ask for the cannon. Another thing against me, is that there is not a man in the country that I know of capable of working in the furnace, but the greatest difficulty I have to overcome, is iron men as we call them, are the very worst sort of men to manage, colliers not excepted. Not one of a hundred of them but will take every advantage of his master in his power. If I have just the number of hands for the work, every one of them will know that I cannot do without every one of them, therefore, everyone of them will be my master." He also says:—"Those who begin iron works in this country after me, will start many thousand dollars ahead of me, everything they want except stone will be had here. The best method of working the ore will be known, and men will be learned to work it." John Mason died shortly afterwards, and the property was bought by Joseph Vanorman, who formed a partnership with Hiram Capron and George Stillson, and in 1823, after an investment of $8,000.00, the furnace was blown in. The furnace was in blast eight or nine months each year, producing seven or eight hundred tons of iron with a consumption of charcoal equal to 4,000 cords of hardwood. The pig iron was made into sugar and potash kettles, stoves, and other articles for the settlers. Some exports were made to Buffalo, and one shipload was sent to Chicago. About five or six years later, Vanorman bought out Capron and Stillson. The business was successfully operated until 1847, when the supply of ore and fuel gave out, but in the meantime, Vanorman had amassed a considerable fortune. Vanorman utilized the waste gases from his furnace to calcine his ore and heat his blast. The hot blast was patented by J. B. Neilson, of Glasgow, in 1828, and although Aubertot used waste gases in 1814, it was not until George Parry, of Cornwall, invented the cup and cone arrangement about 1850 that the practise became general. In 1845 J. P. Budd took out a patent in England to use waste gases for heating the blast, but Vanorman's stove was in use nearly twenty years before.

In 1820, a furnace was constructed by Mr. Hays to treat ore from the big ore bed at Blairton, in the township of Marmora. There is no record of his venture except that he failed, and the property passed into the hands of the Hon. Peter McGill of Montreal. In 1831 Hetherington, McGill and Manahan incorporated the Marmora Iron Foundry. In 1839 the Government appointed commissioners to ascertain the cost of the removal of the penitentiary from Kingston to Marmora with a view, evidently, of employing the convicts in mining and smelting work; but this was not done, and in 1847 Vanorman purchased the property for $21,000.00. The iron, however, required to be carted a distance of thirty-two miles to Belleville, until a water route was made available by building a road nine miles long from Crow Lake to Healy's Falls on the Trent River, whence the iron was conveyed by boat to Rice Lake, and thence by waggon, twelve miles to the dock at Cobourg. The pig iron sold readily at $35.00 per ton, but upon the completion of the St. Lawrence canals, foreign pig was laid down at Belleville and Cobourg for $16.00 per ton, and Vanorman's venture was a total loss.

After Vanorman, other ventures were the Marmora Iron Foundry, whose losses represented nearly $20,000, and an English company whose loss was about $75,000; while in 1875, an experiment was made of using petroleum for a fuel, with the result that the plant was completely consumed.

In 1837, Uriah Seymour operated a furnace at Madoc. The ore was obtained from the Seymour Iron Mine, five miles north of the village. Limestone was first used as a flux, and material from the locality used for the lining. The linings, however, were slagged out as rapidly as they could be replaced, while a new lining obtained from Rossie in New York State, similar to that used in the furnaces there, afforded no better results. Seymour then substituted for the limestone a sandy clay, on which the furnace ran successfully for eight or nine years, and it was to this feature that Seymour attributed his success. His supply of charcoal becoming exhausted, he sawed cordwood in two-foot lengths, and employing one tuyère only, the furnace was in operation for seventy-five days, iron of excellent quality being produced. Encouraged with these results Seymour then worked the furnace to full capacity with all tuyères in use, but produced an inferior pig. By closing all but one tuyère, however, his production sank to 1¼ tons per day, but the quality was restored. Seymour's partner was killed by an explosion in the mine, and the difficulty of settling with the heirs, and Seymour's ill health, caused the abandonment of operations.

Vanorman resumed smelting in the west part of Norfolk in 1854, having been offered $45.00 per ton for pig iron of equal quality to that of his former production. In 1855, he shipped 400 tons, but the iron would not chill, and he was compelled to sell it at $22.00, and his losses on this venture were $32,000.

In the report of the Royal Commission of 1890, on the mineral resources of Ontario, to which the writer is greatly indebted for these notes, this record of early endeavour and achievement is referred to as a "Hapless record of failures." Upon close analysis, this characterization is by no means justified. The first furnace of 1800, was in blast two years, and it is inconceivable that the furnace would have been kept in operation for that length of time at a loss. The ore supply for the furnace was obtained from small, high-grade pockets of hematite, which occurred in a ferruginous Potsdam sandstone. It is quite reasonable to assume, that the furnace ran successfully until these pockets were worked out, and that no new sources of supply were found within distances that would permit of the economic transportation of ore to the furnace.

John Mason fought manfully against overwhelming odds, and failed mainly through insufficient capital, and inadequate furnace lining. His instance in the year 1813 is the first record of a request to the Government for aid to the mineral industry, and this first request met with a refusal. Let us note the sturdy pride of the old man, who, when the Government refused his request, "therefore, would not ask for the cannon." We may also note his abiding faith, that those who came after him would succeed where he failed.

Vanorman's case constitutes a continuous record of success for twenty-five years. When, however, he shifted the scene of his operations to Marmora, his failure was due to conditions over which he had no control, and which, doubtless, he could not forecast. The improvements in methods of transportation brought the iron producing sections of England closer to the Ontario market than was Vanorman's furnace at thirty-two miles distant. That his former experience had been gained in the treatment of bog ores, and that he was suddenly confronted with the problem of smelting a hard dense magnetite, such as the Blairton ore, need not be considered as factors contributory to his non-success here, for the man who was the first to utilize waste gases for heating the blast, and whose furnace stoves were similar to those in use at the present day, would, we may be assured, be sagacious enough to adopt his treatment to the requirements as imposed in the utilization of an ore of a different character.

The case of Uriah Seymour, who operated successfully for eight or nine years, certainly cannot be called a failure, here again is an instance of remarkable ingenuity in utilizing local conditions in overcoming local difficulties. Last year Ontario's production of pig iron totalled 286,216 tons, valued at $4,716,857, and her production of steel 237,855 tons, valued at $4,168,127. This result has largely been obtained by the aid of that Government assistance so harshly denied John Mason nearly one hundred years ago. The record as a whole is one of achievement and not of failure; and it is fitting, that some testimony be borne in the praise of those men who, with patient courage and unfailing resource, "blazed the trail."

A NEW IRON ORE FIELD IN THE PROVINCE OF NEW BRUNSWICK.

By JOHN E. HARDMAN, S.B. Ma.E., Montreal, Que.

(Ottawa Meeting, March, 1908.)

The discovery of large deposits of iron ore near the shore of the Bay of Chaleur, in the Province of New Brunswick, in formations belonging to the Pre-Cambrian, or Cambro-Silurian, period comes as a surprise both to geologists and mining men, who hitherto may have regarded New Brunswick as containing less profitable mineral wealth than any of the other Provinces. When to this statement is added the further one that, the present facts indicate the probability that this district contains as large, or larger, deposits of merchantable iron ore as have hitherto been found in the Dominion, there will be no excuse needed for presenting to the notice of this Institute a preliminary, and somewhat fragmentary, account of the field.

No geological reconnaissance of this portion of New Brunswick has been made (so far as the publications of the Survey show) since the seasons of 1879 and 1880, when Dr. R. W. Ells examined the district as well as could then be done by canoe traverse of the principal streams which flow into the Bay of Chaleur. The County of Gloucester was then, and in parts is to-day, a wilderness which is traversed in the winter time only by trappers and lumbermen, and in the summer time by sportsmen, for the river and its tributary streams have long been choice ground for salmon and trout fishing.

The district under consideration lies approximately along the meridian of 65° 50′ West Longitude, and the parallel of 47° 25′ North Latitude, and is near the southern boundary of the County of Gloucester. The limits of the field have as yet been by no means defined or determined, but may be taken, according to present knowledge, as having an extreme length of some 20 miles north and south, with a width of not less than 5 miles. This extreme length takes in the field on the "Mill Stream" (so-called) lying some 8 to 9 miles north-west of the town of Bathurst, as well as the portion, which is hereafter described more fully, on the northern bank of the Nipisiguit River. The larger section has an area of approximately 30 square miles. There is a linear gap of about 16 miles between the Nipisiguit area and the small area on the Mill Stream.

The rocks in which these deposits of iron ore are found are all metamorphosed or crystalline. They have been mapped as Pre-Cambrian and belong, probably, to one of the Huronian members.

In a general way they consist of micaceous and chloritic schists and slates with some quartzites. They are frequently cut by small veinlets of quartz, and are also infrequently penetrated by dikes of jasper.

The surface rock about the outcrops is a mica schist, but the immediate hanging wall of the deposit is igneous, being a gabbro-diorite; the underlying rock or foot wall is a completely altered rock showing, under the microscope, only chlorite and muscovite, and its origin is uncertain, but it suggests (as is shown in the hanging) that it comes from a true volcanic.

The foot wall rock is filled with cubic crystals, both large and small, of pyrite on the edge near the body of iron ore, but its lower portion is more free from this metallic sulphide. The structural and stratigraphical relations remain to be worked out.

The designation of the ore found in this field is best given by the words "Magnetic-hematite." It has, as a rule, the characteristic cherry red streak and dark grey colour of hematite, but in spots and in the vicinity of jasper intrusions is altered to a black ore which is magnetite. As a rule the ore is attracted by the magnet a frequent characteristic of many grey specular ores. The magnetism, however, does not permeate all portions of the ore body, but is most frequently noted in the vicinity of the small intrusive veinlets of quartz and jasper which here and there penetrate the ore mass; in such places the ore has been converted into a strict magnetite which gives the characteristic black streak, but remote from such intrusions the red streak of hematite is everywhere noted.

At the northern edge of this field (on the Ellis property) the only ore seen is a grey specular, which has not been exploited, but which appears to be more steeply inclined and to have a width of not over 5 or 6 feet.

The shore of the Bay of Chaleur contains a narrow strip of rocks belonging to the lower and middle Carboniferous, which is followed to the south by red and purple shales and sandstones which represent, probably, the Mill Stone Grit, as they are followed by, and include some of, the typical coarse grey sandstones of the Grit. This Carboniferous system extends along the eastern bank of the Nipisiguit River for 13 or 14 miles, but the western bank shows only the old granites and gneisses of Laurentian Age for the same distance. The inclination of the Carboniferous is very slight, the average running from 3 to 4 degrees from the horizontal. Above, or to the south of, the Laurentian and lying directly upon the granite are reddish and grey schists and slates, shading into blue or black slates which, in places, are highly disturbed and occasionally cut by quartz veins which render the schists more quartzose and less felspathic. Frequently the black slates are ferruginous with pyrites, and in places the silicification has formed hard green quartzites whose colour is doubtless due to a mixture of chlorite.

It is in this series of altered schists and slates that the iron beds occur. Twenty-eight years ago these schists and slates were provisionally regarded as "Cambro-Silurian" or portions of them as "Pre-Cambrian." Although unaltered eruptives were not noticed in the field the microscopic examination of the hanging and foot wall country indicate their presence in the vicinity.

Geological exploration of the region is exceedingly difficult owing to the dense growth of timber which covers it, and to the frequent patches of thick moss which cover the rock exposures. Undoubtedly a field party will be put into this new district during the coming summer in an endeavour to more clearly define the probable limits of the field, and to make a correct section, if possible, of the rock series in which the ore occurs.

Geography and topography.—The property lies about 21 miles from the town of Bathurst in a south south-westerly direction, and on the north bank of the Nipisiguit River. The country rises quite rapidly in this distance, so that the elevation of the beds is about 450 to 500 feet above sea level. Going south-west the country rises steadily until the hills of this section are reached, which vary in height from 800 to 1,500 feet above the sea level. The general character of the country is hilly and broken, with stretches of level lands along the main river. The general direction of the slight elevations which give a rolling character to the country is north-west and south-east, and across these ridges, with a general strike of north north-east, run the bands of the formation which carry the iron ore, and which in consequence are sometimes exposed along the crests of the ridges.

Discovery.—The first discovery of ore in this field dates back to the year 1902, when Mr. William Hussey of Bathurst, in attending some traps which had been set on Austen Brook (a tributary of the Nipisiguit River) hurt his foot upon a rock beneath the snow which rock turned out to be a piece of float ore from the crest of the hill nearby. The heavy character of this small boulder puzzled Mr. Hussey, who knocked off a piece and took it home with him where it was shown to one or two people, and, by the kindness of Mr. T. M. Burns, was taken to Fredericton for examination by a Provincial Government official there, who at once pronounced it to be iron ore of a fairly good quality.

The previous history of iron ore deposits in New Brunswick had not been such as to make their mining particularly attractive as a venture, and it is not therefore surprising to find that little interest was shown in the matter. I am informed that a representative of the Dominion Iron and Steel corporation visited the locality a few years ago, but saw only the scattered and comparatively small outcrops in the area which is now designated as "No. II." I am also informed that this gentleman entertained a favourable opinion from the small surface exposures he was then able to see. But, in the winter of 1905, when in the same locality Mr. Hussey remembered his previous mishap and made a short but more thorough examination of the region, with the result that he found other outcrops and an abundance of fragments or boulders of ore on the southern bank of Austen Brook. This convinced Mr. Hussey and Mr. Burns that the ore was distributed over a quite extensive area, and these gentlemen secured Rights to Search upon several five-mile locations in this district.

Through the assistance of friends, advice was received from Dr. Eugene Haanel, the Dominion Superintendent of Mines, and under his authority Mr. Einar Lindemann made a survey of a portion of the field with the magnetometer, in whose use Mr. Lindemann was skilled. The Government of New Brunswick were also petitioned (under statutory regulations) for the use of the Diamond Drill belonging to the Province, which was granted, and the first hole was finished about the beginning of December, 1906, by which time Mr. Lindemann had completed his magnetometric survey and fyled his report. Mr. Lindemann's opinion, as expressed in his report, was favourable to the existence of large bodies of ore, but could not, of course, indicate the purity or otherwise of such ore. For this reason the then owners decided to continue the work of drilling the field and obtaining analyses of the ore found in the cores.

The following record of the seven holes drilled is necessarily abbreviated, but for the purposes of this paper will be sufficiently comprehensive.

Borehole No. 1 was located some 200 feet south of the northern end of the deposit found on Area No. I. At the northern end of this area there is a small hill, rising on the southern bank of Austin Brook precipitously to a height of 78 feet, from which height there is a gradual descent to the south of nearly 40 feet, and at the base of this slope and on the hanging, or western, wall of the deposit, No. 1, Borehole was put down to a depth of 162 feet. It was in ore continuously from 35 feet to the bottom, giving 127 feet of core which was analysed for Insoluble matter, Iron, Phosphorus and Sulphur, the average length of core represented by each analysis being 10 feet. In this core there was found to be great variation; Insoluble matter ranged from 8.04% to 27.74%; Metallic Iron had a minimum of 39.6% and a maximum of 57.2%; Phosphorus varied from .486 to 1.007, and Sulphur showed variations from .047% to .699%. Close inspection of the results when tabulated showed that the ore occurred in bands or strata, ribbon-like, and that these strata were easily separated the one from the other, so that it would be quite possible to hand-sort the ore into two piles, one of which would easily exceed 52% of metallic iron with a minimum of silica, and the other would contain approximately 45% of metallic iron with the maximum amount of silica. These bands or strata of good ore range from 10 to 25 feet in thickness. Subsequent stripping of the surface clearly showed a banded structure.

No. 2 Borehole was put down approximately in the middle of Area No. I, about 800 feet south of the first borehole. Its depth is 161 feet. It began in iron ore and showed 140 feet of merchantable ore. Like No. 1 hole it shows a banded structure and out of the 140 feet there are 60 feet which average:—

Metallic Iron 54.11%, Insoluble matter 16.7%, Phosphorus 0.73% Sulphur 0.098%.

On the bank of the Nipisiguit River, and at the extreme southern end of Area No. I, Borehole No. 3 was located but, unfortunately, upon the foot wall instead of on the hanging wall of the deposit; it therefore proved barren, but a sample taken from the surface at this point gave:—Metallic Iron 51.6%, Silica 15.28%, Phosphorus .82%, Sulphur .05%.

No. 4 Borehole was put down about 450 feet to the westward of the outcrop and about its centre; this made it on the hanging wall of the ore body. The total depth attained by this hole was 527 feet, the first ore was encountered at a depth of 434 feet and for 70 feet, or to a vertical depth of 504 feet, the ore was found continuous and of the same quality as has been shown in the previous analyses.

These four holes proved the existence of an ore body of at least 2,140 feet in length to a depth of 500 feet below the surface, which, in itself, is a very considerable deposit. Of this large amount of ore fully one-half will give 53% Metallic Iron and not over 15% of Silica.

Area No. II, so called, lies about 1,000 feet to the eastward of Area No. I. It presents at least five distinct outcroppings in the shape of knobs or small lenticular masses, the axis of which has a more easterly direction, being north 30° east, as against north 15° east for Area No. I. No boreholes were put down upon this area, which previously had had some stripping done by a representative of the Dominion Iron and Steel Company. From the lines of the magnetometric survey made by Mr. Lindemann it will be fair to assume a length of 1,500 feet for the axis of the ore body in Area II. Surface samples from this Area gave the following analysis:—

Iron	50.23
Silica	15.32
Phosphorus	0.623

Manganese	1.29
Sulphur	0.044
Alumina	0.94
Lime	2.18
Magnesia	0.26

Area No. III is an oval shaped area lying from 3,000 to 5,000 feet north of the northern bank of the Nipisiguit River in Lot 12 of the 17th Range of the Township of Bathurst; the major axis of this Area has a direction of north 30° east, and a length so far proved of 2,400 feet. Within this Area are half a dozen or more outcrops which, if I may express my belief, will be found to unite when stripping has been accomplished, into one or possibly two large lenses or bodies of merchantable ore. Up to the present time only three drill holes have been put down on this Area, which have proved large bodies of a better grade of ore than in Area No. I, and have shown the dip to be to the westward at angles ranging from 54 to 56 degrees.

Borehole No. 5, at a distance of about 700 feet from the southern edge of this Area, was sunk vertically upon the hanging wall of the ore body to a depth of over 350 feet. Ore was encountered at a depth of 23 feet, and the core was continuously in ore to 347 feet, showing a vertical depth here of at least 324 feet, or, on dip of 55°, a transverse width of ore *in excess of* 190 feet. Thirty-three analyses were made of this core in portions representing (with one exception) 10 feet of the core. The same structure was revealed that was shown by analyses of Boreholes 1, 2 and 4, namely, that the ore was composed of bands of varying quality, there being in this cross-section 4 bands of excellent commercial grade and 3 bands of a lower grade than is, at the present time, in demand. The first 50 feet of the core, i.e., from 23 feet to 73 feet, gave the following average analysis: Insoluble matter 13.4%, Metallic Iron 52.68%, Phosphorus .99%, Sulphur .047%; this was followed by 50 feet of ore giving over 20% of Insolubles and less than 45% of Iron. Then followed 20 feet with 15% of Insolubles, 52.58% of Iron, .752% of Phosphorus, and .05% of Sulphur. This, in turn, was succeeded by 70 feet of ore averaging only 44.3% of Iron and running high in Silica and Sulphur. After this came 50 feet of good ore, averaging 53% Metallic Iron, which in its turn is followed by 40 feet of 46% ore; the whole concluding with 44 feet of ore, the analysis of which gives 12.25% of Insolubles, and 54% of Metallic Iron.

This hole was put down on what, upon further investigation, may prove to be the easternmost bed in this No. III Area; at a transverse distance of 250 to 300 feet to the west another series of strongly magnetic lenses appear, but none of them have been drilled. The last hole, No. 7, is located about 750 feet north of No. 5; it encountered iron ore at a depth of 30 feet and passed out of the ore at about 107 feet; in this 77 feet there are nearly 60 feet of excellent ore. Beginning at 40 feet in depth up to 83 feet there is a length of core 42 feet 6 inches long, which averages 53.10% Metallic Iron, with 17.02% of Insoluble matter. From 91 feet to 107 feet there are 16 feet of ore averaging 54.32% Metallic Iron, with 14.37% of Insolubles.

Consideration of these figures will, I think, clearly indicate that iron ore in very large quantities exists in this hitherto unknown region. The depths to which the boreholes have proved the existence of the iron, coupled with the horizontal extent over which the ores are known to exist, and the widths (which have been measured to average fully 100 feet) demonstrate that the bodies are large.

The analyses of the cores is not altogether satisfactory from a chemical point of view inasmuch as the method followed (by digestion in acid) does not show the true Silica, but only Silica plus silicates and other insoluble compounds, which, from the iron master's standpoint, may be a very different matter. In the present case the "Insolubles" are really country rock, which has previously been mentioned as igneous. The insolubility of many silicates in strong acids is well known to chemists. The gabbros and diorites of the hanging wall, with the muscovite and chlorite of the foot wall, contain silica percentages ranging from 50 to 80. In the few complete analyses which have been made of the ore (the silica having been determined correctly, either by fusion or by the hydro-fluoric acid method) the actual percentage of Silica has ranged from 7 to 12, and there have been found amounts of alumina ranging from .05 to 1.2, lime from 2% to 3% and magnesia from ½% to 1%.

By hand picking or rough lump sorting fully one half of these large ore bodies can be made to average from 57 to 58% Metallic Iron, with 10% of Silica; the Phosphorus in such ore will run about 0.88% and the Sulphur 0.055%. With ores of such a character no gentleman conversant with the iron ore markets of the European Continent would be disposed to quarrel.

For such a basic ore the demand is now large and steady, and the location of this new field within 20 miles of a sheltered deep water harbor enhances its commercial importance, as ocean shipments from this harbor can be made during at least 9 months of the year.

The property, including some 30 square miles of territory, passed into the control of the Drummond Mines Limited in November, 1907, and by this corporation it will be actively exploited this summer; it will also be tested in the furnaces of the Londonderry Iron and Mining Company, although its composition is such as to occasion no uncertainty as to the quality of pig iron obtainable from it.

Although the ore is a non-bessemer, the significance of this new district to Eastern Canada is very great. Iron ores of good quality are scarce in our Dominion and so far have been at considerable distances from the seaboard; it is therefore with the feeling that this new field is well worthy of a preliminary notice, and that it will probably add very largely to the Dominion's resources of furnace oie, that I have ventured to bring this account to your notice.

CHARCOAL:—THE BLAST FURNACE FUEL FOR ONTARIO

By R. H. Sweetzer, Columbus, Ohio.

(Ottawa Meeting, March, 1908.)

The blast furnaces of Ontario have for the most part depended on the United States for their fuel. Whether the coke comes direct from American ovens or whether coal is shipped to Canadian coke ovens, the fuel cost per ton of pig is higher than in countries provided with their own supply of fuel. The use of electricity for smelting Ontario iron ores has been tried, but as a commercial operation electric smelting for making pig iron is, and for many years will be, impracticable. At the present time there is in Ontario such an abundance of material for making an ideal blast furnace fuel, that it seems but necessary to prove the superiority and to indicate the possibilities of this fuel to start a movement that will place Ontario in the position the Province should occupy in respect to the manufacture of iron and steel and to make her independent of all outside sources of blast furnace fuels. There is only one fact that inclines one to hesitate in presenting these views, and that relates to the destruction of the forests. But there is so much land in Ontario that must be cleared for settlement and civilization that this objection need not be seriously considered for many years to come.

Charcoal was the first fuel used in the primitive blast furnaces, and its use was continued in England until the destruction of the forests brought about prohibitive laws and the blast furnaces were compelled to use coal and coke. On this continent charcoal was the almost universal fuel up to the middle of the last century, and its use has been continued in some sections of the United States and Canada to the present day. But with few exceptions the charcoal blast furnaces now in operation are not up-to-date nor are they large producers. Those furnaces which have been equipped with modern machinery are already feeling the lack of charcoal and in some cases have even imported part of their supply from Canadian kilns. The rapid destruction of the forests supplying wood for charcoal, together with the usual small capacity and light weight equipment of existing charcoal blast furnaces, has brought about the generally accepted opinion that the use of charcoal as a blast furnace fuel is almost a thing of the past. With nearly all the countries that are now large producers of pig iron this is true; but with at least two great possible producers, Canada and Russia, charcoal is the logical, the best and the cheapest blast furnace fuel for present and, for a number of years of, future use.

Charcoal has three great advantages over coke as a blast furnace fuel; and these three main advantages bring about several other economies in operation and construction. Charcoal requires:—

1. Less fuel per ton of pig iron;
2. Less limestone per ton of pig iron;
3. Less blast per ton of pig iron.

LESS FUEL

Charcoal, on account of its purity, is almost 100 per cent. fuel, whereas coke contains from seven to fourteen per cent. of ash. The ash not only lessens the total amount of available fuel, but it also requires a part of that fuel to furnish heat for the smelting of the ash. This brings the net available fuel in coke to from 80 to 90 per cent. of its weight.

Actual results have shown that charcoal pig iron was made on 2,083 pounds of charcoal, where under similar conditions it took 2,207 pounds of coke per ton of pig iron. These results were obtained at the blast furnace of the Algoma Steel Co., Sault Ste. Marie, Ontario, during the time that No. 1 furnace was using charcoal and No. 2 furnace using coke, April, May and June, 1905. Nearly all conditions were similar, except that the charcoal was very poor and the coke was good. Some few furnaces in the Great Lakes region will make iron on less than 2,200 pounds of coke per ton of pig, but charcoal iron can be made on less than, 1,900 pounds of charcoal and a fuel rate of between 1,600 and 1,700 pounds per ton of pig has been reached under favorable conditions. A good average figure for the amount of coke per ton of pig iron for the whole year round is 2,300 pounds; the amount of charcoal on an average is about 400 pounds less.

LESS LIMESTONE.

It requires only one third to one fourth as much limestone for flux in a charcoal furnace as it does in a coke furnace. This is chiefly because there is no sulphur at all and scarcely any ash in the charcoal. Most of the sulphur in coke iron comes from the coke itself; this is especially true where only Lake ores are used. If there is not much sulphur in the mixture, then the slag can be more fusible and can carry much less lime than is permissible when the fuel and the ores carry considerable sulphur. This advantage of charcoal fuel is of especial importance in the smelting of ores from Ontario on account of the presence of sulphur in so many of them.

Some charcoal blast furnaces in Michigan use only 175 to 200 pounds of limestone per ton of pig iron made; but at the Soo it was found that between 300 and 400 pounds were required. Some coke furnaces are so favorably supplied with good ores and low-ash coke that it takes only 800 to 1,000 pounds of limestone per ton of pig, but most of them require 1,000 to 1,400 pounds, and some take even more on account of lean ores or high sulphur in the mixture.

The less limestone required for flux, the less slag there will be to carry off heat from the furnace, and the less bulk of material will have to be taken care of inside the furnace. Consequently there is less flux to handle in filling the furnace, and the less slag there is to be taken away from the furnace.

LESS BLAST.

The question of the quality of the air that is taken into the blowing engines to furnish the blast for the furnaces has received so little attention until very recently, that it is usual to find that no special arrangements have been made to get proper air. Even in many comparatively new plants the blowing engines take the air right from the hot, and often moist, engine room. At the Soo, the air enters the blowing engines through large intake pipes that extend from the air valves out through the side of the building to the out-doors, thus furnishing the air at the temperature and dryness of the outside atmosphere. This temperature is many degrees cooler than that of the inside air, at all times of the year. In some of the best equipped plants the Gayley Dry air Blast Apparatus has been installed with much success. In Ontario, on account of the natural cold and dryness, there is not so much need of this apparatus, as there is in the central and southern parts of the States.

Under ordinary circumstances it takes about 140,000 cu. ft. or 5 tons of air to make one ton of coke pig iron. A ton of charcoal iron under the same conditions can be made with 91,000 cu. ft., or about 3¼ tons of air. This great difference in favor of charcoal is the basis of many of the ecomonies in the construction of a charcoal blast furnace compared with a coke furnace of the same capacity. Requiring only 65% as much blast means a corresponding reduction in the capacity of the blowing engines, boilers, and hot blast stoves; it means lower blast pressure on the engines, stoves and furnace; it means less volume and less velocity of the waste gases and consequently less flue dust carried over into the down comers and dust catcher. This last item has been found to actually bring about a higher yield of pig iron from ores smelted in a charcoal furnace than when the same ores are smelted in a coke furnace.

THE PRODUCT.

The pig iron made in a charcoal furnace is almost always low in sulphur; and it is possible to make iron with extremely low silicon, and also low sulphur. Although this is possible with a coke furnace, yet it is difficult to make very low silicon and yet have low sulphur. If a coke furnace works badly the pig iron made is invariably high in sulphur; with a charcoal furnace in distress the iron may be, and generally is, all white iron, but still the sulphur never gets high enough to do any harm, and seldom, if ever, goes over .040%.

The analysis of charcoal iron can be varied as desired within the same limits as in a coke furnace. Charcoal iron can be used for any purpose that coke iron is used, and besides can be used for some purposes for which coke iron is not suitable.

Charcoal iron for the basic open hearth process would always be low in sulphur, and the silicon could be as low as desired.

The biggest blast furnace ever operated with charcoal for fuel was the No. 1 furnace of the Algoma Steel Co. at Sault Ste. Marie

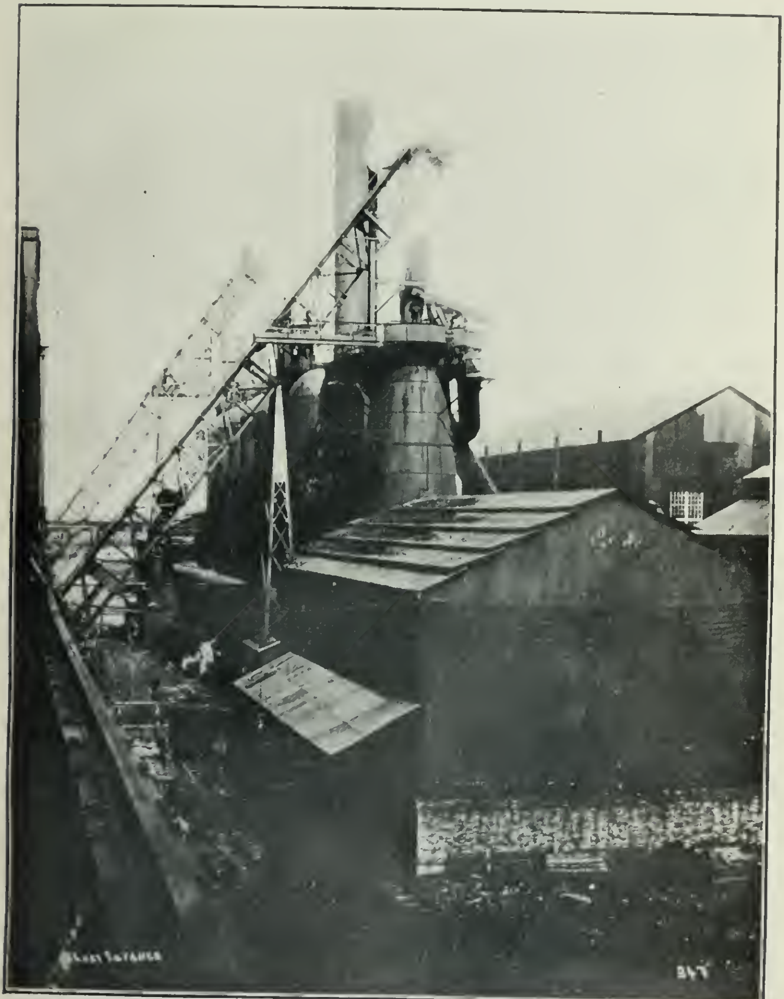


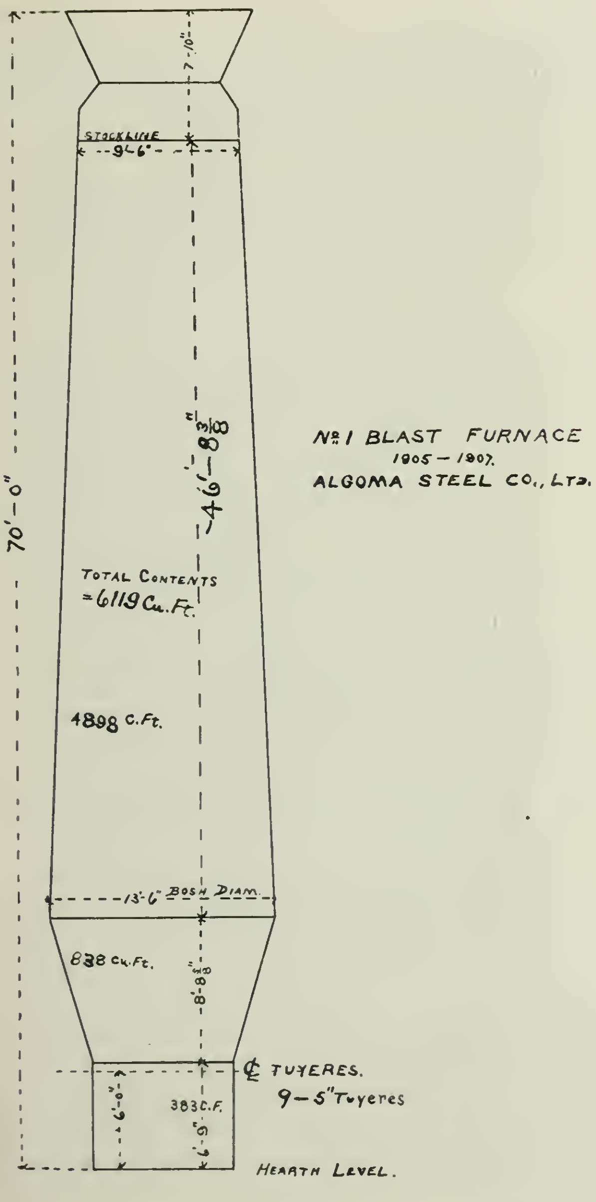
Photo of No. 1 Blast Furnace, The Algoma Steel Co., Sault Ste. Marie, Ont., while running on Charcoal, 1905.

Blast Furnaces and Ore Dock of The Algoma Steel Co., seen from the River. No. 2 Furnace on the Left.

Ontario. This furnace was 70 feet high, 13½ feet diameter in the bosh, and 8½ feet diameter in the hearth. It was first blown in on March 6, 1905, and was operated as a charcoal furnace until July 16, 1905. Then for good and sufficient reasons the fuel was changed from charcoal to coke without any change in the construction of the furnace, but there was a decided increase in the volume of the blast and in the amount of limestone used. This furnace was large for a charcoal furnace, and it made a new world's record for output; it was, however, small for a coke furnace, yet the production was very large for the rated capacity. Comparing the best month's work on charcoal with the best month's work on coke, we get a fair idea of the main points of advantage in favor of the charcoal. But there is one fact that must be taken into consideration, and that is that at no time while the furnace was running on charcoal was there a large enough supply of charcoal in sight to warrant running the furnace at the rate of best working; the volume of blast had to be kept down to suit the available supply of fuel. While running on coke there was a sufficient supply of fuel and the furnace was blown according to its needs.

The following table gives the best month's record for charcoal, and the best for coke:

Month	Charcoal May, 1905	Coke February, 1905
Number of days	31	28
Total product in tons (2,240 lbs)	4,040	5,618
Average product per 24 hrs	130.3	200.6
Pounds fuel per ton of pig iron	2,016	2,326
Pounds limestone per ton of pig iron	308	954
Pounds ore per ton of pig iron	3,842	4,291
Per cent. of Messabi ores used	33.7	41.5
Theoretical yield in pig	58.5%	56.5%
Actual yield in pig	58.3%	52.2%
Per cent. iron in ore mixture	54.84%	52 9%
Deficit in pig	.2%	4.3%
Average silicon in pig iron	1.63%	1.15%
Average sulphur in pig iron	.014%	.026%
Pounds fuel per 24 hours	262,742	466,785
Cubic feet air per pound of fuel	41.60	54 67
Pounds fuel per 24 hours, per cubic foot capacity	42.93	76.28
Cubic feet air per ton pig iron	81,423	127,205
Average temperature of air for blowing engines	46.6°	13.0°
Average gram's moisture in air	2.49	0.86
Advantage in cost of labour per ton pig		$0.28
Tons pig per 24 hours per 1,000 cu. ft. capacity	21.29	32.8
Cu. ft. capacity of furnace per ton pig per 24 hours	46.9	30.5
Total pounds fuel used	8,146,000	13,070,000
Total pounds air used	338,952,437	714,642,885
Height of furnace	70′–6″	70′–0″
Bosh diameter	13′–6″	13′–6″
Hearth diameter	8′–6″	8′–6″
Stockline diameter	9′–6″	9′–6″
Bell diameter	6′–0″	6′–0″
Cubic contents	6,119 cu. ft.	6,119 cu. ft.
Number of tuyeres	9	9
Diameter of tuyeres	5″	5″
Biggest Day's product	173 tons	237 tons
Biggest Week's product	1,004 tons	1,453 tons
Biggest Month's product	4,071 tons	6,131 tons


7'-10"
STOCKLINE
9'-6"
70'-0"
46'-8 3/8"
TOTAL CONTENTS
=6119 Cu. Ft.
4898 C. Ft.
13'-6" BOSH DIAM.
838 Cu. Ft.
8'-8 3/8"
℄ TUYERES.
9—5" Tuyeres
383 C.F.
6'-0"
6'-5"
HEARTH LEVEL.
No. 1 BLAST FURNACE
1905—1907.
ALGOMA STEEL CO., LTD.

THE REDUCTION OF IRON ORES IN THE ELECTRIC FURNACE.

By R. Turnbull, St. Catherines, Ont.

(Ottawa Meeting, March, 1908.)

The purpose of the present paper is to outline the progress accomplished, so far as the author's knowledge goes, in the working out of the interesting problem in connection with the reduction of iron ores in the electric furnace since the close of the Government experiments at Sault Ste. Marie in March, 1906.

The experiments themselves have been faithfully portrayed in the Government report issued by Dr. Eugene Haanel. Attention may, however, be drawn to the fact that as the short ton of 2,000 lbs. was taken as a basis for those experiments, instead of the long ton of 2,240, corrections should be made in respect to the figures and costs given in the report in estimating the exact cost of the long ton of pig iron and the amount that can be produced per h.p. year.

In July, 1906, the writer was asked by Mr. H. H. Noble, of San Francisco, Cal., to inspect an iron property situated near the junction of the rivers McLeod and Pitt, in Shasta county, with a view to the erection in that neighbourhood of an electric smelting furnace. As a result of this visit, Mr. Noble determined to install immediately a furnace of 2,000 h.p. capacity, which, having regard to the high grade quality of the ore, was expected to produce 25 tons of pig per 24-hour day.

The mine is situated at an altitude of about 1,500 feet and forms the crown of a hill composed entirely of solid magnetite ore. A rough estimate, assuming an average depth of 300 feet, gives ore in sight of over two million tons. A quarry has been cut in one of the faces, and about 5,000 tons of ore have been taken out. The face of the quarry, which is about 150 feet in breadth, is one solid mass of magnetite, averaging between 68 to 70% metallic iron.

An average analysis of the ore shows—iron, over 69%; sulphur, 0.024; phosphorus, 0.016.

Adjoining the iron mine is a large deposit of pure limestone, and the contact with the iron ore, even on the surface, is very striking. This body of limestone runs down and cuts beneath the iron ore body on one side of the hill only, at a depth of about 300 feet from the top. At this point the ore is much poorer, and sulphides of iron and copper are found; in some places pure iron pyrites have been extracted. The iron body, on the contrary, bends back in the opposite direction to the limestone, and pure iron ore is found on the opposite side of the hill in large blocks 1,000 feet from the top.

The smelter is situated at an altitude of about 500 feet, and at a distance in a straight line of something under a mile from the mine. The problem of conveying the ore and limestone to the smelter was therefore simple. Meanwhile an aerial tramway is being installed, by which the ore can be laid down at the smelter at less than $1.25 a ton, this price including the royalty to the owners of the mine.

In further reference to the smelter : the furnace was first of all designed to work one-phase only, but later was changed to three-phase, this latter being a distinct departure in electric furnace work, in the case of large capacity. It was built on the same principle as the furnace employed at Sault Ste. Marie, with the exception that it was hermetically closed on top by an iron cover, and the charging was accomplished by means of four 10-inch vertical iron pipes about 10 feet long from an upper charging floor. Two of these pipes were placed between the three electrodes and the other two at each end of the furnace, thus insuring an equal distribution of the charge round the electrodes. The 10-inch pipes were enclosed in cast iron pipes 14 inches in diameter, through which the escaping gases were drawn, the idea being to admit air at the lower end and to burn the gases with a view of preheating the ore as it descended through the smaller pipes, which were always kept full with the charge. The shape of the furnace was oblong, 12 feet long and 5 feet wide, the depth inside forming the crucible being 3 feet 3 inches. The current was supplied by three 500 k.w. transformers, 22,000 volts on the primary side and 50 on the secondary. This voltage was never maintained when the furnace was in operation, owing to the main lines being overloaded, and at no time was it possible to get over 1,200 h.p. The voltage generally fell as low as 35, which, while not interfering in any way with the working of the furnace, obliged the electrodes to carry a much higher density of current than would have been the case had the voltage been maintained at 50. The power was generated at a distance of forty miles from the smelter and delivered at the smelter sub-station at a very low cost.

To give in detail an account of all the troubles, difficulties and successes which were experienced would occupy over much space and time. A brief summary of these experiences may, however, prove of interest.

First: The power obtainable being altogether inadequate, we were unable during the first runs, when the furnace was in good condition, to follow the programme originally outlined.

Second: The water supply was so poor that it was impossible to obtain a sufficient supply for the water-cooled parts of the furnace, and this resulted in part of the cover being melted in the second run.

Third: The efficiency of the escaping gases between the exterior pipes and the ones through which the charge was descending was so great, and the charge was preheated to such an extent, that the ore became soft and sticky in the pipes, thus preventing the charge descending easily as it did when cold or at a red heat.

Fourth: The cast iron cover, which was kept perfectly cool by the charge so long as this charge came down evenly and regularly, got white hot as soon as the charge became sticky and descended at irregular intervals, with the result that a large hole was melted in the cover, which rendered it useless for further operations.

At this stage it was decided that a new cover should be obtained, and of a modified form to prevent the sticking of the charge in the pipes Mr. Noble, however, being averse to this proposal, on account of the inevitable delay, the damaged cover was taken off, and some other trials were made. One constituted working the furnace open as in the case of the furnace at Sault

Ste. Marie, and the other by partially covering it with brick arches. In each case the heat coming from the top of the furnace was so great that it was impossible for men to approach it.

Dr. Heroult being of the opinion that, even supposing the furnace could be made to work satisfactorily with a modified cover, it was not sufficiently practical to solve the problem; it was therefore arranged between Mr. Noble and himself that the furnace as it stood should be used for other purposes until a new style of furnace had been worked out, and that in the interval an aerial tramway should be installed between the mine and the smelter and other improvements made to cut down costs on raw material.

The foregoing experiences have justified the following conclusions:

First: The practice of using the electrodes on the top of the furnace embedded in the charge should be entirely abandoned in the future smelting of ores electrically, except, possibly, in the case of small furnaces of not over 500 h.p. capacity, where only one electrode would be required.

Second: A three-phase current can be used successfully, no trouble being experienced on that score. This is of great importance where the power must be transmitted from a distance.

Third: The metal bath did not form under and around the electrodes only, as was at first feared, but over the entire surface of the crucible, thus allowing the use of only one tap-hole.

Fourth: The heat in the electric furnace must be generated at the same point where the blast enters the blast furnace, not in the charge itself, but below it. This can be done by having the electrodes on the side or between the shafts, as in the case of the Heroult-Haanel furnace, or in the one designed by myself. I may say, however, that our present efforts are all toward the creation of fixed electrodes instead of movable ones, the current to be regulated by special transformers, giving fixed watts but allowing the volts and amperes to vary as the condition of the furnace may demand. This will simplify the work to a great extent and do away nearly altogether with the consumption of electrodes. It will also allow of the upper part of the furnace being kept entirely free, and the escaping gases could either be used for the preheating of the charge or collected for other purposes.

In the spring of last year Mr. R. H. Wolff, of New York, and myself decided to erect a plant in Canada, in order to demonstrate that iron ore could be commercially and profitably smelted in the electric furnace. It was decided that the furnace should be of 3,000 h.p. capacity, with an expected output of 30 tons of pig per day. In passing it may be mentioned that a site was found at Welland, Ontario, which is excellently situated in regard to transportation facilities, and, being near Niagara Falls, power can be had at a reasonably low cost. Although no production of pig iron has yet been made, several electric furnaces are already running, the product at present being mainly of ferro-silicon; but ere long it is expected the production of ferro-chrome and ferro-tongstene will commence, and in the near future, if the tests about to be made are satisfactory, pigiron.

As the large furnace was designed for the use of a three-phase current, the work thereon was not prosecuted until results from California were available, to make sure that the principle was correct. The experiences in California, as related, suggested the advisability of caution, and work on the furnace was meanwhile abandoned, to permit of the testing of Dr. Heroult's new style of furnace, which he is erecting at his own expense, and which is to be on the fixed electrode principle with special transformers for the regulation of the current.

The capacity of this new furnace will be 500 h.p. It is circular in shape and stands about seven feet high. The electrodes of which there are three, one corresponding to each phase, are arranged radially at a certain distance above the metal bath. The exact height at which these electrodes will work to chief advantage can only be determined by practice. This also will greatly depend on the possible range of voltage in the transformers. The design permits the electrodes to be entirely protected from the charge, and at no time are they embedded in it, the heat being furnished by an arc which strikes between the electrode and the charge, the voltage necessary to strike this arc being regulated, as before mentioned, by the special transformers. The furnace, which is being built at our Welland works, is nearly completed and will be in operation, it is expected, during March.

In conclusion it may be stated that three main points have been conclusively established since the Government experiments at Sault Ste. Marie :—

First: The amount of monoxide gases escaping from the furnace will not only suffice for a preheating of the charge approaching the melting point, but sufficient will still remain for accessory work outside of the furnace.

Second: Special basic slags for the elimination of sulphur are entirely unnecessary. Tests have lately been made by us with ores containing over 1% in sulphur, with a resulting product showing only from a trace to 0.035%, a slightly basic slag only being used.

Third: Movable electrodes must be abandoned. They are not only a mechanical nuisance, but, as the main point at which to strive in the electrical reduction of ores is a low cost of the product, there will always be anxiety and trouble so long as we have the electrodes sticking in the charge. As this always means extra costs, he who can produce an efficient electric furnace with a practical means for using fixed electrodes, in the manner I have tried to indicate, will have solved the problem of the smelting of iron and other ores electrically.

DISCUSSION.

DR. STANSFIELD:—I must thank Mr. Turnbull for the details of cost, etc., which he has given in his paper. Such details are generally very difficult to obtain, as gentlemen engaged commercially in electric smelting do not care to publish their methods or results. Mr. Turnbull referred to the utilization of the carbon monoxide liberated in an electric iron smelting furnace. I have discussed this point at length in my own paper on electric smelting, and so I shall not speak about it at present. I should like to know whether Mr. Turnbull uses stuffing boxes around the electrodes to keep the gases in the furnace?

MR. TURNBULL:—No, but the furnace is always under pressure, so that no air can get in, which keeps a reducing atmosphere always within the furnace; otherwise the electrode and carbons would be eaten away.

DR. STANSFIELD:—Would you give us any figures as to the costs of the electrodes and their consumption?

MR. TURNBULL:—I do not know by our latest experiments. We made about 40 tons of pig iron, but it was impossible to get any data as to the consumption of power or electrodes. I do not think the latter will go over the figures given by Dr. Hanson in his report. If you are afraid multiply it by two.

DR. STANSFIELD:—What about the cost?

MR. TURNBULL:—That depends upon the cost of raw material. They could be produced, I should say, in Canada at two cents a pound, perhaps a little less. But of course no one can buy them at that. You have to know the process of making them and so have to pay probably five or six cents a pound.

POSSIBILITIES IN THE ELECTRIC SMELTING OF IRON ORES.

By ALFRED STANSFIELD, D.Sc., Montreal.

(Ottawa Meeting, March, 1908.)

In view of the many recent attempts that have been made to employ electrical energy instead of fuel for the smelting of iron ores, it appears worth while to indicate, in a short paper, what can probably be accomplished in this direction, the manner in which successful results can be obtained, and the advantages and drawbacks of the electrical process.

In the ordinary metallurgy of iron the ore is smelted in a blast-furnace with coke, producing pig-iron. This is an alloy of iron with some 2% to 4½% of carbon, ½% to 4% of silicon and small quantities of other elements. It is decidedly more fusible than wrought iron or steel, and on this account is very suitable for foundry purposes. Bessemer steel and open-hearth steel are made from pig-iron by removing from it in the Bessemer converter, or the open-hearth furnace, a considerable proportion of the carbon silicon, etc., which it contains, the product being nearly pure iron retaining a little carbon and some manganese.

Crucible steel is used for tools. It contains about 1% of carbon, and is made by adding the necessary amount of this element to pure varieties of iron or steel, and melting the material in crucibles so as to obtain a perfectly sound product.

Electrical energy has recently been employed to replace, in such operations, the heat which is ordinarily obtained by burning fuel. Electrical energy is somewhat expensive, and it was naturally employed at first for the production of the more valuable products, such as crucible steel, where the cost is of less importance. The electrical production of cast steel for tools and similar purposes may be accomplished in two ways—(1) by melting down pure varieties of iron and steel with suitable additions of carbon and other ingredients, just as in the crucible process, but using electrical energy for heating instead of coke or gas; (2) by melting a mixture of pig-iron and scrap steel as in the open-hearth process, and removing the impurities, such as sulphur and phosphorus, so thoroughly by repeated washing with basic slags that a pure molten iron is at last obtained. This can then be recarburised and poured into moulds. Both of these methods are now employed commercially for the production of good qualities of tool steel. The larger sizes of electrical furnace that have already been constructed hold 5 or 10 tons, while the crucible will only hold about 80 lbs., and the high efficiency of the electrical method of heating more than compensates for the greater initial cost of electrical energy as compared with heat derived from fuel. The resulting steel is found to be even better than crucible steel, and can be produced at less cost. It is, therefore, only a question of time until the crucible process shall be entirely replaced by the electrical process in all localities where electrical energy can be produced at a moderate figure.

Two forms of electrical furnace have been used for making cast steel:—(1) the Héroult steel furnace, which resembles an open-hearth furnace through the roof of which hang two large carbon electrodes. Electrical connection is made to these carbon electrodes and electric arcs are maintained between the lower end of each electrode and the molten slag in the furnace, thus producing the necessary heat. This form of furnace has been found to be very suitable for the second of the above processes, that is, the one in which pig-iron and scrap steel are melted together and refined until pure enough to convert into cast steel.

An entirely different form of furnace has been devised in which no electrodes are required. This furnace consists of an annular shaped trough containing the steel. This ring of steel acts as the secondary of an electrical transformer. An alternating current is supplied to a primary winding, and the primary winding and the ring of steel both encircle an iron core, as in the ordinary transformer. The alternating current in the primary circuit induces a very large alternating current in the secondary circuit, that is, in the ring of steel, and in this way enough heat is produced to melt the steel. This type of furnace has been constructed lately in somewhat large sizes holding as much as 8 tons of steel and consuming 1,000 electrical h.p. It is apparently well suited for the first mentioned process, that of melting down pure varieties of iron and steel just as in the crucible process.

The amount of energy needed in these furnaces amounts to about 800 or 900 K.W. hours per ton of steel, using cold stock, or 600 or 700 K.W. hours when the pig-iron, which usually forms part of the charge, is supplied molten. This amount of electrical energy would cost more than the coal used in producing the same amount of steel in the open-hearth furnace, but the resulting steel is far more valuable than the open-hearth steel.

The above short account of the production of crucible steel in the electric furnace has been introduced, as this is the only commercial process for the production of iron or steel which is at present in operation. The present paper deals rather, however, with the electrical smelting of iron ores.

In reducing iron ore to a metal, iron can be obtained in a relatively pure state, such as wrought iron, and this was the method adopted by the ancient metallurgists in their small furnaces or hearths; but in the modern blast-furnace, with its higher temperature, the coke which is needed for the production of heat carburises the resulting iron, producing pig-iron. In the electric furnace, however, fuel is not used for the production of heat, since this is obtained electrically. Some carbonaceous material must be added to the charge in order to eliminate the oxygen of the ore, yielding metallic iron, but the amount of this carbonaceous material can be regulated so as to yield either pure iron, steel or pig-iron at will.

Although this has been realized by the pioneers in the electric smelting of iron ores, certain difficulties in the operation have led them to smelt the ore for the production of pig-iron instead of for the production of steel, although the difference in price of these materials would be sufficient to pay for all the electrical energy needed for the direct production of steel from iron ore, and it is surprising that this more attractive proposition has not gained more attention from metallurgists.

A number of experiments have been made on the direct reduction of steel from iron ore in the electric furnace, but the most satisfactory work that has been accomplished relates to the production of pig-iron from the ore, and this will be described first. This work has been carried out by Héroult, Keller and others. The furnaces they have adopted are similar to the one employed by Héroult recently in the experiments at Sault Ste. Marie. This consisted of a vertical shaft similar to a small blast-furnace, in which hung a central carbon electrode. The crucible of the furnace was lined with carbon and served as the other electrode, the electric current passing between the hanging electrode and the molten metal in the crucible of the furnace. The ore, with fluxes and carbon sufficient for its chemical requirements, was fed in around the vertical electrode, and became heated and melted by the heat produced by the passage of the current. The electric current in this furnace produces enough heat to carry out the chemical reactions involved in the reduction of the ore to metal, and the fusion of the resulting pig-iron and slag. The carbon is required for the reduction of iron oxide to metal and for the carburisation of the metal to form pig-iron.

The Keller furnace is practically the same as the Héroult furnace, except that it consists of two shafts instead of one and that these two shafts are worked in conjunction with one another, the current entering through the vertical electrode in one shaft and leaving by the vertical electrode in the other shaft. A connecting trough or passage enables the electric current to flow from one part of the furnace to the other, and serves to collect the resulting pig-iron and slag from both of the shafts. This furnace has the advantage of using a higher voltage than the single shaft furnace of Héroult. The results of operating furnaces of this class show a consumption of electrical energy of about 0.3 h.p. year, and about 800 or 900 lbs. of coke or good charcoal per long ton of pig-iron. Supposing that the general costs of operating this furnace and the blast-furnace were equal, these figures would indicate that the electrical furnace would need to obtain energy at a cost per h.p. year of less than that of two tons of coke in order to compete with the blast-furnace. Thus, if coke costs $3.00 a ton and electrical energy $5.00 per h.p. year the cost would be about the same by the two processes, and with power at $12.00 per h.p. year, the electric furnace could not compete with the blast-furnace unless the price of coke were as high as $7.00 per ton. In considering these figures it should be remembered that the heating power of one electrical h.p. year is about the same as that of three-quarters of a ton of good coal or coke, assuming that the latter is completely burned. Looked at from this point of view, it will be obvious that even these small and admittedly imperfect electric furnaces are more economical, that is to say, they use the heat better than the large blast-furnaces.

The electrical furnace possesses certain advantages over the blast-furnace, which in some cases may over-ride the high cost of electrical power. One is its ability to use without much trouble ores of a sandy or powdery character. This ability depends upon the absence of a blast in the electrical furnace. In the blast-furnace powdery ores are liable to be blown out of the furnace by the blast, or it obstructs the passage of the blast through the furnace. In the electric furnace there is no blast introduced, and these difficulties are less serious. Another advantage of the electric furnace is in regard to the smelting of titaniferous and other difficultly fusible ores. In the blast-furnace these ores are liable to give trouble on account of the slag becoming pasty, but in the electric furnace it is possible to obtain a higher temperature and thus to overcome any difficulty of this kind. The high temperature which can be obtained in the electric furnace is advantageous in regard to the treatment of sulphurous ores. In the iron blast-furnace, the sulphur contained in the coke or the ore is prevented from entering the pig-iron by the presence of lime and by maintaining strongly reducing conditions in the furnace; the lime then forms calcium sulphide, which passes into the slag. In the electric furnace it is possible to obtain higher temperatures, thus enabling a larger proportion of lime to be used, and even more strongly reducing conditions to be obtained than in the blast-furnace. Large amounts of sulphur can, therefore, be eliminated in the electric furnace, as has been shown in the experiments at Sault Ste. Marie.

Another point in favour of the electric furnace is that it does not require, as the blast-furnace does, a very high quality of coke for fuel. In the blast-furnace a soft or powdery coke becomes crushed and obstructs the action of the furnace, and is less efficient than a harder variety; but in the electric furnace, where the coke or charcoal is needed merely as a chemical re-agent, any convenient form of carbon can be employed—coke, charcoal or small anthracite—and probably in improved furnaces even such fuel as peat, sawdust or soft coal could be utilised for reduction.

Looked at from a commercial point of view the electric furnace producing pig-iron has many difficulties to overcome before it can compete successfully with the blast-furnace. One very important difficulty is the small scale on which the electric furnace has so far been constructed. It will be seen from the account of the Héroult furnace that the height of the shaft of this furnace is limited by the length of the electrode which is introduced into it. More recent furnaces have been designed by Dr. Haanel and by Mr. Turnbull, in which this difficulty has been overcome by a system of inclined or lateral shafts down which the ore passes, so that the electrode does not hang down the whole height of the ore column. Another weak point in the construction of the electric furnace is that no provision has been made for utilising the carbonaceous gases which escape at the top of the furnace. In the Turnbull furnace already referred to, it is proposed to utilise the gas by burning it in a rotating tube furnace down which the ore passes before it enters the electric furnace and is mixed with the charcoal. In this way the heat available in this gas will be utilised, and an economy in the working of the furnace may be expected.

In view of the importance of reducing the consumption of fuel and electrical energy to the lowest possible point, the writer has calculated what could be expected in this way if the gases arising from the reaction between the charcoal and the ore were used partly for the reduction of the ore and partly for preheating the ore. Such a result could be attained in a furnace consisting essentially of three parts. In the upper part the otherwise waste gases are burned by air introduced there and communicate their heat to the incoming ore to which the fluxes but not the charcoal have been added. In the middle portion of the furnace the gases arising from the lowest portion, which may be considered to be wholly carbon monoxide, react on the heated ferric oxide, if that were the variety of ore to be treated, and reduces it to ferrous oxide. The charcoal is introduced in the lowest section of the furnace and completes the reduction of the ore to metal. Electrical energy is introduced into this section of the furnace and serves to melt the resulting pig-iron and slag, and to supply the heat necessary for the preceding chemical reactions. The details of the construction of such a furnace have not been worked out at present. In a furnace of this kind it can be calculated that one ton of pig-iron can be obtained from an average ore by the use of 0.2 h.p. years of electrical energy and about 600 to 800 lbs. of coke or good charcoal. This includes a reasonable allowance for loss of heat. A further allowance should be made for irregularity in the use of the electrical power and, taking this into account, we may consider that one-quarter of a h.p. year and 600 to 800 lbs. of coke or charcoal would be required for one long ton of pig-iron from the ore.

Considering these figures, it will be seen that the use of ¼ electrical h.p. year will save about ⅔ of a ton of coke, or that 1 electrical h.p. year should not cost more than 2⅔ tons of coke if the electric furnace is to compete with the blast-furnace. Thus an electrical h.p. year at $12.00 would correspond to coke at $4.50 a ton. The considerations previously mentioned in regard to the use of cheaper fuel and cheaper ore in the electric furnace would also apply in this case, and with improved design and construction the size of the electric furnace may be increased so as to admit of a large and economical output of pig-iron.

Electric smelting plants on a small commercial scale have been put up at Welland, Ontario, and Baird, California. While very little has been heard of these, the writer understands that at Baird considerable difficulties have been met with in the operation of the furnace. No doubt these difficulties will ultimately be overcome. No attempt has been made at present to utilize the waste gases, but this point will be attended to later.

The direct reduction of steel from the ore has been carried out by Stassano and others, but no economical scheme for this purpose has ever been put into operation on a large scale. The Stassano furnace consists of a chamber, about one metre cube, lined with magnesite bricks. The ore, mixed with the necessary fluxes and charcoal for its reduction and made up into briquettes, is placed in this chamber, and is heated by an electric arc which is maintained above the ore. In this furnace it is possible to reduce the ore to metal and to remove any impurities, such as sulphur and phosphorus, although Stassano did not actually demonstrate this as the ores he employed were very pure. The method of heating the ore is, however, uneconomical, and it was not to be expected that commercial results could be obtained. Stassano still experiments with his furnace, but no longer uses it for the direct reduction of the ore.

Steel has also been obtained directly from the ore by Dr. Héroult in his electric steel furnace mentioned in the early part of this paper, but he found the process uneconomical and preferred to use pig and scrap as the materials for making steel in his furnace. Experiments in the laboratory have been made at different times with a view to the direct reduction of iron ore to steel. In this connection may be mentioned the experiments of Messrs. Brown and Lathe in the Metallurgical Laboratory at McGill, which were described in the last number of the Institute Journal. These experiments are being continued this year and the writer hopes to be able to communicate some interesting results at a later date.

In any operation for the direct reduction of iron ore to steel the following difficulties should be borne in mind:—

1. The difficulty of eliminating sulphur when this is present in the ore, the blast-furnace producing pig-iron being far more efficient in this particular than a steel furnace such as the open-hearth. It may possibly be necessary on this account only to use ores that are relatively free from sulphur in the direct production of steel.

2. Another difficulty lies in the different conditions required for the reduction of the ore and the final refining treatment to which the resulting steel must be subjected. Thus the operation of making steel must always be intermittent in character, while the reduction of ore in the blast-furnace is a continuous operation.

Until these and other difficulties have been overcome, it is not likely that we shall have any successful production of steel directly from iron ore on a commercial scale. Nevertheless, the high price of steel as compared with pig-iron renders this proposition particularly attractive to the electro-metallurgist. At present the most satisfactory method appears to be that of reducing the ore to pig-iron in one furnace, and turning this into steel in a separate furnace as in ordinary metallurgical practice.

DISCUSSION.

MAJOR LECKIE:—May I ask about the sulphur in the pig iron. If you started to make steel, what was the percentage of reduction and how much remained in the steel product?

DR. STANSFIELD:—The steel was made directly from ore which was intentionally contaminated with 1% of sulphur and 1% of phosphorus. The steel contained some ten per cent. of sulphur, a considerable elimination of this element having been accomplished, but not nearly enough for high quality steel.

PROGRESS WITH THE GRÖNDAL PROCESS OF CONCENTRATING AND BRIQUETTING IRON ORES.

By P. McN. Bennie, Fitzgerald and Bennie Laboratories, Niagara Falls.

(Ottawa Meeting, 1908.)

The growth of an art is reflected in the broadening meaning of its definitions. Mining and Metallurgy are twin arts so closely related that it is hardly conceivable how they could have had other than simultaneous birth. Mining might be more broadly defined as the art of getting minerals and ores out of the earth, while metallurgy is the art of getting metals out of ores. They make mutual demands upon each other, as, for example, when Mining discloses the nickel-cobalt arsenides of the Cobalt district, the ores are laid at the door of Metallurgy, with the announcement. "There's something new for you; get those things out for us."

Metallurgy makes similar requests of Mining, and it is within the province of this paper to recount briefly to what progress the mining of certain kinds of iron ore has been stimulated by the demands of metallurgy.

Last year our laboratories prepared a paper dealing with the magnetic concentration of iron ores by the Gröndal process, with some remarks upon the briquetting of such concentrates. This year we are happy to report considerable progress along both lines, as having great interest for Canada, and as indicating that the elements of a very important industry, as yet undeveloped, exist within her borders.

The conditions of supply in the iron ore markets of the old world are in a measure comparable to those which exist on this side, and particularly in the States. Recent years have witnessed the gradual depletion of ores best suited for the Bessemer process, until now there is a universal appeal from the metallurgical world to the mining world for relief from burdens which are becoming heavier year by year upon the shoulders of pig-iron and steel makers. The only visible means of relief seems to be (aside, of course, from the discovery of new ore bodies) some method of improving the quality of iron ore supply, such as an increased iron content, a lowering of slag-forming impurities, with reduction of sulphur and phosphorus to the lowest limits. Magnetic iron ores lend themselves readily to such treatment.

There exist in Sweden and Norway large quantities of magnetic ores ranging from 30 to 60 per cent. iron content, with varying amounts of sulphur and phosphorus. In order to recover a sufficient percentage of iron to make operations profitable, fine grinding is necessary. With fine grinding the iron can be brought up by concentration to between 63 and 68 per cent. Under these conditions the Gröndal process of wet concentration gives very satisfactory results. Last year the *Engineering and Mining Journal* published a list of 19 magnetic concentration plants actively in operation in Sweden, 12 of which now use Gröndal apparatus entirely. At the present time there are a number of additional plants under construction, destined to use Gröndal apparatus for concentration and briquetting. To show the substantial manner in which treated ores are coming to the relief of the iron ore situation abroad the following is a list of :

WORKS WHICH ARE USING THE GRÖNDAL PROCESSES FOR CONCENTRATING AND BRIQUETTING

WORKS	Tons Ore Treated.	Concentrates	Briquettes
1. Strassa	150,000	75,000	60,000
2. Bredsjö	40,000	....	20,000
3. Herrang	60,000	....	30,000
4. Guldsmedshyttan	90,000	45,000	30,000
5. Uttersbergs	24,000	....	12,000
6. Flogberget	50,000	....	24,000
7. Lulea	60, 000	....	50,000
8. Sandvikens	....	....	12,000
9. Horndal	....	....	12,000
10. Helsingborg	....	....	50,000
11. Cwmavon (Wales)	....	....	36,000
12. Alquife (Spain)	....	....	40,000
13. Penn. Steel Co.	200,000	100,000	....

Where tons of concentrates are not given, the whole output is briquetted· Where only briquettes are given, concentrates or fine or purple ores are used.

There are also under construction the following plants :

UNDER CONSTRUCTION.

WORKS	Tons Ore Treated	Concentrates	Briquettes
1. Hellefors	20,000	....	10,000
2. Vigelsbo	20,000	....	10,000
3. Salangen	300,000	....	100,000
4. Sydvaranger	1,200,000	....	600,000
5. Traversella	50,000	....	25,000
6. Riddarhyttan	20,000	....	10,000
			755,000

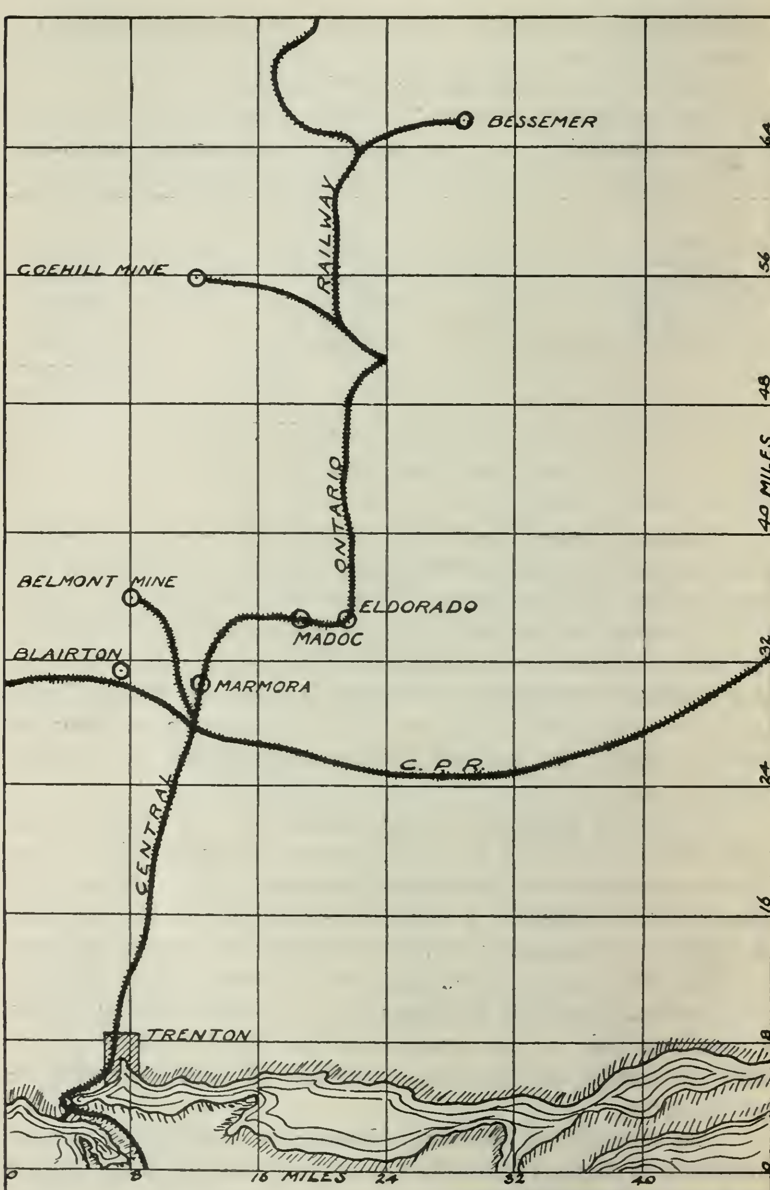
SYDVARANGER DEVELOPMENT.

The plant under construction at Sydvaranger is an interesting example of the extent to which the exigencies of metallurgy will drive mining into the remote corners of the globe. If anyone should propose to this Institute, as a feasible and profitable plan, the mining of iron ore containing only 38 per cent. metallic iron, in a latitude corresponding to that of our scarcely known Baffin Land, or as far north as the mouth of the Mackenzie river, he would probably be advised to take a complete rest for his health's sake.

Yet such a project is actually under way. A company has been fully financed by powerful German interests, all arrangements made with the Norwegian Goverment, and comprehensive plans perfected whereby a minimum production of 600,000 tons of concentrates annually will be produced, shipments to begin in 1910. The plant will consist of 40 units each containing ball-mill, crusher, tube mill and separators. At least 100 separators will be required. It has been found that standard Gröndal ball mills will handle, on the average, 135 tons of hard magnetite ore per 24 hours.

The company at Salangen, Norway, is composed of certain German iron masters who will themselves absorb the entire annual production of 100,000 tons.

The foregoing has had to do with the commercial develop-



Map of the Central Ontario Railway Valley.

ment of the Gröndal processes. There have been some technical advances, however, of considerable interest, as follows :

(1) The introduction of heavy rock crushers, of the Gates or Blake type, for preliminary crushing, thus throwing less work upon the ball mills.

(2) Where the ore is of suitable character the use of magnetic cobbing machines to get rid of such rock pieces as contain little or no iron. This reduces the amount of ore to be handled in all subsequent operations, per ton of product.

(3) Somewhat finer grinding in the Gröndal ball mills. It is generally found that the magnetite particles reduce more quickly than the gangue particles, so that the finer grinding does not necessarily involve reducing all the particles to pulpy condition. The practical effect of such finer grinding is a higher percentage of recovery and a higher iron content in the concentrates. As most of the concentrated material is destined to be briquetted, the fact that the grains are smaller is of no moment.

With regard to briquetting, the following may be noted as improvements :—

(1) Better design of briquetting presses, reducing the wear. The life of the die plates has been quadrupled. At Cwmavon, working on pyrites residues, a single set is good for about 500 tons of briquettes.

(2) The original briquetting furnaces and cars were one metre wide. It has been found that this may be increased to 1.5 metres without materially increasing the investment The result of the change is a 50 per cent. increase in the daily production of the furnace. The furnaces therefore will give a tonnage approaching the nodulizing kiln, with the advantage that the briquettes are more desirable from the metallurgical point of view.

(3) The fuel consumption, which in the one-metre furnaces had reached the low figure of 7 per cent. of the weight of briquettes produced, should be still further reduced in the wider furnaces.

(4) Bilbao spathic ore has been treated very successfully. The ore was first ground in a tube mill to 0.75 mm. mesh. The mill will grind about six tons per hour, using 75 horse-power to drive it. The ground ore was mixed with a little water, pressed and burnt in the usual manner. The original ore ran 47 per cent.

iron, which, with the loss of carbon dioxide in the briquetting furnace, brought the iron content of the finished briquette up to 58 per cent.

FUEL ECONOMY.

Last year's paper referred to the fuel economy introduced by the use of Gröndal briquettes as due to several reasons.

(1) High iron content and consequent small amount of material to be slagged off.

(2) Porosity of briquettes, permitting an enormous surface of contact between reducing gases and iron oxide (this porosity averages over 20 per cent. of the volume of briquettes).

We do not feel that our tests are sufficiently complete to warrant positive figures as to fuel economy, as several factors influence the results. We may refer, however, to one test of 1,000 tons of Strassa briquettes, containing 65 per cent. Fe., put through a blast furnace at Cockerills' well known works, Seraing, Belgium, where a fuel economy of 15 per cent. was claimed. If such results turn out to be actually realisable in practice they would have great significance for Canadian furnace men.

MARKET PRICES.

During the past year the following prices have been paid: *For Concentrates*, containing 68 per cent. Fe., for home consumption in Sweden, about $3.65 per ton, on cars at concentrators. For export, containing 65 per cent. iron and about 10 per cent. water, $4.25 at port of export.

For Briquettes, f.o.b. port of export, for briquettes containing 65 per cent. Fe., sales have been made at $5.45 per ton.

10,000 tons have been engaged for Germany for this year at about $5.25 at same port. Purple ore briquettes from Helsingborg bring about $6.00 per ton c.i.f. Stockton. Pyrites residues briquettes from the South Wales works command from $5.50 to $6.35 delivered, according to cost of transport. These briquettes contain about 62 per cent. Fe. with sulphur down to 0.044 per cent.

The following table is shown, giving results from various ores by the Gröndal concentrating and briquetting methods:

RESULTS OF GRÖNDAL METHODS OF CONCENTRATING AND BRIQUETTING

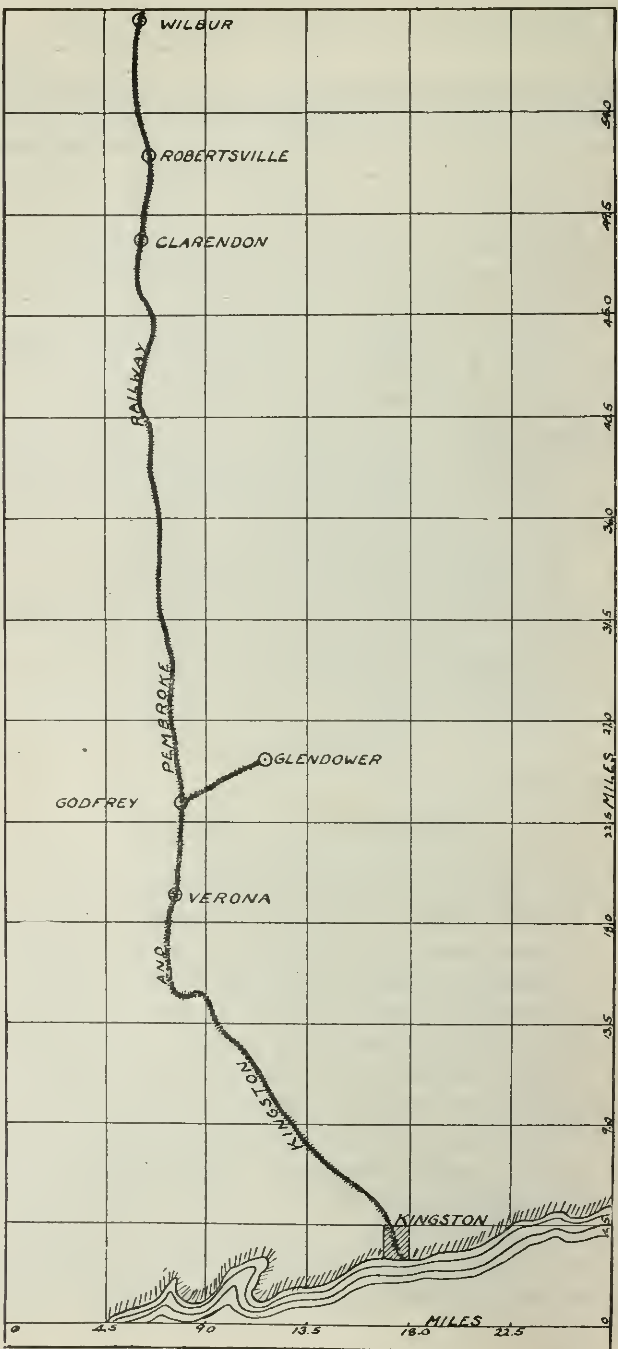
	Crude Ore.			Concentrates			Tailing	Briquettes		
Ores.	Fe. p.c.	S p.c.	P p.c.	Fe. p.c.	S p.c.	P p.c.	Fe. p. c.	Fe. p.c.	S p.c.	P p.c.
Bredjso....	35.0	0.15	0.010	67.2	0.050	0.004	6.9	65.1	0.020	0.004
Flogberget.	27.3	0.31	0.003	67.4	0.040	0.003	7.1	65.3	0.007	0.003
Guldsmed-shyttan..	50.7	3.0	0.003	70.1	0.5	0.002	10.2	68.2	0.010	0.002
Helsingborg (purple ore)	60.6	0.17	......	....	......	......	....	60.6	0.023	......
Herrang ...	40.2	1.21	0.003	67.3	0.170	0.002	6.4	65.5	0.003	0.002
Hjulsjo	39.7	0.12	0.008	67.1	0.035	0.004	10.1	65.2	0.015	0.004
Lulea	58.2	0.110	1.230	71.1	0.015	0.005	12.0	69.3	0.005	0.005
*Riddarhyttan	52.8	0.025	0.006	64.2	0.017	0.003	7.4	....	......	......
Salangen...	35.7	0.039	0.23	69.3	0.019	0.009	4.9	....	......	......
Strassa	46.8	0.030	0.015	69.2	0.015	0.003	6.1	67.1	0.005	0.003
Stripa.....	40.3	0.030	0.010	67.1	0.020	0.002	12.2	65.2	0.005	0.002
*Sydvaranger......	38.0	0.066	0.030	68.3	0.026	0.014	5.5	68.0	0.006	0.014
Uttersberg	34.5	0.020	0.024	62.6	0.020	0.016	9.3	....	......	......
*Vigelsbo ..	35.2	0.45	0.026	64.6	0.089	0.002	6.7	....	......	......
Cwmavon ..	61.43	1.65	0.019	....	......	......	....	61.5	0.044	......

*Under construction.

Importance to Canada.

It seems to us that these results contain a lesson to us on this side of the Atlantic well worth a moment's consideration. In the first place, there are in Canada, and particularly in Ontario province, numerous bodies of magnetite of some extent, which to-day are practically dormant. There is a rapidly growing production of pig iron and steel, with a correspondingly increased demand for ore. Some makers have even had to resort to the use of imported ores. Yet right in Canada there are all the elements of a vast and profitable industry—an industry of basic importance to a country's prosperity—requiring only the awakening touch of intelligent capital to spring into active being.

Without making a plea for any particular apparatus, but assuming that the Gröndal methods are employed, two locations present themselves as promising. These are shown as follows:—



Map of the Kingston and Pembroke Railway Valley.

CENTRAL ONTARIO VALLEY.

In Fig. 1 is shown an outline of the C.O. railway, upon which we have marked some of the deposits of magnetic ores. At some of these deposits there could doubtless be mined a certain amount of shipping ore, but all of them contain large quantities of ore from 45 per cent. down in iron, which could profitably be treated, The distances from Trenton are approximately as follows:

To Marmora	30	miles
" Blairton	35	"
" Madoc	40	"
" Eldorado	40	"
" Belmont	35	"
" Coe Hill Mines	75	"
" Bessemer Mines	85	"

Now if a central briquetting plant were to be located at Trenton, to which all materials could be sent, we would have a plant producing marketable products within an average distance of 50 miles from the mines, which is less than the distance from many Lake Superior mines to nearest lake ports.

KINGSTON AND PEMBROKE RY.

Fig. 2 shows a similar scheme, with Kingston as terminus, with the following approximate distances:

To Godfrey	29	miles
" Verona	25	"
" Glendower	35	"
" Clarendon	55	"
" Robertsville	59	"
" Wilbur	67	"
" Calabogie	89	"

From these points an average freight rate of 65 cents a ton could probably be obtained. A central plant at Kingston would be under practically similar conditions with respect to its sources of supply as the Trenton location. It might be found upon close study that it would pay to ship all ores to a central point where both concentrating and briquetting could be done in a single plant under one management.

COST OF PRODUCTS.

Based upon 40 per cent. ore, as a maximum figure of 80 cents per ton loaded at mines, 2 tons would be needed per ton of concentrates	$1.60
Average cost of concentration on a production of 200 tons daily	.40
Cost of concentrates	2.00
Average cost of briquetting on 200 ton basis	.45
	2.45
Freight on 2 tons ore at 65c.	1.30
Cost of briquettes	$3.75

MARKET VALUES.

Under the above conditions we would have for sale a briquette containing from 63 to 65 per cent. metallic iron, low in sulphur and phosphorus, easily reducible in the blast furnace with economy of fuel; such briquettes would be superior to the average run of Old Range Bessemer ore, on which the guarantee is now 55 per cent. iron. The present price for such ore is $5.00 per ton, according to *The Iron Trade Review* of February 13, 1908. In European and United States markets Gröndal briquettes would readily command a minimum price of 10 cents a unit, or $6.30 delivered. This leaves a margin of $2.65 per ton to cover freights and profits. There is no reason to believe that equal selling prices could not be realised in Canada. The Swedish companies using the process have formed the Iron Export Association, whose products find a plentiful and profitable market in Europe. It is interesting to note that every operating company has been a financial success from the start.

With rich ores commanding a premium and the iron and steel world eager for them, there is no good economic reason why many idle spots in Canada should not teem with this modern industry; why Mining should not once more respond to the call of metallurgy.

DISCUSSION.

Mr. Murray:—Can you adapt this process to a complete outfit for supplying a hundred-ton furnace. Do your fixed charges make that commercially possible?

Mr. Bennie:—With the reduction in scope there is an increase in the cost owing to the fixed charges, but with a multiplicity of units that would be reduced. A concentrator No. 5 will take care of 100 tons a day, and two of them will handle two hundred tons, while one of the modern briquetting furnaces will do fifty tons, so that it is possible to carry on operations on a fairly small scale.

If you examine the third column of the diagram you will find that many of these plants produce a thousand tons a month, which is about 35 tons a day, a little under the capacity of an oven in a single unit plant. Others of them produce from five to twelve thousand.

Mr. Gibson:—I would ask if the Gröndal process is suited for silicious ores, when considerable quantities of such impurities as sulphur and phosphorus are present?

Mr. Bennie:—Nearly all the Swedish ores are silicious, but by the Gröndal process there is no trouble separating the silicious particles from the iron by magnetic separation, taking the one and leaving the other ; but when it comes to sulphur, if it is magnetic sulphide, it will go into the concentrate. The briquetting is in itself an efficient desulphurizer. The briquettes are made with a water binder. They are pressed, and the oxidation in the process of burning converts them from magnetite to ferric oxide. There is an almost complete elimination of sulphur, due to the enormous area of contact between the gases and the surface of each particle forming the briquette. That is a peculiar feature of the Gröndal briquette, the porosity and reduction of sulphur. Phosphorus, if it is not removed during concentration, is not removed during the burning.

Mr. Gibson:—There is one other question. What is the average result of concentration, so far as the metallic contents of the iron are concerned? How much is lost in the tailings?

Mr. Bennie:—It varies with the ore from 12% to 4.9.%

Mr. Murray:—What is the loss in shipment?

MR. BENNIE:—It is negligible. The records show that the shipments have arrived in excellent condition. The briquettes are extremely hard, with a volume porosity of 21 or 22.

MR. OBALSKI:—Has the Gröndal process ever been tried for titaniferous ores? Has the same process been tried for concentrating and briquetting the magnetic sands of Quebec province? If that process could be adapted to these I think it would be advantageous. I would ask if Mr. Bennie knows whether any practical test has been made on these two—the titaniferous ores and the magnetic sands?

MR. BENNIE:—As to titanium, when you mention that to a blast furnace man, he generally says he is bored. But with our advancing necessities for iron ore, titanium is not regarded as the same bugaboo it used to be, and the blast furnace managers have been sent to look at such ores, and several big experiments have been successfully made with it in slagging off the titanium in the furnace.

As to briquetting these ores, the Swedish ores are not so highly titaniferous as those of Quebec. I have only seen reference to titanium in them in one case, where a gentleman said that the reason Swedish steel was so good was that for years it had been known to contain "vanadium." I am quite certain that what he referred to was titanium, although he was an expert employed to exploit the value of vanadium. Experiments with a view to briquetting black river sands have been made, using the St. Lawrence River sands, and a company has been formed with considerable capital to study that matter. It has been feared that the concentrates from the river sands could not be briquetted for the reason that they are all water-worn particles of different diameters without any binding. That was true, but by simply crushing these particles and forcing them into irregular shapes it has been found possible to briquette them. I have no fear that briquettes with 2% titanium would not be deleterious in furnace operation if treated carefully. The briquetting process is one of pressure; the briquettes are given five or six blows with 1,800 lbs. falling weight, modelled and water-bound, and passed by cars to the furnaces in that form.

DR. PORTER:—May I ask as to the tailings value whether that is the percentage of iron in the tailings or the percentage lost from the original ore?

MR. BENNIE:—I think the logical conclusion is that it is the percentage of iron in the tailings.

DR. PORTER:—Then the actual percentage lost would be far less.

MR. HAULTAIN:—What is the content of the original ore?

MR. BENNIE:—I understand in general they were concentrated about 2 to 1.

MR. HAULTAIN:—Yes, but what is the content of the iron ore originally treated.

MR. BENNIE:—The first column shows that, running from 27.3 to 58, they are able to treat ores containing 30% with profit.

MR. HAULTAIN:—The percentage lost, then, is greater than these figures, not less.

MR. ROWLANDS:—At Herräng, where I visited, they kept very close track of the tailings and all products. The losses of iron in the tailings will average about 5% according to my recollection.

MR. DIXON CRAIG:—In Ontario it seems that nothing has been done about this attractive project. So far as I know, there is no really large deposit of iron ore in the Kingston and Pembroke district, which may possibly be the reason. Do the Pennsylvania company treat their concentrates?

MR. BENNIE:—Yes. They have experimented with a large rotary kiln, which they figured would be cheaper, but the thing to consider is the metallurgical value of a nodule as compared with that of a porous briquette. The nodules rely upon a sort of skin formed upon the outside, and the desulphurizing is hindered by the non-porosity of that skin. I do not consider a nodule as good a metallurgical product for the furnace as the briquette. It is a mere matter of ultimate economy.

As to the ore in the district you speak of, did you ever try to buy any of those mines? I was assured by a gentleman claiming to control one of them that he had 3,000,000 tons in sight. Take Bessemer ore; they are shipping from Wilbur, and Coe Hill has 27,000 tons they would like to ship if it were not for the sulphur. With regard to the amount of investment, if anyone wanted to go into anything of that sort, $150,000 would be necessary for a central concentrating and briquetting plant with a daily capacity of 400 tons of briquettes.

DR. BARLOW:—In Ontario we have no definite criterion, as there has been practically no intelligent prospecting. At Port Henry, as a result of the magnetic surveys recently made there, they found ore bodies every week in a district supposed to have been thoroughly explored. These ore bodies resemble our central Ontario ore bodies very much.

MR. CRAIG:—As far as Bessemer is concerned, two ore bodies have shown up about half a mile apart, and the owners claimed they were continuous and had a hole about 40 feet down on each ore body. They claim a tonnage of about six million, but these are not established facts. To say you can count upon millions in any deposit in this region, would be very risky. I think if any have half a million tons they may be considered good deposits.

DR. BARLOW:—With reference to the Anglo-American company, I know they have some very good properties, but many of the ore bodies were underlaid with syenite, and I do not think any of them have given indication of being of economic importance. I refer to the bodies at Coe Hill, Blairton and that district, where all that has been done is surface stripping, so you cannot form any intelligent judgment. I would like to see some more light regarding that iron ore deposit extending from Coe Hill in a south-westerly direction, and see if ore in larger bodies could not be located.

MR. HARDMAN:—Mr. Bennie has told us that the cost of a ton of cleaned ore, at the point where the works are situated, was $3.45, and that the market price was $5.00 for that ore, on a basis of 55% metallic iron—is this market price available at the *point of production* or must we add to the $3.45 the cost of the freight from the works to the market, where the $5.00 is available for such ore.

MR. BENNIE:—Yes, there is $2.65 margin between the cost I assume and the $5, which is put conservatively low for that ore—that is the difference between the two, and I say that $2.65 will amply take care of the freight and profits. But I count upon $6.50 for the ore, rather than $5, counting upon the higher values. As to the location of the plant, I can merely suggest it, and the reason that I made it central is that very uncertainty of these lenticular masses of magnetite. With the exhaustion of one and the discovery of another, you always have a source of supply; and if the field is entirely exhausted it is not such an awful job to go somewhere else and find more magnetite. It is not an installation of the same character as a blast furnace plant.

THE CARBONACEOUS AND BITUMINOUS MINERALS OF NEW BRUNSWICK.

By R. W. Ells, LL. D., Ottawa, Ont.

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The great central Carboniferous basin of New Brunswick has long been known as a possible field for the production of coal, and in the portion known as the Grand Lake basin this mineral has been mined on a small scale for over 100 years. Such mining has, however, been done till within a very few years in the crudest way, under the supposition that owing to the prevailing thinness of the seam there found a regular system of development would be unprofitable. This supposition has, however, recently been shewn to be untenable, and within the last half dozen years coal mining has been carried on in a more scientific manner and with fairly profitable results.

The great extent of the carboniferous rocks in this province early led to the presumption that at some point in the basin, which comprises over 10,000 square miles, thick underlying deposits of workable coal should be found. This hypothesis was in part due apparently to the early and erroneous views expressed as to the horizon of much of the formation itself, since in the earlier study of these rocks they were supposed to include, above the Lower Carboniferous portion, not only the Millstone-grit, but a considerable thickness of the Productive measures of Nova Scotia and the Upper Carboniferous as well, all of which were held to occur in the Grand Lake basin. Later and more detailed study of these rocks, however, over a large area proved conclusively that in no portion of the great basin could any sediments which might be the equivalents of the coal-bearing rocks of Nova Scotia be found, but that there was a stratigraphical break between the Millstone-grit, which practically constitutes the mass of the Carboniferous basin, and the upper or Permo-Carboniferous series, which occurs in the eastern part of the province, in the county of Westmorland and in certain small areas around the shores of Northumberland Strait and the northern part of the Gulf of St. Lawrence, as at Shippigan and Miscou. These outcrops of the newer rocks constitute the western margin of the Permo-Carboniferous formation which occupies the whole of Prince Edward Island.

The original theory that somewhere beneath the wide spread but generally thin stratum of coal which can be found in many portions of the central basin, other thick seams might occur, was also disproved some years ago by a number of borings made at widely separated points throughout its extent. In a number of cases these holes pierced the Carboniferous sediments proper to the underlying formations, in some cases the Lower Carboniferous red beds, in others into the Devonian slates. In none of these borings was any trace of workable coals found beneath the seam which has been worked for many years.

The proximity of this seam to the surface was such that in some cases its mining was effected by simply stripping off the surface drift or upper shales and removing the coal from the exposed bed. It was found that this could be done with profit where the covering did not exceed eight to ten feet, but for greater thickness of cover small drifts were driven from the banks of the creeks along the outcrops of the seam, and this work was carried on whenever the duties of the farm permitted a few days' rest from ordinary agricultural labor, but all such mining was done in the simplest and most economical way possible. No attempt was made to separate the associated pyrite, shale or other impurity, and the output sent to the market by wood boats or by hauling overland to Fredericton, as run of mine coal, proved objectionable in many ways for domestic or steam purposes, the unseparated sulphur being especially hard on grate bars, while the associated shale and stone produced a very large percentage of ash, so that in quality the Grand Lake coal was regarded as being very far from a first-class fuel.

Quite recently, and chiefly through the agency of Mr. King, of Chipman, mining on the principal seam at the new town of Minto was undertaken in a more proper fashion. This mine was originally known as the Kennedy, and in the early days gave the most satisfactory results as regards output of any in the district. A shaft was sunk to a depth of 30 feet to the seam, a certain thickness of the roof shale being removed for head room, and the underground workings laid off in proper order for successful mining. The appointment of a duly qualified inspector by the Intercolonial railway, and the fitting up of proper screening appliances, soon led to the separation of the objectionable ingredients in the output with most beneficial results, so that now the coal, as thus prepared and used on the railways, is found to give as good satisfaction for a steam fuel as that obtained from the thick beds of Nova Scotia.

The thickness of the coal worked in the King mine at Minto, which is the present terminus of the railway from Norton, on the Intercolonial, is 33 inches, the section being:—

Top coal.	24 inches
Shale parting.	3 "
Bottom coal.	6 "

thus forming a workable thickness of 30 inches of coal.

In the workings when examined in 1906, levels had been driven off from the shaft for 800 feet with branch drifts every 35 feet. The amount of coal per acre is estimated at 4,000 tons. The mine is quite dry, and the coal on arriving at the bank head is put through the screen and loaded direct on the cars. The men are paid by the chaldron of 1½ tons, at a cost of about $1.00 per ton for mining. After passing the inspector it is hauled to Norton station, a distance of 57 miles, where it sells for $3.00 per ton, while the unscreened portion of the output brings $2.25, and the screenings, which amount to about 34 per cent. of the output, sell for 90 cents, the whole being mined and shipped at a fair margin of profit, said to average 50 cents per ton.

The coal seam at this place is nearly horizontal. It, however, soon dips to the south, but rises again to the mines in this direction, of which there are a number located along the extension of the railway from King's mine, so that nearly all the mines in this district can ship direct by rail. King's mine is the only one as yet using steam power for hoisting, the other mines in the vicinity using horse whims.

Owing apparently to a thickening of the shale parting towards the south, most of the mines in this direction confine their mining at present to the upper seam, which varies from 20 to 24 inches. There is no co-operation between the several mines in this area, each operator apparently preferring to work independently. At several of the mines in the immediate vicinity of King's the thickness of the coal worked ranges from 26 to 28 inches, and if these areas were combined into one, operations would undoubtedly be carried on with a larger percentage of profit to the operator.

In all this district at Minto, formerly known as Newcastle creek, there are now eight mines which ship their output by rail. These are owned by George King, Harvey Welton, O'Leary Bros., J. Coakly, J. MacDonald, Evans Bros., Edward Kelly, and J. F. Gibbon. These areas are worked continuously all the year, and the output is of about the same general good quality when properly screened. One mine of this group still continues to ship by water, the output being hauled by team to the wharf on Grand Lake, about four miles distant.

Besides these there are a number of mines forming group 2, and apparently working on the extension of the same seam, but nearer Grand Lake to the eastward. They all follow the old system of shipping run of mines by water in barges or wood boats to St. John and Fredericton, and the mines are worked at intervals in the old way, the coal being hauled to the wharf by teams. This necessitates much handling—from mine to team, from team to wharf, unloading and loading on boats, etc.—so that the output in all is shifted some six to eight times. As a consequence much of the coal becomes badly broken, and as but slight attempt is made to separate either the stone or sulphur the quality is greatly inferior to that shipped by rail. In all, this part of the output ranges from 3,500 to 4,000 tons per year. Portions of this eastern field is still worked by the process of stripping and open cuts.

A royalty of 10 cents per ton is paid to the Government on all coal shipped by rail, that going by water being exempt, in accordance with an agreement made many years ago. In 1906 the average shipments by rail were given as about six cars of 20 tons each, the amount raised being limited by the scarcity of miners. This shipment includes all grades of the output. The working days average 300 per year, and the estimated output from the district in 1906 is given as about 50,000 tons.

This amount may not seem very large when compared with that from the mines of Nova Scotia, but as contrasted with the output of 6,000 to 8,000 tons of a dozen years ago shews a very appreciable improvement, due to better methods of working. There is ready market for all that can be raised, and there is no doubt that if an amalgamation of the several mines in the area could be effected, with a sufficiency of men these mines would supply the greater part of the coal requirements of the province as regards soft or bituminous coal, while the profits on the mining of the whole would tend to be more satisfactory.

Other small mining areas occur around the head of the lake, as at Coal creek, but the seam here is also thin and the work desultory, so that no mining on a large or permanent basis has as yet been attempted.

In the eastern part of the Carboniferous basin, on a branch of the Richibucto river, in Kent county, a seam similar to that worked at Grand Lake was opened up several years ago. This seam was also worked to a very limited extent in former years, merely for local use. It has a thickness of about 16 to 18 inches. The new company commenced by driving a level into the face of the cliff about forty feet above the stream which is known as Coal Branch, which in 1906 had reached a distance of 1,300 feet in the principal opening, and a second had been driven for 700 feet with cross drifts every 25 feet. A capping of grey shale covers the coal, and there is a two-foot bed of fire-clay beneath. In mining, about three feet of the roof shale is removed to form a working face. The coal is taken from the mouth of the tunnel to the bank head, a distance upward of about 50 feet, by a horse whim situated at the top of the bluff, and there loaded direct upon cars on a branch railway running to Adamsville station on the Intercolonial railway, a distance of some seven miles. In character this coal is almost identical with that mined at Minto, but is not screened, being delivered to the railway as run of mines.

The whim or hoist is run by three horses, which can raise to the bank head three tons at a load. Though the seam is thin the quantity raised in the three months of 1906, between March 1st and June 1st, aggregated 3,000 tons, which is hauled to the Intercolonial for 40 cents per ton, the price for the output there being $3.25 per ton.

The miners are paid 38 cents per box of 600 lbs. and work in 8-hour shifts. In 1906 from 6 to 8 men were employed on each shift. The seam occasionally swells out to a thickness of 24 inches and thin local partings of shale occur with pyrite in the joints and thin bands as well as in nodules. In spite of the thinness of the seam the men on the shifts mine on the average four boxes or 2,400 lbs. per man. The coal is cleaty, splitting readily into broad flakes of an inch or more, burns freely with strong heat, generates steam readily, and is reported as giving satisfactory results on the locomotives. With $1.75 per ton for mining and freight to the Intercolonial, the percentage of profit, after deducting other expenses, is not large, but it is claimed to yield, wlith present appliances, a fair margin. It has thus been established that even with the thin seams found at various points in the province, with due regard to economy in handling, coal can be mined at fairly remunerative rates, and here as at Minto, the output is only limited by the scarcity of miners.

The only other area at which attempts to mine coal of this formation is at Dunsinane, on the Intercolonial, about 14 miles north of Sussex. Here also the conditions are very similar to those already stated, and two seams have been located by boring with an aggregate thickness of 28 to 30 inches. The presence of a shale parting of variable thickness, sometimes amounting to 12 to 14 feet, has hitherto prevented the utilization of both seams. In several of the bore-holes, which have been sunk in this basin it was found that the seams tended to come together by the thinning out of the shale parting. Attempts by boring are now in contemplation to ascertain if at some point these two seams do not coalesce, in which case it should be possible to mine a seam similar to that of the best mine at Minto.

The thickness of the main or upper seam at the outcrop is about 18 to 20 inches, and that of the lower is stated as 9 inches, all of which is reported as good coal, and in one boring a thickness of 12 inches is assigned to the underlying seam. The formation, which is Millstone-grit, is apparently thin, and at a depth of 300 feet the drill passed down into a series of purple and grey grits and shale, apparently of Upper Devonian age.

Attempts to mine a bed of supposed anthracite were made about thirty years ago on the east side of Lepreau harbour at

Belas basin, as also at the village of Musquash, a few miles to the east, on the line of the N.B. Southern railway. Several bore-holes and shafts were also sunk in an area of black shales a short distance south of the latter place, near the road to Beaver harbour. The rock formation in all these places is, however, of Devonian age, and near the base of that series of formations in what is known as the Dadoxylon sandstone. The strata consist generally of hard quartzose sandstone with interstratified beds of black graphitic shale and sometimes brownish-tinted beds, generally in a highly inclined position.

At all these places the mining was done in the black shale, portions of which contained sufficient carbonaceous matter to burn quite readily under strong draft, but leaving so large a percentage of ash, ranging from 35 to near 40 per cent., as to render the product unfit for domestic or steam purposes, so that all attempts at further mining have long since been abandoned and the workings have fallen in.

The mining of this deposit at Lepreau consisted of four shafts sunk to depths of 95, 130, 135 and 140 feet. The thickness of the carbonaceous band was stated by the miners to average 20 feet, but of this by far the greater portion was merely a black graphitic shale of no value whatever as a fuel. The rocks are highly inclined, reaching in part the vertical, and the main shaft was sunk for 110 feet on an angle of 80 degrees, when it inclined to the south and continued downward to the bottom. In places the thickness of the anthracit c portion was stated to reach four feet and was graphitic throughout. It resembles much of the product from the so-called coal basins of Massachusetts and Rhode Island, the output from which is now used to some extent for the manufacture of graphite. The Lepreau deposits appear to occur along a line of fault between the grey sandstone and shales and underlying reddish beds of a lower part of the formation, and the rocks in the vicinity are often much crushed along the line of contact.

The mine at Musquash village is in a similar band of black graphitic shale at or near a similar contact. Here an inclined shaft was sunk to a depth of over 300 feet, but beyond the presence of the glazed graphitic shale and occasional pieces of the graphitic anthracite nothing of the nature of true coal was found. On the road south to Beaver harbour, at what is known as Gilbert's mine, already alluded to, a similar black carbonaceous shale occurs, and a reported expenditure of $40,000 to $50,000 was made with a similar lack of economic results. It, however, seems probable that in some of these areas, owing to the soft and highly graphitic nature of the shale bands, the extraction of the mineral graphite might be carried on at a profit, since, with the exception of the black graphitic shales at the Suspension Bridge over the St. John River, which are of an entirely different horizon, no attempts at graphite mining have been made.

Of a different character and horizon are the deposits of bituminous shale found in Albert and Westmoreland counties, in the south-eastern portion of the province, which have been for many years known under the name of "Albert shale." For a long time they were classed in the geological scale as a portion of the Lower Carboniferous formation, though their position as uncomformably beneath the Lower Carboniferous limestone and gypsum division has long been recognised. Recent detailed investigation in this province has now clearly demonstrated the fact that they are an integral portion of the Upper Devonian formations.

The Albert shales came into prominence some sixty years ago, through the discovery by Dr. Gesner, a former provincial geologist, of the peculiar mineral known as Albertite, the mining of which for nearly thirty years proved to be one of the most profitable of the mineral developments in New Brunswick. Its mode of occurrence has been stated in numerous publications, including the official report of the Geological Survey, a detailed examination with map of the area being made in 1876 by Dr. Bailey and the writer. The mineral Albertite was found to occur in true vein form, with a length of about half a mile, and was followed downward to a depth of 1,500 feet.

Although the greater portion of the Albert vein was long ago removed, and the works closed down as a producer for over a quarter of a century, other veins are known to exist in the area, and in the upper portion of the old workings a large mass of the mineral still remains untouched, owing to the fact that in the eastern half of the workings all that part above the 450 feet level was not extracted. On the other and smaller veins nothing beyond shallow surface prospecting has been done, the uses to which the output was formerly applied, which was chiefly as an enricher of bituminous coals in the manufacture of gas, having ceased. At the present time there appears to be no means by which Albertite can be utilised on the large scale, other than for the distillation of the contained bituminous matter in the form of oil, of which it contains over 100 gallons per ton.

The Albert shale beds extend from east to west for over 70 miles through the counties of Westmorland, Albert and Kings, and their peculiar features appear to be continuous throughout, though in certain portions the percentage of bituminous matter is much less than in the richer beds of Albert county. They are in places covered over by more recent deposits of Lower Carboniferous age, such as conglomerates and shales with limestone and gypsum, which unconformably overly the shales. In Albert and Westmorland counties, more especially at the Albert mines, at Baltimore and further west on the upper part of Turtle creek, as also to the east, near the Memramcook river, north of Dorchester, these shales, which are often thin and papery, contain beds of a brownish-black, tough and massive shale, which range in thickness from two to five feet, while on Turtle creek the color of these beds becomes grey and they have a reported thickness in places of about 18 feet. They contain an even larger percentage of oils than the brown beds, and splinters of the material kindle readily from the flame of a match The yield of oil from the brown beds is somewhat more than 60 gallons per ton, while of the grey the yield by analysis is given at over 80 gallons They are all clearly interstratified portions of the shale formations, occurring after the manner of beds of coal in the Carboniferous, but without distinct fire clays. These brown bands of oil-shale, which have sometimes been styled Cannelite, are tough, breaking with a conchoidal fracture, giving a sound like wood when struck with the hammer. As far back as 1862-64 they were quite extensively mined for the distillation of petroleum, a plant being erected at Baltimore, which was operated for several years, or until the discovery of the great oil fields of western Ontario and of the United States so reduced the price of crude oil as to render further distillation of these rocks unprofitable. Large quantities of the crude shale were also exported from Taylorville, on the Memramcook river, to ports in the United States for the same purpose, the price obtained being $6.00 per ton.

Extensive boring operations for oil in these shales have been carried on for many years, culminating some seven years ago in the formation of a new company, by whom control was obtained from the local government of the greater part of the supposed oil-lands in the province. As a result over seventy holes were bored, principally in the area between the Memramcook and Petitcodiac rivers, on a somewhat broad belt of the shales which extend across from Albert county. In one hole at least a reported depth of 3,000 feet was reached, but no trace of oil was found. In about 50 per cent. of the holes, oil in small quantities was met with, and since the closing down of boring operations a certain number of these have been pumped from time to time with a small yield of crude petroleum and water, but in so far as can be learned none of these wells has as yet yielded oil in commercial quantities.

Recently a new company has been organized with the object of producing oil by distillation from the bands of rich oil-shales, which, if properly conducted, should give satisfactory results. Tests have been made in a specially constructed distillation plant in New York, which are reported as being eminently satisfactory, both as regards the yield of crude petroleum and the percentage of paraffine, ammonium sulphate, etc., the proposition being made to erect a proper distillation plant for commercial purposes on the rich shales of Baltimore, which were formerly utilized.

As a source of fuel supply the oil-shales have been used locally to some extent and found to give satisfactory results when burned in open grates or for the generation of steam, and further tests are in contemplation. They burn very freely, give out an intense heat, are comparatively free from sulphur and are clean to handle, while the resulting ash, though considerable, does not seem to form an insuperable objection to their employment. If the shale is broken to suitable sizes it burns completely to a fine grey ash without any trace of clinker. It generates steam more rapidly than ordinary bituminous coals, and the ash is held to possess fertilizing properties which are valuable for the production of certain crops, so much so that at Baltimore for some years the farmers have used the waste from the old dump at that place as a top dressing for their lands, with reported beneficial results.

Of these shale bands four outcrop at the surface at the Albert mines, five at Baltimore, and two thick beds at least on the waters of Turtle creek, about two miles further west. The mining of these shales can be carried on after the manner of coal beds, the enclosing shales being thin and papery, excavate easily, so that the removal of the oil-bands is comparatively simple. The percentage of oil is large, exceeding in amount that obtained from the shales of Scotland and England, which have been so extensively used for distillation for many years, and from which, to judge from the published reports on that industry, very large profits are obtained, even in the face of competition from Russia and the United States, while the value of the by-products is a very important feature. As regards the actual processes used in the shale districts in Scotland, but little information can be obtained, as the several companies there working are close corporations in so far as giving out information is concerned; but from the fact that the industry has been carried on for half a century continuously, and from the scale of profits which have been published, the enterprise in Scotland has clearly been a commercial success. The yield of oil from the Scotch shales now being worked is given as from 20 to rather more than 30 gallons per ton of shale, which as compared with the known oil contents of the bands in the Albert shales, which yield from 60 to more than 80 gallons per ton from beds equal in size to those of Scotland, and in some places even larger, is a very encouraging feature as regards the proposed development of the Albert county fields.

Several years ago a series of analyses was made of the coals from the Minto coal basin in the Grand Lake district, which, as compared with the analysis of coal from Connellsville, Pa., give the following results:—

	Moisture	Vol. Matter	Fixed Carb.	Ash	Sulphur
Connellsville, Pa.	1.10	32.75	57.08	9.07	0.85
Balkims	0.60	36.94	55.03	7.43	4.48
Evans	0.80	36.58	52.94	9.68	5.81
Kings	0.60	35.36	55.40	8.64	5.63
Gibbons	0.58	33.90	52.37	13.14	6.09
O'Leary	0.72	37.28	52.41	9.59	2.99
Welton	0.65	33.85	56.58	8.92	5.25
Coakley	0.74	34.56	55.72	8.98	8.46
McDonald	0.67	37.13	52.89	9.31	4.72
Kelly	0.60	35.80	54.35	9.25	3.92
Dunsinane	1.28	34.18	49.06	7.58	7.90

The values of the oil-bands in the Albert shales from Baltimore, N.B., can be seen from the results obtained by analyses by Professor Hislop, of England, the test being made on a one ton sample, and by Dr. Charles Baskerville, of the college of the City of New York, on a sample of eighty pounds weight.

The result of the former test is as follows:—

Lubricating Oil	11 gals.
Burning Oil	25 "
Paraffin Wax	48 lbs.
Sulphate of Ammonia	72 "

The result of Dr. Baskerville's analysis is as follows:—

Naptha	6 gals.
Lubricating Oil	9 "
Burning Oil	11 "
Paraffin Oil	5 "
By-products, containing tar, sulphur compounds, creosote, etc.	31 "
	62 gals.

DISCUSSION.

DR. ELLS:—Might I ask Dr. Porter if he has any specimens from these New Brunswick seams in the experiments he is making.

DR. PORTER:—We have some.

DR. ELLS:—Have you made attempts at coking?

DR. PORTER:—No, we have deferred that.

DR. ELLS:—The most important of the bituminous rocks are the Albertite shales in Albert county. These form a belt extending 60 or 70 miles from near St. John down to the easterly part of the province. They were opened first in 1852 on a vein of Albertite which ran for over half a mile with a width in places of 15 or 16 feet. Although the greater portion of the Albert vein was long ago removed, and the works closed over a quarter of a century ago, other veins are known to exist in the area, and in the upper portion of the old workings a large mass of the mineral still remains untouched, owing to the fact that in the eastern half of the workings all that part above the 450 feet level was not extracted. On the other and smaller veins nothing beyond shallow surface prospecting has been done, the uses to which the output was formerly applied, which was chiefly as an enricher of bituminous coals in the manufacture of gas, having ceased. At the present time there appears to be no means by which Albertite can be utilized on the large scale, other than for the distillation of the contained bituminous matter in the form of oil, of which it contains over 100 gallons per ton.

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The yield of oil from the Scotch shales now being worked is given as from 20 to rather more than 30 gallons per ton of shale, which, as compared with the known oil contents of the bands in the Albert shales, which yield from 60 to more than 80 gallons per ton from beds equal in size to those of Scotland, and in some places even larger, is a very encouraging feature as regards the proposed development of the Albert County fields. Recently 50 tons have been sent to Scotland for a thorough test, and this should be satisfactory.

MAJOR LECKIE:—The value of this mineral depends very much on the manner in which it is treated. There are large deposits near the surface there which can be worked by steam shovel, and this coal if washed and briquetted would make a first-class fuel for locomotive works, but if used as produced, when freed as much as possible from stone it makes an excellent gas producer for power purposes, quite as good as the coal of higher grade in Nova Scotia. The shales found in connection with the Albertite when treated in a gas producer will yield up their hydrocarbons and add to the product of the coal. It would not be waste material. I remember that a friend of mine, in St. John, mined and distilled the shales of Albert County a good many years ago, but after the discovery of the petroleum of Ontario and the United States, the works for the distillation of the shales were abandoned. I understand that Mr. Pearson, of Halifax, and some others are reviving the idea of again treating these shales. There are very large quantities of them and they vary in richness at different points. I have seen these shale deposits in New South Wales that have been referred to; some of these shales have been shipped all the way to England from Australia; some of them are high grade and some low grade. At our Quebec meeting some years ago Mr. Dowling read an interesting paper in which he pointed out the greater value of the lignites of the North-West by being treated not by firing direct in the furnace, but by conversion into gas. The moisture itself in a properly constructed gas producer can be so utilized in the destruction of the carbon that it will add very much to the quantity of effective gas. Perhaps this committee to be appointed by the President might bear in mind, when examining different kinds of coal, the purpose to which it can be best used and also the best mode of treating it.

Mr. COSTE.—May I say a few words upon something which does not appear to be covered by the paper and which I think is important. Dr. Ells has included the carbonaceous and bituminous minerals of New Brunswick in one paper and he gives us a great deal of valuable information about the coals and the bituminous shales of that Province. But I would like to point out the very great difference in the deposits between these two minerals. The coal is, of course, forming regular beds of a sedimentary basin, while the bituminous minerals are in veins like the Albertite vein and in impregnations through portions of the shales and other rocks in a very irregular manner and these bitumen deposits are along fissured zones or belts. The one mineral is entirely different from the other so far as the nature of the deposit is concerned. One quarry of oil shales might be opened in one horizon and another quarry in another horizon and neither of the horizons would be impregnated with oil in other places, as in the oil shales fields of Scotland, and, on the whole, the rich oil shales in New Brunswick are very irregularly distributed along several distinct belts. The bitumen in these shales is evidently a subsequent foreign impregnation, and as a proof of that I wish to point out, it is not only found in the Albert shales but it is also found in the lower carboniferous strata above and in the pre-Cambrian below, both of which formations are unconformable on the Albert Devonian shales. Surely, then, the bitumen or oil are impregnations subsequent to the youngest formation or to the lower carboniferous and its origin cannot have anything to do with decomposition of organic life in either of these formations. Of course coal will burn and so will the oil shale, but that is the only point of resemblance there is between them. When we consider the nature of the deposits or their origin there is no resemblance. I would like also to emphasize the fact pointed out by Dr. Ells that the Albert shales impregnated by bitumen extend over a large area. Dr. Ells mentioned a distance of 70 miles which is a much longer belt than they have in Scotland, and as Dr. Ells has also pointed out, the Albert shales are richer in oil than the Scotch shales.

DR. ELLS:—The vein-like nature of the Albertite is so well known and has been mentioned in so many papers that probably I did not mention it in this paper.

MAJOR LECKIE:—The vein cuts the shale right across. It is a true vein, and is not impregnated from the shale.

MR. COSTE:—I merely wanted to emphasize the great difference between the two substances, coal and bitumen, as these two entirely different substances are generally confused, one for the other, and are also confused with organic matter.

CLASSIFICATION OF COAL.

By D. B. Dowling, Ottawa, Ont.

(Ottawa Meeting, March, 1908.)

Several schemes of classification have been advocated from time to time, and these have served the need of various regions, but no one so far seems to have been applicable to the majority of the coal fields of America. During the series of tests carried out by the U.S. Geological Survey very exhaustive analyses were made of a great variety of coals, and from the intimate knowledge of the coal fields and the mass of chemical results, Mr. Marius Campbell constructed a scale of relative values bound together by a simple ratio, namely, the total Carbon divided by the total Hydrogen in the fuel. To obtain this ratio it is necessary to have an ultimate analysis of the coal, and it is for this reason alone that the scheme outlined has for us little present value.

A criticism of this classification appears in the Canadian Mining Journal for May 1st, 1907, by S. L. MacCallum. There are evidently some omissions in the published form as it is difficult to see what the substituted scheme means, and so its merits are not apparent.

The Carbon-Hydrogen ratio proposed by Mr. Campbell is probably not far from the ideal, but, as remarked before, is not of present value, since of the hundreds of analyses of Canadian coals there are to be had only about ten ultimate analyses on which to work. Another objection might be taken from the prospector's standpoint. The ultimate analysis is a costly one and takes time, and if he has a great number of samples he will be impatient at the delay and also apprehensive as to the cost. The ordinary proximate analysis has from long usage become a pretty fair rough index of the value of the coal.

To judge of the fitness of any scheme, it should be applied to the coals that we know, and so far the only scheme that we can try with a wide range of coals must be dependent on the proximate analyses which we have in abundance, rather than the few ultimate ones. For this reason it seems possible to adopt some empirical rule by which the elements of a proximate analysis of an air-dried coal may be used, for such, I take it, our ordinary run of samples may be called. We have for comparison the St. Louis analyses of both air-dried and fresh from the mine coal, and the scale dependent on the Carbon-Hydrogen ratio. Applying the fuel ratio, the calorific ratio, etc., we find that the fuel ratio fails in the lignites. Also the hygroscopic moisture fails for the higher coals. The total volatile and fixed carbon ratio does not discriminate between the lignites and the softer dry coals.

I have made several scales using proportionate parts of each of the items given in the proximate analyses, but the simplest that approximates to the Carbon-Hydrogen ratio is one that I have provisionally called the "split volatile" ratio.

$$\frac{\text{Fixed carbon} + \frac{1}{2}\text{ volatile combustible}}{\text{Moisture} + \frac{1}{2}\text{ volatile combustible.}}$$

This scheme is not ideal, but will, I think, be useful as a rough working scale.

The question then comes "How close does this work out using approximate analyses of air-dried coal as compared with that given by the Carbon-Hydrogen ratio?" From the annexed tables prepared from the St. Louis analyses and the few complete ones of Canadian coals, it will be seen that in the higher grades the agreement is very close as the ratio proposed is approximately more than double the fuel ratio, and therefore is in sympathy with the Pennsylvania practice.

In the lower grades, where the water content is a high factor, this is given more prominence, and the results seem to conform quite closely to the order in which the calorific values run. In the middle of the scale there is considerable variance from the order of arrangement given by the Carbon-Hydrogen ratio, but in the comments on the tables several analyses are given to show that it is hard to say which order is preferable.

TABLE I.

Classification of a Series of Coals, by Campbell's scheme, with Calorific and proposed ratios.

No.	From	$\frac{C}{H}$	B.T.U.	$\frac{FC.=\frac{1}{2}V}{H_2O=\frac{1}{2}V}$	Group.
1	Pennsylvania No. 3	26.7	14.906	13.59	A.B.C.
2	Arkansas No. 5	20.7	15.270	10.40	D & E
3	W. Virginia No. 11	19.6	15.786	8.567	F.
4	Arkansas No. 1	18.9	15.393	7.348	
5	W. Virginia No. 10	18.7	15.927	8.489	
6	W. Virginia No. 6	17.8	15.743	7.245	
7	*Old Man River n.br. No.* 29	17.5	15.178	5.691	
8	*Mill Creek No.* 39	16.9	15.072	4.53	G.
9	W. Virginia No. 4	16.1	15.440	6.26	
10	W. Virginia No. 3	15.5	15.325	4.56	
11	W. Virginia No. 1	14.7	15.129	3.72	
12	W. Virginia No. 2	14.4	15.048	3.28	
13	Indian Terr. No. 2	14.3	14.624	3.37	H.
14	*Wellington Mine No.* 33	14.0	15.422	3.292	
15	Kansas No. 1	13.9	14.280	2.98	
16	*Upper Belly River No.* 32	13.6	14.896	2.876	
17	*Old Man River No.* 31	13.4	15.462	3.00	
18	*Bow River No.* 28	13.2	13.872	2.90	
19	*Old Man River No.* 30	13.2	14.936	3.105	
20	*Coal Banks Main Seam No.* 26	13.0	12.376	2.623	
21	Missouri No. 1	12.9	13.997	2.76	
22	Kentucky No. 3	12.6	13.702	2.69	
23	Missouri No. 4	12.6	14.276	2.40	
24	Iowa No. 2	12.4	13.471	2.647	I.
25	Indiana No. 2	12.3	13.340	2.46	
26	*Belly River No.* 22	12.2	12.498	2.49	
27	Wyoming No. 2	12.2	13.331	2.61	
28	Montana No. 1	11.5	12.139	2.53	
29	Iowa No. 5	11.2	12.711	2.38	
30	New Mexico No. 1	11.2	12.309	2.267	J.
31	Texas No. 2	10.9	10.881	1.97	
32	*South Saskatchewan No.* 2	10.4	11.098	1.83	
33	North Dakota No. 1	10.1	11.465	1.523	
34	Texas No. 1	9.4	10.990	1.448	

In the above table the U.S. coals are given the names used in the Report of the coal tests in Professional Paper No. 48. The Canadian coals, the number given in Report of Progress, G.S.

C., 1882–84, part M. The caloric value in British thermal units is for theoretically clean coal, but in the Canadian tests a different calorimeter is used, and these may not be in accord with the scheme of values given the American coals.

The same set of coals arranged in the order which they would take by the proposed "Split Volatile" ratio is shown in Table II., so that the two schemes may be better compared.

TABLE II.

Classification by Split Volatile Ratio.

No	Locality	Split Volatile Ratio	B.T.U	C — H	Number in Table I	Shifted	Group in Table I
1	Pennsylvania No. 3. . .	13.59	14.906	26.7	1	0	A. B.&C
2	Arkansas No. 5.	10.40	15.270	20.7	2	0	D. & E.
3	W. Virginia No. 11. . . .	8.56	15.786	19.6	3	0	F.
4	W. Virginia No. 10. . . .	8.48	15.927	18.7	5	up 1	F.
5	Arkansas No. 1.	7.34	15.393	18.9	4	down 1	F.
6	W. Virginia No. 6.	7.34	15.743	17.8	6	0	F.
7	W. Virginia No. 4.	6.26	15.440	16.1	9	up 2	G.
8	*Old Man R.N.Br.* 29 . .	5.69	15.178	17.5	7	down 1	F.
9	W. Virginia No. 3.	4.56	15.325	15.5	10	up 1	G.
10	*Mill Creek No.* 39.	4.53	15.072	16.9	8	down 2	G.
11	W. Virginia No. 1.	3.72	15.129	14.7	11	0	G.
12	In. Territory No. 2. . . .	3.37	14.624	14.3	13	up 1	H.
13	*Nanaimo* 33.	3.29	15.422	14.0	14	up 1	H.
14	W. Virginia No. 2.	3.28	15.048	14.4	12	down 2	H.
15	*Old Man R. No.* 30. . . .	3.10	14.936	13.2	19	up 4	H.
16	*Old Man R. No.* 31. . . .	3.00	15.462	13.4	17	up 1	H.
17	Kansas No. 1	2.98	14.280	13.9	15	down 2	H.
18	*Bow River No.* 28.	2.90	13.872	13.2	18	0	H.
19	*Upper Belly R.* 32	2.87	14.896	13.6	16	down	H.
20	Missouri No. 1	2.76	13.997	12.9	21	up 1	H.
21	Kentucky No. 3.	2.69	13.702	12.6	22	up 1	H.
22	Iowa No. 2	2.64	13.471	12.4	24	up 2	I.
23	*Coal Banks No.*26. . . .	2.62	12.376	13.0	20	down 3	H.
24	Wyoming No. 2.	2.61	13.331	12.2	27	up 3	I.
25	Montana No. 1.	2.53	12.139	11.5	28	up 3	I.
26	*Belly RiverNo.* 22	2.49	12.498	12.2	26	0	I.
27	Indiana No. 2.	2.46	13.340	12.3	25	down 2	I.
28	Missouri No. 4	2.40	14.276	12.6	23	down 5	H.
29	Iowa No. 5	2.38	12.711	11.2	29	0	I.
30	New Mexico No. 1.	2.26	12.309	11.2	30	0	J.
31	Texas No. 2	1.97	10.881	10.9	31	0	J.
32	*S. Sask. No.* 2	1.83	11.098	10.4	32	0	J.
33	N. Dakota No. 1.	1.52	11.465	10.1	33	0	J.
34	Texas No. 1	1.44	10.990	9.4	34	0	J.

In this table the arrangement is by the proposed Split Volatile ratio, and in the last three columns are given first the numbers of the arrangement in Table I. by the Carbon-Hydrogen ratio, with next the number of places the new scheme has shifted each item whether up or down. If it remains in same position in scale this is indicated by 0. The last column gives the group to which each item belonged in Table I.

COMMENTS.

In studying this table it will be seen that no great disagreement occurs for the higher class coals, but that through the intermediate grades there is some transposition. Thus, Nos. 7 to 10 appeared in Table I in the order 9, 7, 10 and 8 of Table II. To criticise the two arrangements the analyses are here given:—

No.	H_2O.	Vol. Combust.	Fixed Carbon	Ash	B.T.U.	Fuel Ratio
7	0.98	28.72	61.87	8.43	15.440	2.16
8	1.75	19.99	58.40	19.86	15.178	2.92
9	1.00	30.25	58.38	11.37	15.325	1.93
10	1.63	28.43	57.57	12.37	15.072	2.02

The order of precedence by Carbon-Hydrogen ratio is:—

	1.00	30.25	58.38	10.37	15.325	1.93
	0.98	28.72	61.87	8.43	15.440	2.16
	1.63	28.43	57.57	12.37	15.072	2.02
	1.75	19.99	58.40	19.86	15.178	2.92

It is clear by the calorific values that neither scheme is quite right, but the rough method of Table II. does not seem to be out very much.

The positions of the Canadian coals in the series are somewhat unsettled, but the two schemes of analysis may account for this. The Coal Banks sample is given a higher position by the C-H classification than it would have by either the "Split Volatile" ratio or the calorific value.

The greatest change made in any of the items is No. 28, a coal from Morgan Co., Missouri, referred to as Missouri No. 4. This deposit is what might be called a freak coal. The bed is described as a pocket upwards of 60 feet thick, and the extent a few acres. The mine is not developed, and the coal seems to have characters that might point to a different life history than the ordinary coal seam. It is also quite evident that the Cannel coals cannot be classed by this method.

Near the lower end of the scale the agreement is complete.

The general result would seem to be near enough for provisionally classing coals whose properties are known only by proximate analyses of air-dried samples. The last column of Table II. shows that the classes proposed by Mr. Campbell are not badly disarranged, although some interchanging is to be found at the limits of each class, but the groups can be distinguished.

The names commonly used instead of the letters referred to above are generally acceptable, except perhaps the different sense in which *semi-anthracite* and *semi-bituminous* are used, and I would be glad to see the latter name disappear.

The practice heretofore in classifying coals has depended almost entirely on the physical characters, such as for weathering flame, etc.

Lignites are described as coals having a brownish powder, that do not remmain firm on exposure to dry air and stain a boiling solution of caustic potash a deep brownish red.

Lignite Coals stand weathering better and do not colour a potash solution so deeply.

Coals.—The lower grades impart a brownish yellow color to the potash solution, but withstand weathering.

In the higher grades the distinctions are rather vague, but it is generally understood that anthracites burn with very little flame.

In classifying lignites by the potash solution we sometimes have coals that are clearly above that grade in other properties. One example of this might be cited, as it is No. 21 in the Survey Report above referred to. No. 21 is called a lignite, while No. 22 is lignitic coal. The two analyses are:—

	Moisture	Vol. Combust	Fixed Carb.	Ash
Lignite	7.83	34.21	52.09	5.87
Lignitic Coal...........	9.18	34.97	49.00	6.85

The lignite stands weathering better than the lignitic coal. It is also dry, high in fixed carbon and has less ash. So the potash test is not always the best guide.

The Canadian coals that have been selected for a list are pretty well known, and from them a scheme of names for classes and their limits is submitted below:—

	Split Vol. Ratio	
Seam A, Anthracite Mine, near Banff	24.17	
Cowgitz, Queen Charlotte Islands	17.73	Anthracite.
Bankhead, Seam No. 2, B level	15.79	
Canmore Mine, Seam No. 3	15.30	
Hooper Creek, Skidegate Channel, Q.C.Is.	14.53	Semi-
Canmore Mine, Seam No. 1.	14.23	Anthracite.
Canmore Mine, Sedlock Prospect	12.64	
Sheep Creek, Burn's Location	12.03	
Canmore Mine, Seam No. 2	11.82	Anthracitic
Morrissey, Seam No. 2	11.58	Coal.
Canmore Mine, Seam No. 4	11.00	
Canmore Mine, Seam No. 5	10.16	
Canmore Mine, Seam No. 6	10.40	
Coal Creek, Fernie, No. 4	8.92	
Coleman, Coking Seam	7.73	High Carbon
Michel Mine, No. 3.	7.41	Bituminous.
Morrissey Seam, No. 1	7.32	
Coal Creek, Fernie, Mine No. 2.	7.01	
North Fork, Old Man River, near Mts	5.69	
Union Mine, Comox, B.C.	5.11	
Coleman Steam Coal.	5.04	Bituminous.
Acadia Coal Co., Ford Pit, Pictou, N.S.	4.65	
Hub Seam, Sydney, N.S.	4.35	
Harewood Mine, Comox, B.C.	3.70	
Wellington Mine, Nanaimo, B.C.	3.29	Low Carbon
Pincher Creek, Alta.	3.14	Bituminous.
Coal Creek, Bow River	2.90	
Coal Banks, Main Seam, near Lethbridge.	2.62	Lignitic Coal.
Belly River, 5 miles below Little Bow River	2.49	
Blackfoot Crossing, Little Bow River.	2.39	Lignite.
Seam below Edmonton.	2.26	Lignite.
Red Deer River, Coal Banks Seam.	1.98	Lignite.
South Saskatchewan, near Stair	1.94	Lignite.
Sutherland's Mine, Souris River.	1.42	Lignite.
Mouth of Long Creek, Souris River.	1.28	Lignite.

The scale I propose would be that coals whose proximate analyses were obtainable, be classed by dividing the *fixed carbon* and *half the volatile combustible matter* by the moisture and *half the combustible matter,* and arranging the ratio thus obtained under the following classes:—

CLASSES.

Anthracite	15	up
Semi-Anthracite	13	15
Anthracitic Coal	10	13
High Carbon Bituminous	6	10
Bituminous	3.50	6
Low Carbon Bituminous	3	3.50
Lignitic Coal	2.50	3
Lignite	1.20	2.50

DISCUSSION.

MR. J. C. MURRAY:—I presume your ratio would fluctuate with the physical conditions; because in the matter of size, and in the matter of weathering, the samples of coal would not have equal absorbing powers.

MR. DOWLING:—The fluctuation for fresh coals would be very slight, as the air drying could be done on coal ground to a standard size. The large coal takes longer to lose the moisture than the smaller size. For weathered coal the impression is general that the coal has lost in volatile matter; but the evidence gained from experimentation is conflictory; in some instances the outcrop showing more volatile matter than the unweathered portions. This might form a subject for investigation for the Mines Branch of the Department of Mines. Weathered specimens also show a marked decline in calorific value from those obtained from inside the mine.

DR. STANSFIELD (McGill University):—Can you say how far these figures would vary according to the time of the year?

MR. DOWLING:—I would not like to give any figures for that; but in the American reports you will find some tables showing the difference and it practically varies with the moisture in the atmosphere. Coal will dry to the humidity of the air and no more.

DR. STANSFIELD:—Would it not be desirable to have something more definite than merely air drying in giving a scheme of classification?

MR. DOWLING:—It certainly would, but my trouble is that the analyses I have are dated from 1859 to 1903 or 1904 and I do not know the conditions under which they were collected nor under which the analyses were made. The American specimens are possibly sealed and shipped direct from the mine and then are weighed and air dried immediately to ascertain the loss.

DR. PORTER:—I may say that a series of tests on a considerable scale is now being carried out at McGill University, under the auspices of the Dominion Government, and I am able to make some explanation of the methods which we have found it expedient to follow in connection with this matter of air drying. We find, as would be expected, that a sample of coal air dried under one condition of atmosphere and temperature gives an altogether different result from a sample of coal dried under other conditions. After a considerable series of experiments we have found it expedient to arrange a dry box or cupboard in which the temperature is kept uniform and in which the degree of moisture is kept approximately constant by means of a chemical solution. We cannot keep it absolutely constant, but we maintain a very even temperature and secure an almost perfectly constant humidity by means of a solution which, if the degree of moisture falls below a certain point, yields moisture to the air in the box, whereas if it rises it absorbs it. All the samples are kept under these conditions until they arrive at a uniform weight.

This method is not perfect because if we had adopted some different temperature and some different degree of moisture we should have different results, but it is the most practical plan we have been able to work out and it will make the results of the series of tests which are now going on accurately comparable one with another; and as we use average room temperature and humidity, it will, I think, give them great value for practical purposes. I should like to be able to give you further information in regard to this work, but it is as yet in such an unfinished state that it seems scarcely proper to do so, and I am sure the Government would not wish us to go off at half cock. All I can say is that we are working in the line of the work that has already been done by the United States. We are not so rich a country and are not able to spend as vast sums as they are expending, but we are trying to do our work, at least, quite as well. Indeed, it should be better, because we have the advantage of their experience to go upon, and assuming equality of ability and earnestness we should produce results which will be free from some of the errors of their work. At all events our investigation will be a serious attempt at a careful and correct and reasonably complete study, both scientific and technical, of the coals of Canada. I look upon Mr. Dowling in the work he has been doing with our coals as our best friend, and as the man who has done more than any one else as yet to make a really scientific study of the coals of Canada. (Applause.)

THE PRESIDENT:—In respect to the assaying of coal, I have often noticed in the course of our work in British Columbia that no two assays even of the same sample would tally. It is quite evident that the various assayers use different methods for determining the constituents of coal. It struck me that it might be a good thing for the Institute to appoint a committee to take the matter in hand, and, at the next annual meeting, recommend an uniform system of assaying coal, as that recommended by the Canadian Mining Institute, so that all our coal assays would be comparable and this is certainly not the case at the present time. That Committee might also include coke within the scope of its investigation (hear, hear).

MR. J. C. MURRAY:—The chief source of error in the proximate analysis of coals comes in during the determination of volatile combustibles. The usual practice calls for three and a half minutes over the ordinary bunsen flame and three and a half minutes blast. The length of flame, height of support, protection of flame, etc., are most important factors. So varying is laboratory practice in these respects that I doubt whether any two determinations of volatile combustibles made in different laboratories would agree. In my own work I have found the Chaddock burner the best means of standardizing conditions. The blast is not to my mind a necessity. It introduces mechanical errors and is never exact.

DR. PORTER:—The President has suggested that it would be well to have a committee of the Institute to try to arrive at a standard method of coal analysis which could be followed by all analysts. That is a very desirable thing. Anyone who is making a study of coals finds great difficulty in interpreting reports of analyses because of methods at present in use. I spoke a moment ago of our work in connection with the coal tests undertaken for the Mines Department. We have a specially trained chemist who has for years been working exclusively on coals and who is giving this subject most earnest study. We have at last arrived at a series of methods which seem to be the most satisfactory we can get, and I am quite sure that I shall be granted permission to give all our results and methods to a committee, if one is appointed, as I hope it will be, and I think in the end we can arrive at methods which will be simple enough to be easily followed by any chemist and yet be far more satisfactory than those commonly used at present.

Mr. Murray has spoken of one of the evils of the proximate analysis but there are others. The classification referred to by Mr. Dowling, which is Mr. Campbell's method of interpreting ultimate analyses, seems to be the best yet devised. The proximate analyses as ordinarily done cannot be made a standard owing to unavoidable errors. On the other hand absolute accuracy is unnecessary in many cases, especially in works practice, because usually the works themselves make tests in their own laboratory, and although a chemist here and another chemist there cannot get uniform results by the proximate method, a chemist working in any one laboratory and with the same appliances does get fairly uniform results which are perfectly satisfactory for the comparisons and control of routine operations.

MR. J. C. MURRAY:—In view of the President's suggestion I have much pleasure in moving that a committee of the Institute be appointed, consisting of five members, to take up the matter of standardizing the methods of coal analysis.

DR. STANSFIELD seconded the motion, which was agreed to.

THE PRESIDENT:—I will consider the matter and announce the names of a committee at a later meeting.

THE UTILIZATION OF PEAT FOR INDUSTRIAL AND METALLURGICAL PURPOSES.

By E. Nystrom, Ottawa, Ont.

(By permission of the Director of the Mines Branch of the Department of Mines.)

The utilization of the peat bogs in Canada has so far been rather neglected. Attempts have been made, however, to manufacture peat fuel (mostly peat briquettes), but in most cases these attempts have been of a more or less experimental character, and very little peat fuel has been placed on the market.

In certain European countries, on the other hand, peat is used to a large extent, and the manufacture of air-dried peat fuel there is a sound business proposition. The conditions in Canada for this manufacture are quite as favourable as those in Europe, and in many cases even better, on account of the longer and hotter summers. With suitable methods and machinery, and especially where other fuels are comparatively expensive, the manufacture of peat fuel in Canada ought to be a paying undertaking.

It must be remembered, however, that a careful investigation of the nature and extent of the bog, as well as of local conditions, such as labour and market, are of the utmost importance, and these factors should be carefully considered before operations are started.

Tests made with different fuels have demonstrated that the fuel value of one ton of ordinary coal is equal to that of 1.8 tons of air-dried machine peat or to that of 2.5 tons of wood.

The different methods and machinery used in Europe and the results there obtained are fully described in the report on peat which will shortly be issued by the Mines Branch of the Department of Mines, Ottawa.

In this paper attention will only be drawn to certain methods permitting the utilization of peat bogs on a larger scale.

Generation of Electric Energy.—The most rational utilization of peat bogs is probably by the generation of electric energy at power plants located close to the bogs. In this case the bulky peat fuel needs to be transported only a comparatively short distance without re-handling. Another important factor is that peat fuel in the producers employed can be used with a moisture content of 40–45%, whereby the dependence on favorable drying conditions is considerably decreased. A peat fuel with a content of 20–30% moisture is, however, to be recommended whenever it can be obtained.

The firm Gebrüder Körting, of Hanover, Germany, has so far erected the greatest number of peat gas plants. These plants are located in Sweden, the oldest one of 300 h.p., at Skabersjö, and the newest one, of 1,000 h.p., at Wisby.

The principal parts of such a plant are: gas producer, scrubber, saw dust filter, gas engine and dynamo.

The gas producer is a suction producer in which the gases drawn off from the freshly charged peat are drawn from the upper part of the producer through the grate and carbonized fuel bed in the lower part to the gas outlet placed a little below the middle of the shaft. By this arrangement most of the water vapours and heavy hydrocarbons contained in these gases are decomposed into permanent gases, and the carbon dioxide mostly reduced to monoxide. The gases pass from the producer through the scrubber and saw dust filter to the gas engine.

At Skabersjö the consumption of peat, containing 32.3% moisture, and with a calorific value of 5,364 B.T.U., was three lbs. per eff. h.p. hour. The gas produced had then an average calorific value of 132 B.T.U. per cubic foot.

The consumption of peat with a maximum content of 30% moisture and a calorific value of 5,400 B.T.U., is now guaranteed, with full load on the engine, not to exceed 2.2 lbs. per eff. h.p. hour.

Lately experiments with a view of first saving the ammonia contained in the gases before they are used in the gas engines have been carried out by Dr. Caro at a Mond producer plant in England, and the results there obtained are said to be very satisfactory.

Manufacture of Peat Coke.—In older days peat coke was manufactured in the same manner as charcoal, either by coking in heaps or in ovens discontinuous in their operation. These methods were wasteful and at the best only a small part of the by-products was saved. At present the method invented by the German engineer, M. Ziegler, is the one mostly employed, and undoubtedly the one best suited for this purpose.

Ziegler employs retorts or ovens continuous in their operation and saves all the by-products.

The retorts are heated from the outside by means of the non-condensible gases obtained through the dry distillation of the peat. These non-condensible gases are quite sufficient for this purpose and, as a rule, where several retorts are employed, an excess of gas is obtained, which can be used for the operation of gas engines or other purposes. The retorts are charged at certain intervals with fresh peat bricks (air-dried machine peat containing not more than 25% moisture) and the coke is also drawn off at fixed intervals into air-tight steel cars, where it is left until thoroughly cooled.

The peat coke, if made from suitable peat, is comparable with charcoal, and can be used in blast furnaces or for other metallurgical purposes.

The following analysis shows the average composition of good peat coke:

Carbon........................	87.8%
Hydrogen........................	2.0 "
Nitrogen........................	1.3 "
Oxygen........................	5.5 "
Sulphur........................	0.3 "
Ash........................	3.2 "

Calorific value about 14,100 B.T.U.

At present three peat coking plants employing the Ziegler ovens are in operation, viz., at Oldenburg and Beuerberg, in Germany, and at Redkino in Russia.

The Oldenburg plant was investigated on behalf of the Prussian Government, and the following results were obtained:

Analysis of the peat used—

Carbon	35.3%
Hydrogen	3.4 "
Nitrogen	0.7 "
Sulphur	0.1 "
Oxygen	28.4 "
Ash	0.9 "
Moisture	31.0 "

Per 100 tons of such peat were obtained:

27.3 tons peat coke (dry).
4.5 tons tar.
31.2 tons tar water (not diluted).
37.0 " gases (without air).

The tar produced:

2 tons light oils.
0.7 " heavy oils.
0.3 " paraffin.
1.3 " phenol.
0.2 " asphalt.

The tar water produced:

0.34 tons methyl alcohol.
0.16 " ammonia.
0.44 " acetic acid.

Three tons of air-dried peat are, as a rule, required per ton peat coke. M. Ziegler has also invented retorts in which the peat is only partly carbonized. The product then obtained is called peat half coke, and is used as fuel under boilers and similar apparatus.

In this case 44–48% of the peat charged is obtained as half coke. The commercial manufacture of peat coke on a large scale is naturally dependent on the market for the by-products; where these can be advantageously disposed of, the manufacture of peat coke ought to be a paying proposition.

The Wet Carbonizing Process.—A promising method invented by Dr. M. Ekenberg for the manufacture of peat fuel is at present being introduced.

This method is called the wet carbonizing process, and its principal features are as follows:—

The wet peat as it comes from the bog is put through a special pulping machine and is conveyed from there by means of a pump to a carbonizing oven. The oven consists of a number of double pipes. The wet peat mass containing some 85–90% moisture is forced in between the pipes and is moved forward by pressure and by the revolving inner pipe, which is provided with a screw thread. At the end opposite to where the mass is brought in is a fire box, and the temperature there is highest. The carbonizing takes place at a temperature of 150–175° centigrade, but in order that no steam may be formed, which would necessitate the production of the heat required to transform the water into steam of the same temperature (latent heat) a sufficient pressure, 5–10 atmospheres, is maintained. One half of the pipe system works on the same principle as a recuperator. The heat in the outgoing mass is here transmitted to the incoming mass, and a comparatively small loss of heat is obtained. The water in the peat mass acts as a heat conducting medium, and a uniform charring is obtained throughout the whole mass.

The carbonized mass is pressed in special filter presses, and product then obtained is further artificially dried and briquetted.

The peat fuel obtained by this method has a calorific value approaching that of ordinary coal, and does not absorb moisture.

The greatest advantage with this method is, however, the independence of favourable weather conditions for drying, and the possibility of working the bog the greater part of the year.

MODES OF OCCURRENCE OF CANADIAN GRAPHITE.

H. P. H. Brumell, Buckingham, Que.

(Ottawa Meeting, 1908.)

Outside of those directly interested in the mining or geology of graphite the impression seems to prevail that this mineral invariably occurs in veins or non-descript masses. In view of the fact that all our deposits of permanent value are those of disseminated ore, the writer has undertaken to put together this brief paper on the subject with the hope that those interested in the industry will devote a little more attention to the development of some of our enormous deposits of comparatively low percentage disseminated ore, rather than to the exploitation of the higher percentage, and almost invariably erratic, deposits of so-called "pure lump."

The only ore under consideration in this paper is that found in the Archæan rocks from which, solely, do we obtain any of the crystalline or flake variety, and the area covered will be that in which so much work has been done in the counties of Labelle and Argenteuil, in the Province of Quebec. In the former county the graphite is found most prominently in a more or less wide band of gneiss appearing near the front of the township of Templeton from whence it extends in a north north-easterly direction into the township of Buckingham between the fourth and tenth ranges across which it sweeps, in a general easterly direction, into the township of Lochaber, where it turns again to the north-east, and so passes into the township of Mulgrave. In the county of Argenteuil the graphite occurs, almost invariably, in the limestones which are very strongly developed in the township of Grenville and those townships to the north. These bands of limestone are bounded by the large porphyry and syenite mass to the east, and by the granites of the Rouge River to the west. It will thus be seen that in these two counties the mineral occurs in two very distinctly different rocks. Not only do the rocks differ, but the ore also, that of Labelle county being mainly a disseminated one, while that of Argenteuil occurs in veins and segregated masses; although the limestones, in the vicinity of these deposits, are often impregnated with disseminated scales of graphite to a considerable distance from the ore body.

To treat the subject in a broad sense and for convenience in this paper, the modes of occurrence may be briefly summarized as follows:—

1st. As disseminated ore, where the graphite occurs in small, bright, scaly crypto-crystalline particles, in a grey or red weathering gneiss, the particles lying parallel to the apparent stratification, or in larger similar particles in quartzite, pyroxenite or coarse grained granite.

2nd. In the form of true fissure veins, usually cutting diorite or other eruptives.

3rd. As veins or irregular masses and contact deposits in limestone.

Of these three very distinct modes of occurrence the most important is, beyond all doubt, the first. These gneisses are very distinctly foliated and consist essentially of quartz and orthoclase with sillimanite, hornblende, pyroxene and pyrite, the latter mineral on weathering giving a reddish rusty appearance to the rocks. Interstratified with the gneisses are bands of crystalline limestone, frequently lenticular and not usually of great thickness. Dr. R. W. Ells—"Bulletin on Graphite"—says of the disseminated ores of Labelle county:—"The occurrence and association of the mineral are to a large extent the same at most of the places indicated. Certain local conditions are found here and there which must be considered in any mining scheme proposed, but generally it may be said that the chief attention as regards future developments must be made in connection with large bodies of the disseminated flake graphite, as promising the most steadfast returns. Though the vein form frequently occurs at most of the points where attempts to work the graphite have been made, and has shown in such cases a mineral of great purity, the uncertainty of such deposit is such that, by itself, the employment of capital on a large scale would scarcely be warranted. . . . .

"The most persistent of the graphite deposits, however, are those which are found as disseminated flake. In the Buckingham district this variety is found usually in the grey mica gneiss in bands or beds which sometimes have a thickness of from ten to fifteen feet, or in places even more as well as in limestone. In some of these beds the graphite is very thickly distributed, and the rock is quite black from its presence, indicating a high percentage of the mineral. Several assays were made by Dr. Hoffmann in the Survey laboratory some years ago, which were published in the report for 1876-77, and are as follows:—

'A specimen of disseminated ore from lot 28, range VI, Buckingham, owned by the Montreal Plumbago Company, the sample being regarded as a fair average of one of the largest and most extensively worked beds in the area with a breadth of eight feet, gave by assay, graphite, 27.518; rock matter, 72.438 per cent. A sample from lot 22, range VI, Buckingham Mining Company, gave graphite 22.385, rock matter, 75.875 per cent. Specimens from lot 20, range VIII, gave graphite 23.798, rock matter, 75.026 per cent.; and from lot 23, range VI, graphite 30.516, rock matter, 69.349 per cent. In all the above occurrences the amount of disseminated ore seems to be large, and in some the presence of the vein variety is also recognized.

'It must not be supposed that all the disseminated ore occurs in beds equally as rich as those just mentioned, but at very many points deposits exist which give amounts of flake from large bodies of ore, which range from 10 to 15 per cent. or even higher.'"

The foregoing is a very terse and accurate statement of facts and it is to ores of this description that the energies of those at present engaged in the business are being bent. Already several extensive and characteristic deposits have been developed, notably those of the late North American Graphite Company, the Buckingham Graphite Company and the Bell Mines, all in Buckingham township, on whose properties are one or more extensive beds of graphitic gneiss, assaying from 20 to 30 per cent. of graphitic carbon.

A very noticeable characteristic of most of the beds in the district is found at or near their contact with any of the later eruptives where there is usually a very pronounced enrichment in graphite. This phase of the subject, however, need not be dwelt upon here.

Regarding the second or vein form of occurrence but little need be said except that the deposits are true fissure veins, usually, in Labelle county, in diorite, at times continuing into the gneiss; in rare instances these veins have been noted in granite, pegmatite, pyroxenite and felsite. The graphite, which is of exceptional purity, occurs in fibrous and foliated forms, the fibres and plates lying at right angles to the enclosing walls, though in some rare instances the fibres and plates occur almost parallel to the walls and have the appearance of having drawn out by some dynamic action. In the latter instance the ore is usually harsh and lack-lustre. In one of the many veins opened on Lake Terror, where the ore occurs in a felsite, a vein of fibrous graphite about two inches in width gave every evidence of intense lateral pressure, the fibres being bent at the centre forming an angle of about 60° without breaking the fibre. Of the purity of the vein graphite of Labelle county, the following assays by G. C. Hoffmann bear ample testimony.

"Vein graphite, foliated.—From a vein running through lots twenty-one and twenty-two of the seventh range of Buckingham. The structure of this graphite was massive, dense, made up of broad and thick laminæ. Color dark steel-gray. Lustre metallic. Specific gravity 2.2689, (containing 0.147 per cent. ash). Its composition was found to be as follows:—

Carbon	99.675
Ash	0.147
Volatile matter	0.178
	100.000

"Vein graphite, columnar.—From the twenty-seventh lot of the sixth range of Buckingham. Structure of the graphite, compact, columnar; the columnar structure is usually erect, and at right angles to the surface upon which it occurs; in some instances, however, it is curved as though from pressure. The graphite breaks readily in the direction of the structure into more or less angular aggregates, each aggregate being made up of thin, narrow foliæ of very uniform width. The length of the columns varied in different specimens from about one and a half to eight centimetres. In this specimen the foreign mineral matter was very evenly distributed through the structure of, and as a film upon, the graphite, so that on incineration the residual ash formed a tolerably perfect cast of the fragment employed. Color of untarnished foliae, dark steel-grey. Lustre metallic. Specific gravity 2.2679 (containing 1.780 per cent. ash). Its composition was found to be as follows:—

Carbon	97.626
Ash	1.780
Volatile matter	0.594
	100.000

Economically this form of graphite has not proved itself of value. The veins are small and very irregular, in no instance exhibiting any appreciable degree of persistence as to size, veins which, on discovery, appeared to warrant systematic operations, invariably pinching out or running off into numerous small pockets and stringers. Many attempts have been made to operate these deposits, but in no instance, within the knowledge of the writer, has the venture proved profitable.

In treating of the third mode of occurrence, that of deposits in crystalline limestone, as illustrated by all of those of Argenteuil county, it is, by reason of the small amount of development work done, extremely difficult to accurately describe the ore bodies. Scattered through the limestone are numerous irregular masses of a very pure foliated graphite, at time having all the appearance of true veins, though more frequently appearing as contact deposits in the neighborhood of small eruptive masses and dykes which cut the limestones at many points.

In writing of the property of the National Graphite Company lot 9, range V, Grenville township, Dr. R. W. Ells describes a very typical deposit as follows:—

"The country rock is for the most part crystalline limestone which is cut by granite and other intrusives. The graphite usually occurs irregularly at, or near, the contact of the limestone with granite or diabase dykes, both rocks being present in the openings, also in irregular vein forms which are massive rather than columnar in character, ranging in thickness from fifteen inches to two feet. These are not solid, but apparently sometimes in dyke matter.

"Several openings have been made on the property. In the main pit the rocks are limestone with bands of rusty gneiss which are traversed by a white granite dyke and this in turn by a dyke of light green diabase. The graphite occurs principally in two irregular veins, and also in the granite mass, and there is a small vein on the edge of the diabase. The veins are shattered and mixed with a whitish, sometimes reddish, granite.

"The granitic looking rock has somewhat the aspect of a vein in some respects rather than a true dyke. It carries several minerals including scapolite, hornblende, graphite, pyroxene, pyrite, apatite and others. South of the principal opening, where mining has been carried on, the surface rocks for some distance appear to be all limestone, and in several small prospecting pits, sunk in this rock, a small percentage of disseminated flake graphite was observed."

The ore of Argenteuil county is of a very high degree of purity as is evidenced by the following assays by G. C. Hoffmann:—

"Vein graphite, foliated. From the north half of the third lot of the second range of the Augmentation of Grenville. An exposure here was at one time mined to a small extent. At the opening of the excavation it showed a thickness of about ten inches, but the pure graphite was found to form a lenticular mass which appeared to be separated from other masses of the same character by intervals, in which the graphite became intermixed with the limestone. Structure massive, dense, made up of broad and thick laminæ, closely interlocking each other at diverging angles, thus presenting a radiated arrangement, the sides of the vein forming the basal line. Color, dark steel-grey. Lustre metallic. Specific gravity 2.2714 (containing 0.076 per cent. ash). Its composition was found to be as follows:—

Carbon	99.815
Ash	0.076
Volatile matter	0.109
	100.000

"Vein graphite, columnar. From lot one of the sixth range of the Augmentation of Grenville. Structure massive, dense, made up of stout, narrow laminæ, interlocking each other at such an angle as to present an almost columnar appearance. In parts, viz., those in closest proximity to the vein rock, this structure was so fine as to appear coarsely fibrous. Color, dark steel-grey. Lustre metallic. Specific gravity 2.2659 (containing 0.135 per cent. ash). An analysis showed it to contain:—

Carbon	99.757
Ash	0.135
Volatile matter	0.108
	100.000"

The graphite, as well as occurring in veins and contact deposits of various forms, is found at times in the limestone in the shape of almost perfect spheres, concretionary in form, the plates or fibres of graphite radiating from a centre consisting of a small particle of quartz or other foreign mineral. These concretionary spheres range in size from about one-tenth of an inch to two inches in diameter, and do not appear to follow any apparent bedding of the limestone, but to be scattered irregularly therein.

In summing up the three modes of occurrence it is not thought necessary to draw attention to specific failures to operate profitably the last two classes of deposits, but it may be said, in a general way, that, without exception, no deposit of vein or "pure lump" graphite has been found, on development, to be worthy of consideration as a commercial venture.

This conclusion was foreshadowed by Sir W. E. Logan who, in 1866, concluded his report to the Geological Survey by saying:—"The veins of this mineral hitherto found in the rocks of this country, although affording a very pure material, appear to be too limited and too irregular to be exclusively relied on for mining purposes, which should rather be directed to making available the large quantities of graphite, which, as we have seen, are disseminated in certain beds."

DISCUSSION.

MR. OBALSKI:—This has been a very interesting paper, the more so as it has been read by one of our recognized authorities on Canadian graphite. It appears that we have in Canada large resources in graphite of good quality, and I would like, therefore, to ask Mr. Brumell why there should have been so many failures in an industry which promises so well?

MR. BRUMELL:—Mr. Obalski asks a very comprehensive question, which I will try and answer in a few words. I object to the word "failure," as our business has not yet reached success publicly, though we have demonstrated to ourselves that we can produce high-grade graphite commercially. The prime reason of our non-success in the past is the fact that our ore is essentially a milling and not a shipping one, the industry, in point of fact, being a milling rather than a mining one. The problem of separation is not a simple one, and we have been working on it for many years. In the early '60's separation was made by the old Cornish system of buddling, upon which we have been steadily improving, until to-day by more complicated mechanical means we are producing stuff of a higher percentage than that from any other portion of the world. I refer, of course, only to that variety of graphite treated in my paper, namely, flake. During the early days of the industry it suffered from bad management, ignorance of milling practice and unscrupulous business methods, coupled with a very decided prejudice in favor of the Ceylon product, which occurs in lump form of great purity, requiring no further treatment than crushing, grinding and sizing for the various uses to which it is put. This latter, combined with cheap native labor, cheap ballast freight rates and a small market, were difficult to overcome, but by dint of perseverance and the expenditure of large amounts of capital we have succeeded in producing and marketing profitably the highest grade of graphite on the market to-day. We have now passed the experimental stage and are simply awaiting the necessary working capital to enable us to proceed and operate extensively the properties and mills already developed, and I find that capital is very shy when it has to deal with an industry which had earned such a bad name as had ours.

MR. CIRKEL:—I would like to ask Mr. Brumell whether, as a general rule, the richness of the graphite deposits close to the eruptive dikes to which he refers, is such as to invite work. Mr. Brumell states that this is a common feature in the case of disseminated graphite.

MR. BRUMELL:—I should say most decidedly so. If a prospector goes into a district where the rocks are disturbed by eruptive masses he will find, in Labelle county, a very decided enrichment at or near the point of contact. Bands which run from 10 to 12% away from these points are often enriched to as high as 45%, which is very high. At times where the diorites cut the gneisses you will find veins of pure graphite extending out of the dyke into the gneiss itself.

DR. BARLOW:—These gneisses are those belonging to the Grenville series and represent the extreme phases of the recrystallization of slaty rocks containing a considerable amount of bituminous matter. The bituminous matter in the Hastings series has been altered into this graphite, which often forms an important constituent of the sillimanite gneiss. Through central Ontario very frequently there is more or less graphite found in this gneiss, but it has apparently not reached that stage of enrichment in which it becomes really the ore.

MR. COSTE:—I would like to emphasize the conclusion to be drawn from the distinctive fact observed and well brought out by Mr. Brumell, that the gneiss and limestone or other rocks in contact with the eruptive rocks are very much enriched with graphite. This shows conclusively that the old idea of considering graphite as a product of organic matter must be given up. From what I read and see I conclude more and more every day that most of the deposits of carbon in our rock strata, except coal, are due to emanations from the interior of the earth of hydrocarbons, just the same as many of the deposits of salts, metals and sulphur are due to emanations of chlorides, sulphides and other gases or vapors in conjunction with the coming into the strata of igneous or volcanic rocks. Magmatic gases and vapors, as it is now conclusively proven, contain in a high degree hydrocarbons, and all the facts elucidated in the field indicate that this graphitic gneiss is nothing else than an old sandstone impregnated with vapors of hydrocarbons changed to graphite. At the meeting of this morning I pointed out that we had a similar phenomenon in the Albert shales of New Brunswick which were, subsequently to their formation, impregnated with hydrocarbons as well as the other formations of that district, and all these formations are also there cut up by solid hydrocarbon veins. There the final stage in which we find the hydrocarbon vapors are Albertite veins or impregnated oil shales. In less altered Paleozoic rocks, such as in Pennsylvania, Ohio and West Virginia, and in younger formations such as the Tertiary of California, we find the hydrocarbon emanations in extensive oil and gas deposits, which are evidently also extraneous impregnations of porous rocks along fissured lines and fissured belts, or as in Texas and Louisiana, regular mud volcanoes or salses not extinct yet as much of the oil or the salt waters found in connection with the oil in these States are hot at the present time.

MR. BRUMELL:—I do not agree with Mr. Coste's views that the origin of graphite and natural gas is similar. When he refers to the origin of graphite as being inorganic then I most decidedly agree with him. It seems to me that such a change as he describes should take place where the eruptives cut the gneisses at which points the graphite is found in greatest quantities. Where eruptives cut the limestone there is invariably found a silicate of lime, and in our gneisses, which are calcareous, and where there are large quantities of iron pyrites, you will find sulphate of lime. I would therefore suggest that these masses, in conjunction with silicious or other waters, acted upon the original rocks and freeing the carbon while forming sulphates and silicates redeposited the carbon as graphite in the rock. In the Grenville field the limestones where not graphitic near the eruptive masses are reticulated with veins or vein-like deposits carrying tremolite, scapolite, wollastonite, hornblende, pyroxene, titanite, zircon and other silicates and oxides. In Labelle County, where most of the gneisses are calcareous, the existence of eruptives is evidenced by silicates and minerals other than the original gneiss constituents, such as hornblende, pyroxene, scapolite, apatite, selenite, tourmaline, etc.

MR. BENNIE:—I am, perhaps, the only member of the Institute who has been professionally engaged in the manufacture of artificial graphite. I would meanwhile ask Mr. Coste and Mr. Brumell by what agency they suppose the carbon might be deposited in the graphitic state. My experience has been that the carbon so deposited is in the amorphous state, and high temperature is required to produce carbide and decompose it to accomplish the metamorphosis to a graphitic carbon.

MR. COSTE:—Answering Mr. Bennie, I would say that the principal agencies no doubt were high temperatures and pressures and changes in these, inducing deposition in the amorphous or crystallised state.

MR. BENNIE:—We have never tested the temperature, but in manufacturing the artificial graphite at Niagara Falls we use petroleum coke, the residue from petroleum distillation and perhaps a hundred different kinds of anthracite coal. With some anthracites we have found under high temperature and no pressure other than the ordinary, a graphitic body, which physically and optically appears to be the same as the Ceylon graphite. We have two samples, one of Ceylon graphite and one made from anthracite coal, which cannot be distinguished.

MR. COSTE:—In Africa the diamond, pure crystalline carbon, is found in volcanic pipes, and there are also found in these diamond mines hydrocarbon gases which have interfered with the work in the mines by causing explosions. In some similar way I infer that the graphite alongside of these igneous masses has been formed by the crystallization, more or less perfect, of hydrocarbon vapors. Mr. Bennie does it, he says, with petroleum coke, which is a product of oil or hydrocarbon; why cannot nature do it also? When the igneous intrusions took place through the sediments of the Grenville series, enormous quantities of magmatic vapors, mostly hydrocarbons, chlorides and sulphides, also invaded the sediments, especially near the contacts or in the fissured zones of these sediments. Mr. Brumell has also pointed out the association of pyrites with graphite; this association of sulphur and carbon strengthens my argument. It is always found in the oil and gas fields, as I have pointed out before to this Institute in previous papers on the volcanic origin of petroleum and natural gas.

MR. BENNIE:—Mr. Coste's theory is as tenable as my own. The carbon in the graphitic state is in a certain degree of crystallization, and the diamond is in another state of crystallization, but they are not hydrocarbons, but pure carbons.

MR. COSTE:—That does not mean that the final origin in both cases is not due to hydrocarbon vapors. When one sees so many facts pointing one way, though he may not know the explanations of the facts in all their details, yet he may be reasonably sure of the main points, and in this case I claim that enough facts in nature point to this conclusion that outside of the coal beds most of the carbon in our rock strata (whether in the shape of diamond, graphite, solid bitumen, oil or natural gas) is due to magmatic emanations from the interior of the earth.

MR. FRITZ CIRKEL:—I have studied a number of authorities on the subject of the origin of graphite, and I come to the conclusion that it is a most difficult problem to deal with; if we commence to discuss these theories I might say that from the beginning we all disagree. Mr. Eugene Coste says that carbon, oil and gas are produced by emanations from the interior of the earth. I cannot see very well how this theory can be applied to the disseminated condition of the graphite, especially in the gneisses. As we all know, the gneiss is not an eruptive rock, and for this reason the carbon must have been there at the time the rocks were formed. We know that the carbon originally present will be changed under certain circumstances into graphite. According to my studies it is likely that this carbon has been deposited as an original mineral and later on converted through agencies we know very little of, such as heat, pressure or electricity, into graphite; this process has been going on to a greater extent, it seems, near the eruptive dikes, as we find close to these quite a number of rich deposits, especially in Canada.

MR. COSTE:—Mr. Cirkel says that as the gneiss is a sedimentary rock, the graphite in it could not be due to emanations accompanying igneous volcanic eruptions. Surely we know absolutely to-day that a great many of the deposits of the numerous minerals we have to deal with, though in sedimentary rocks, are subsequent impregnations of these porous sedimentary rocks. The igneous rocks are sometimes plainly seen invading these sedimentaries, but sometimes not, and even then we often know them to be not far distant laterally or below. We also know (in fact, in the geology of ore deposition, this is the principal acknowledged dogma now) that the invasion of the sedimentaries was accompanied by invasion of magmatic vapors and waters carrying the minerals, including carbon in many cases. That carbon belongs to magmatic waters and volcanic emanations, in fact forms a large proportion of them, is an absolutely established scientific fact.

Mr. BROCK:—It seems to me that in the discussion of the mode of occurrence of graphite too much emphasis is placed upon the difference between the chemical composition of graphite and of ordinary minerals, and not sufficient upon the resemblances between graphite and ordinary minerals in its dissemination through rocks. One striking feature in the occurrence of graphite in Quebec and in various parts of Ontario is its close resemblance in its mode of occurrence with other minerals such as mica, apatite, etc. The graphite occurs in definite veins just as do the other minerals. Graphite is a characteristic mineral in mica veins, and the same explanation of the origin of the one might be supposed to apply to the other. Graphite, like many other minerals, may have different origins. In British Columbia in certain parts you will find highly carbonaceous sedimentary rocks invaded by igneous rocks and heavily metamorphosed. In some cases their dark colour is due to the carbon, and when metamorphosed, you find the rock bleached and the carbon now in the form of graphite. Graphite is also found as an original constituent of certain igneous rocks. It may be difficult to account for these changes and to reproduce them in laboratories, but in nature I think the carbon goes through chemical and physical changes in the same way that the other minerals do.

MR. BRUMELL:—I would ask Dr. Barlow or some other authority if the gneisses we have down there are sedimentary rocks. You can trace the band of gneiss along and find that at a certain point it loses its identity as gneiss and becomes granitic. It is not an intrusive granite, but instead of having a gneissic character it becomes a heterogeneous mass of a mica quartz character–the usual granite. If the gneisses are sedimentary rocks it is possible they may be the result of alteration. I think, however, that they are not sedimentary rocks, but other rocks metamorphosed and given a gneissic character by some dynamic action.

DR. BARLOW:—In reference to the sedimentary character of sillimanite gneisses we have traced them right across country into undoubted rocks of solid character highly charged with bituminous matter, and gradually become lighter in color as they are re-crystallized and the bituminous matter is segregated into graphite. When you ask about the presence of graphite in other gneisses and the tracing into granites, that is one of the most complicated problems of geology. We say one gneiss is undoubtedly sedimentary, another is undoubtedly due to eruptive process through pressure—in fact they are, as Prof. Cushing in the Adirondacks called them, "damnified gneisses," which have unlike structure through eruptive process, by the commingling of the two by actual fusion, and as in the Hastings series you cannot say what they are. They may be stratified or partly igneous gneisses. The sillimanite gneisses with which the graphite is associated are in the main sedimentary. As to the origin of the graphite I agree with Prof. Brock that there may be several explanations. We have it in the syenites in Ontario. I would not say that it was a foreign mineral, it has come in crystallized with the magnetite. It enters into all parts of the rock. The slates up there all belong to the Hastings series, and there are no traces of fossil remains in it, but there is a large amount of bituminous matter in it, and there is no evidence that the bitumen resulted from the fossil remains. A lot of these rocks are certainly from fine tuffs of volcanic origin, but I could express no opinion as to where they got their bituminous matter. The same happens in common Chelmsford and anthraxolite, which was distilled through certain mineral veins of secondary action. But there is no doubt it got it from the rock itself.

DR. J. E. WOODMAN:—I would like to call attention to one or two facts which emphasize the point made by Mr. Coste and Dr. Brock that graphite may have widely different origins in different localities. The burden of all the remarks made on the subject to-day is the association of graphite with igneous rocks, whatever may be the rock in which the mineral is imbedded. I recall at the moment two localities in which eruptives are so conspicuously absent as to indicate that the graphite can have no possible connection with them.

In Nova Scotia we have, in the upper or Halifax formation of the gold-bearing series, a large amount of graphitic material. The strata are black slates, with here and there thin bands of gray quartzite. The graphite is in most places so finely disseminated as merely to give a dead black color to the rock. Here and there, however, it is in discontinuous sheets interbedded with the strata, but somewhat vein-like in detail, and up to six or seven inches in thickness. The only igneous rocks connected with the series in eastern Nova Scotia are granites, which occur in bosses and larger masses. The distribution of the graphite has absolutely no connection with that of the granite.

The second occurrence is still more important. In the State of Rhode Island we have a small coal field, the strata of which are highly compressed, contorted and dynamically metamorphosed. The coal has passed through the stages of metamorphism which give the Pennsylvania anthracite and has become graphitic—so highly graphitic indeed as to render it practically unfit for combustion, except under strong forced draft. Igneous rocks cannot be called upon to account for the presence of the mineral, but extreme dynamo-metamorphism can; and the study of the field conditions would convince most of you, I am sure, that the graphite originates from the coal by almost complete loss of the volatile constituents of the latter. It would seem especially that Mr. Coste's volcanic theory could have no place here.

GOLD IN THE EASTERN TOWNSHIPS OF THE PROVINCE OF QUEBEC.

By J. Obalski, Quebec.

(Ottawa Meeting, March, 1908.)

About the year 1863 much excitement was created in consequence of the discovery of gold in the form of large nuggets, on the Gilbert River, in the Chaudiere Valley. Some of these nuggets were of unusual size, weighing up to 45 ounces; and the finds attracted a large number of prospectors and miners to the locality, where active work was conducted until 1878. But after that date operations became intermittent, and these were on an unimportant scale. In all the yield of gold from the area worked on the Gilbert River, a distance of about two miles, was in the neighbourhood of two million dollars. The day of the individual miner has now passed, however, and if work at these mines is resumed, that can only be successfully attempted on a large scale and by the outlay of considerable capital.

I would meanwhile call attention to the following points:—The Gilbert lead, so-called, follows in general a south-westerly course. Operations were confined to claims situated at an elevation of about 300 feet above the Chaudiere River, which flows towards the north-west. The discoveries of gold were limited to the middle section of the Gilbert, at the altitude mentioned. From that point following along the heights to the north-east of the Chaudiere Valley, gold is found in crossing the Famine River; then at Slate Creek, where some work was done; and again upon crossing the Riviere du Loup; not far from its confluence with the Chaudiere, gold is found, though in smaller quantities, in extensive beds of gravel. Again some of the gravels on the other side of the Chaudiere River, near the first falls, is auriferous. In a north-westerly direction from the Gilbert, gold has been found at Riviere des Plantes, where mining has been carried on. At Beauce Junction are immense deposits of gravel, which may be auriferous, but have not yet been prospected.

From the foregoing, the conclusion arrived at is that the distribution of gold is not confined to a few isolated sections of the region, notably that of the Gilbert, but that the auriferous belt may be traced from point to point as above indicated. Prospecting, therefore, should be made along that belt, without regard to altitudes; and this notwithstanding the prevailing belief in the region that valuable discoveries could not be expected at any elevated point.

On the other side of the Chaudiere River, extensive beds of gravel have also been observed between the Pozer and the Riviere des Meules. The discovery of gold here, especially in respect to the last named locality, is conducive to the supposition of another belt of distribution, perhaps connecting with the former near the great falls of the Chaudiere. But this theory would need to be supported by facts other than those stated. Meanwhile all geological investigation in the region, made with a view to ascertain the origin of gold, has as yet been unproductive of satisfactory results. Consequently there is excuse for advancing an hypothesis which may induce prospecting in localities heretofore neglected.

The formation, as described by the Geological Survey of Canada, consists of Cambrian and Cambro-Silurian schists traversed by dioritic eruptions. Numerous veins of quartz, some of very considerable extent, cut through this formation. Attempts have been made to work these quartz veins, stamp mills in one or two instances having been erected, but gold was never found in commercial quantities. In fact, the writer has never, in twenty-five years, found the quartz from this region to contain visible gold, while assays made under his supervision have never shown values beyond a trace. Of the many theories put forward to explain the origin of the alluvial gold, including that ascribing it to the disintegration of rich portions of these quartz veins, none apparently fit the problem. The writer therefore believes that the most satisfactory method of studying the alluvial deposits, would be to conduct a series of tests along the line of distribution by boring, employing a portable drilling machine. By this means it would be possible to ascertain whether any of

St. Onge Nugget.

Nugget found in 1877 on the Gilbert river, on lot 12 of the St. Charles Concession. Weight, 42 ounces; value, $756.00; photographed from the original.

the ground was sufficiently rich to work. In concluding this, brief note reference should be made to a discovery made last year at the head of the Chaudiere River, in Marston Township.

On lot 20 of range IV of that township, about 2 miles from Lake Megantic, a vein of quartz was accidentally discovered, which showed tolerably good gold values. Some prospecting was done, and a quartzous, slightly calcareous mass, running with the stratification of the accompanying schists and streaked with slight quartzous threads, in some of which numerous grains of gold could be seen, was uncovered. It would seem as if that strip formed part of the formation, but had subsequently become silicified and partly mineralized. The prospecting that may be done in that region will, undoubtedly, afford some interesting information.

Besides the Chaudiere Valley, gold in small quantities has been found in nearly all the streams of the southern portion of the Eastern Townships.

In the streams flowing from Stoke mountain in the townships of Stoke, Dudswell and Westbury, alluvial deposits are found in which pieces of quartz, containing gold, are met with. This is not the case with the Chaudiere alluvial deposits.

On lot 13, in the range VI of Westbury, is a large quartzous mass or quartzous conglomerate, resembling the Marston rock and streaked with quartzous threads in which gold is visible.

In the township of Ditton, alluvial deposits have been worked, which may be compared to those of the Chaudiere, and which have yielded good results to their owners, but no gold bearing quartz has been found there.

In the neighbourhood of Sherbrooke, in Ascot Township, a little work has been done on the alluvial deposits, and in the schists forming the bed-rock, small lenses of quartz containing visible gold are found. This district attracted considerable attention some forty years ago, but it was neglected until recently when the alluvial deposits have again been prospected.

Thus, as we have seen, alluvial gold has been found in many localities in the Eastern Townships, frequently in paying quantities; but so far but little gold-bearing quartz has been discovered. The region, however, is easy of access, and the indications are sufficiently promising to warrant further exploration.

DISCUSSION.

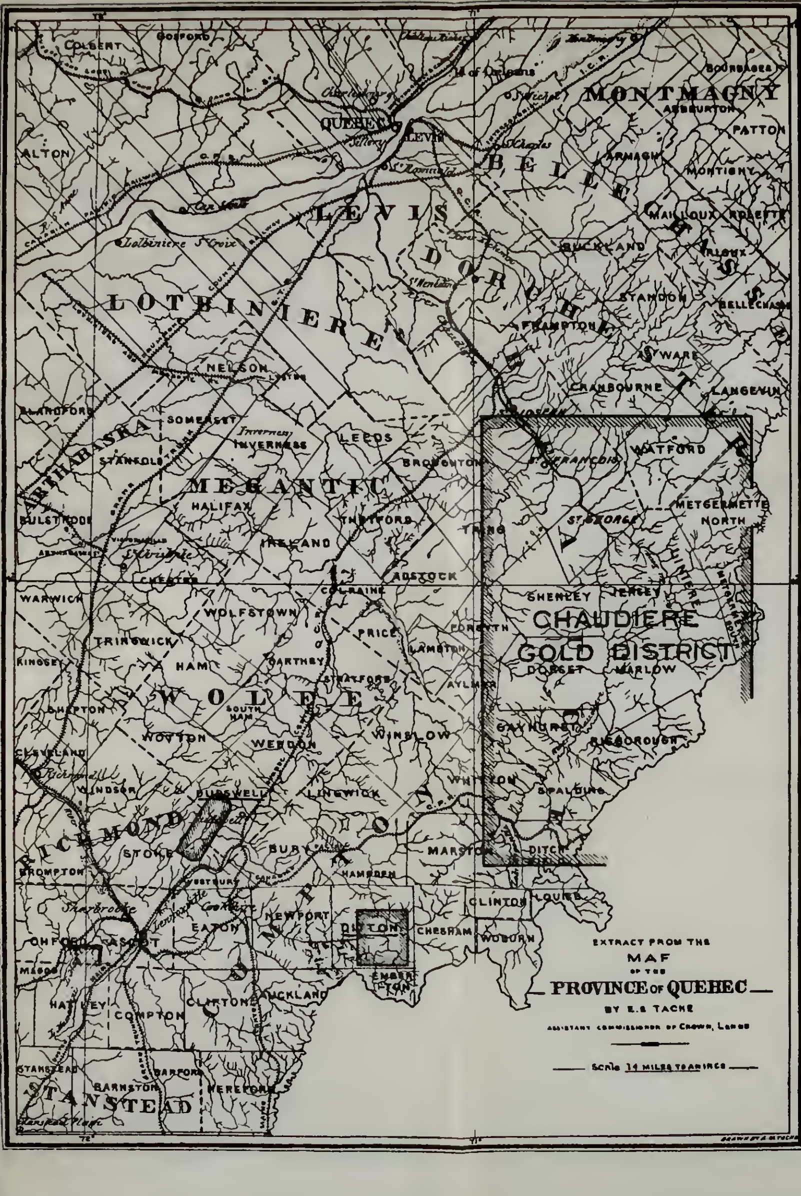
Mr. Obalski stated in reply to Mr. Fritz Cirkel that the new gold district was close to the shore of Lake Megantic.

Mr. Dresser:—Aside from any intrinsic importance which this discovery of gold at Lake Megantic may have, there are one or two points of a great deal more significance than at first appears. There is first the fact that alluvial gold in important quantities has been found along the tributaries of the Chaudiere river and its original source has never perhaps been satisfactorily determined. It is, however, known that alluvial gold in the valley of the Chaudiere has never been found at an elevation of more than 300 feet above the river. In the bed of these tributaries of the Chaudiere, the country rock is distinctly different from that which caps the hills. On the tributaries of the Chaudiere itself the greater part of the rock is volcanic, through which there are possibly some later dykes. There is, of course, the possibility that the rock carrying this gold may be the source of the alluvial gold, or it may be a rock of different formation. If it gives the source of the alluvial gold it certainly adds an important fact to our knowledge and one which would be valuable in prospecting. The character of the gold found in the Chaudiere indicates either a long continued concentration of low grade gold values or concentration for a shorter period of higher grade ore.

The other point, which is perhaps not less important, is the fact that the geological structure on the boundary line and the character of the rocks there are an exact reproduction so far as they are known of those on the Capelton Hills. The Capelton Hills on which are situated the Capelton and Eustis copper mines were first exploited for their gold and, while copper may have been found in small quantities, it was as gold mines that the property was taken up. It would therefore seem within the limits of possibility that if these are not proven to be important discoveries of gold in rock, they may lead to the opening of copper mines as was the case at Capelton. The gold values in the Capelton Hills in the first opening were considerable, but the gold decreased and the copper relatively increased, and we have these two long lived mines which have been in operation for over thirty years. It

McDonald Nugget.

Nugget found in 1866 on the Gilbert river, lot 16 of the de Lery Concession; weight, 45 ounces 12 dwts.; value, $851.26; photographed from a fac-simile in the museum of the Geological Survey, Ottawa.



QUEBEC
LEVIS
MONTMAGNY
BELLECHASSE
DORCHESTER
LOTBINIERE
ARTHABASKA
MEGANTIC
WOLFE
RICHMOND
COMPTON
STANSTEAD
BEAUCE
CHAUDIERE
GOLD DISTRICT
COLBERT
GOSFORD
ALTON
ASHBURTON
PATTON
ARMAGH
MONTIGNY
MAILLOUX
ROBERTS
BUCKLAND
STANDON
BELLECHASSE
FRAMPTON
WARE
CRANBOURNE
LANGEVIN
NELSON
BLANDFORD
SOMERSET
INVERNESS
LEEDS
BROUGHTON
STANFOLD
HALIFAX
THETFORD
TRING
BULSTRODE
IRELAND
WATFORD
ST. FRANCOIS
ST. GEORGE
METGERMETTE NORTH
CHESTER
COLERAINE
ADSTOCK
WARWICK
WOLFSTOWN
SHENLEY
JERSEY
TRINGWICK
PRICE
FORSYTH
LAMBTON
KINGSEY
HAM
GARTHBY
STRATFORD
AYLMER
DORSET
MARLOW
SHIPTON
SOUTH HAM
WOTTON
WEEDON
WINSLOW
GAYHURST
RISBOROUGH
CLEVELAND
WINDSOR
DUDSWELL
LINGWICK
WHITTON
SPALDING
STOKE
BURY
MARSTON
DITCHFIELD
BROMPTON
WESTBURY
HAMPDEN
CLINTON
NEWPORT
DITTON
CHESHAM
WOBURN
EATON
ORFORD
ASCOT
MAGOG
HATLEY
COMPTON
CLIFTON
AUCKLAND
EMBERTON
STANSTEAD
BARNSTON
BARFORD
HEREFORD
EXTRACT FROM THE
MAP
OF THE
PROVINCE OF QUEBEC
BY E.S TACHE
ASSISTANT COMMISSIONER OF CROWN LANDS
Scale 14 MILES TO AN INCH

is, therefore, possible that this gold, if not important for its intrinsic value, may be an important indicator of the existence of copper deposits at greater depth. I mention these facts to show that the discovery has quite an important bearing in view of the possibilities as well as with respect to metal values of the district.

MR. BROCK:—I would like to ask if these gravels in which the placer gold is found in the Chaudiere district are not pre-glacial gravels and, if so, has it been determined from what source they were derived if they are necessarily local?

MR. OBALSKI:—I don't suppose they are local.

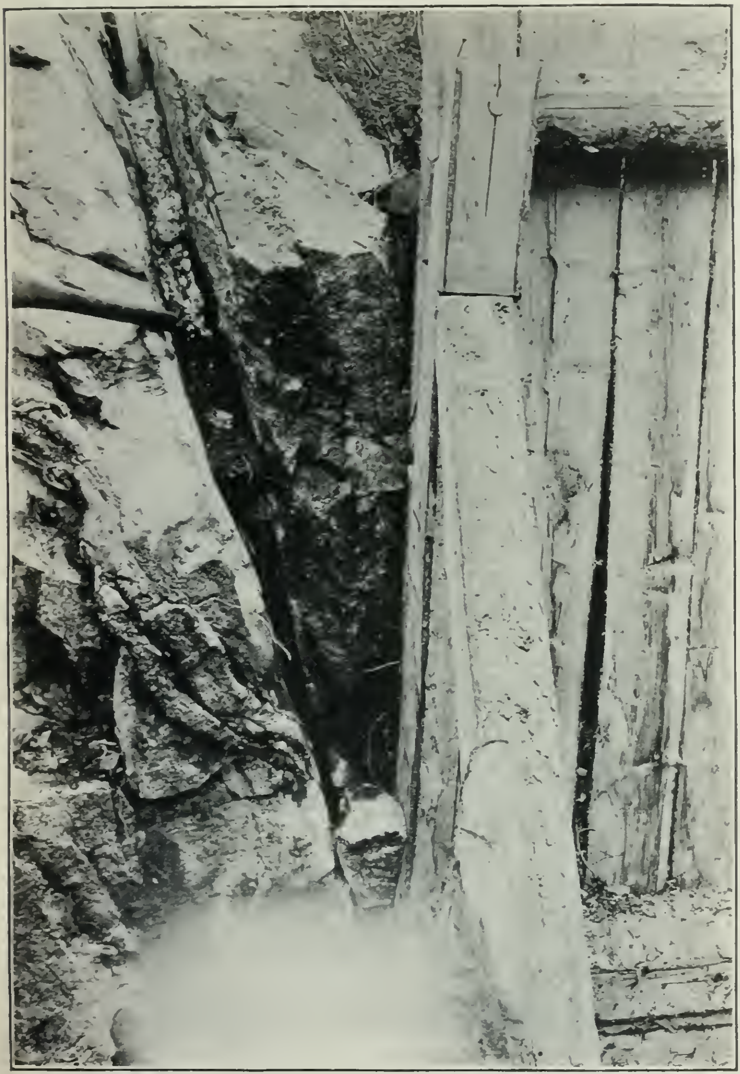
THE ORIGIN OF THE SILVER OF JAMES TOWNSHIP, MONTREAL RIVER MINING DISTRICT

By Alfred Ernest Barlow, D.Sc., Ottawa, Ont.

(Ottawa Meeting, March, 1908.)

Early in the season of 1906, all available territory (from the most optimistic of view points) within the limits of the silver-bearing area of Cobalt had been staked and recorded. Hence it became necessary for the new comers, who had been attracted to the district by stories of its unusual richness, to turn their attention either to the possible discovery of new fields or to the much wider extension of the region already delimited as economically valuable. In their proposed quest, they were encouraged to a large extent by the oft-repeated expression on the part of the government geologists that other mineral areas would likely be found lying much further to the south and west, where it was known that the geological conditions were very closely analogous, if not identical with those obtaining in the vicinity of Cobalt. This belief was further strengthened by the location in the summer of 1905 of a vein containing both cobalt and nickel and carrying very substantial values in gold and silver, on the west side of Rabbit Lake, about 35 miles south of Cobalt. This vein occupies a fissure close to the contact between a conglomerate and diabase, whose general characters and geological age were practically the same as what had already been described as constituting the silver-bearing formations of Cobalt. The find attracted a number of prospectors, who hurried to the new territory in the hope of finding other and perhaps wider and richer veins. The advent of the snow, however, and the non-success of these initial efforts dampened enthusiasm and postponed further prospecting in this direction.

In the spring of 1906, while the snow was still deep over all but the more exposed hills and precipices, reports were per-



DOWNEY VEIN
Mining Claim T.R. 189. James township.
(Specimens from this vein contained about 75 per cent. of silver.)

Outcrop of Big Vein, with native Silver, Smaltite, etc.
German Development Co. Mining Claim M.R. 202, James township.

sistent of the discovery of silver-bearing nickel-cobalt veins in the districts immediately surrounding Annima-nipissing and Bay lakes and Portage Bay. It was even confidently stated that when the veins were properly stripped and developed they would be shown to rival the best of those met with in the more immediate vicinity of Cobalt. Fired by these statements, many enthusiastic prospectors made a rush up the Montreal river, before even the ice had moved, eager to be among the first arrivals on the ground. All exposed rock surfaces for many miles above Latchford were subjected to eager and as critical examination as the unfavourable circumstances would permit, in the hope of discovering the much coveted silver. The arrival of "fly time," however, and the lack of any very pronounced success, again drove many of the prospectors out of the woods, and decided them to wait for a more auspicious time and more favourable tidings before continuing their exploration.

During at least the early part of the summer, the attention of many of the prospectors was largely directed to the region adjoining Annima-nipissing and Bay lakes, although parties were distributed on either side of the Montreal river as far as the "Big Bend." Much of the diabase which overlies the Lower Huronian conglomerates and slates in the western part of the township of Coleman, in the area surrounding Portage Bay, was shown to be considerably shattered, the resultant fissures being occupied by veins containing certain of the cobalt minerals, accompanied in some cases by a considerable proportion of niccolite. The mining development work subsequently undertaken on these veins was somewhat disappointing, as in most cases little or no silver was encountered, and as many of them were small they were not considered of very great economic importance. None of the shafts were driven through the diabase into the Lower Huronian conglomerate, which, there is every reason to believe, underlies the diabase at no very great depth. A combination of the interests affected in this particular district might reasonably be urged to undertake to sink a shaft of sufficient depth or to conduct such diamond drill operations as would demonstrate fully not only the continuity or otherwise of these veins, but also the precise nature of their mineral contents. Until some such action is taken there will always be found earnest advocates for, and also against, the view that the veins will be continuous and will very materially increase in richness when the underlying formations are encountered. The frequent expression and emphasis, however, of such divergent opinions will not advance the knowledge in this regard beyond what we now possess.

The same disappointment was apparently the result of the development work on the veins occurring in the area to the east of Trout lake, which lies a short distance to the southwest of the head of Bay lake. At a few places near Annima-nipissing lake silver has been found in notable quantities, but no great success has yet attended the efforts to trace the veins or fissures from which nuggets have been obtained, either in their vertical or horizontal position.

In August of the same year (1906), reports were prevalent that cobalt, nickel and silver had been found, associated together in the same veins cutting the diabase in the neighbourhood of Maple Mountain, to the west of Lady Evelyn lake. These were known as the "Darby" and "White" discoveries respectively. Still later in the same year came the news that silver had been found in the district surrounding and covered by James township. The information was also added that not only were the geological conditions practically identical with those of Cobalt, but that the silver-bearing area covered a much wider stretch of territory. It was not, however, until the advent of winter that the real rush began to the new territory. Prospectors crowded up the river using every means of conveyance to bring in their supplies and outfit, so that before the snow left the ground in the spring of 1907, all the promising and most of the unpromising territory in and for miles around James township was staked and recorded.

A discovery of valuable mineral was scarcely possible over most of this country, since the ground was covered with over four feet of snow, but this did not deter the hardy, and in many cases, unscrupulous prospector from making the affidavit necessary ere he could record his claim. Most of the claims were thus recorded without discovery and in direct violation of the Mines Act.

Over 90 per cent. of these locations were afterwards thrown open by the Government inspectors; but only to be re-staked and recorded again and again, either by members of the same prospecting party or, when finally abandoned, by the later arrivals in the district. It is estimated that at the beginning of June, 1907, there were over 2,000 prospectors working in the country drained by the Montreal river and its tributaries, and this number was considerably augmented later in the season. Many of these men were thoroughly experienced and resourceful, so that a large part of the region was subjected to very intelligent and critical examination.

The mineral occurrences in the Montreal river district above Bay Lake may be considered as belonging to three distinct areas:

1. Maple Mountain area.
2. James Township area.
3. Bloom Lake area.

The Maple Mountain area consists of a comparatively narrow and irregular intrusion of diabase, occurring to the northwest of Lady Evelyn lake.

This mass of diabase extends, with almost unbroken continuity, from the vicinity of Anvil lake on the boundary between the unsubdivided townships of Whitson and Van Nostrand, northward for nearly nine miles to a point a little east of Boucher lake, near the dividing line between Banks and Speight townships. The outcrops of this diabase cover a strip of country varying in width from about a quarter to half-a-mile, flanked on either side by an arkose or coarse grained quartzite through which it is intruded.

The James township mineral area is very much more extensive, including parts of the townships of James, Smyth, Tudhope, Mickle, Farr and Willet, and embracing what are generally known as the Silver lake and Hubert lake districts. The total area in these townships underlaid by diabase (silver-bearing formation) is very nearly 40 square miles.

The Bloom lake mineral area is confined to a mass of diabase outcropping in the region to the west of a chain of lakes of which Bloom lake is the largest and most important, but including also Wigwam, Lost and Calcite lakes. These sheets of water occupy a valley, running nearly north and south a little over 12 miles to the west of the west town line of James, and within a short distance of the East Branch of the Montreal river. They empty into the Montreal river, through what is known as Stoney or Sydney Creek, nearly five miles above Indian Chute. The Bloom lake diabase is a mass of irregular outline, with a length of about 10 miles and a width varying from half a mile to nearly two miles. Most of the claims so far staked are on the west side of Bloom lake, but a considerable number have been located west of Lost lake.

The region in the vicinity of James township is much the most important of these mineral areas, for it not only far exceeds the others in extent, but also in the comparative richness of the deposits. At present there are two methods of ingress to this district. The land or winter route commences at Earlton on the Temiscaming and Northern Ontario Railway (26 miles north of Cobalt) and crossing the northern parts of the townships of Armstrong, Beauchamp, Bryce, and Tudhope, reaches Elk lake (Elk City) opposite the mouth of Bear River in the fifth concession of James township. This road is about 30 miles in length, 7 miles of which has been already constructed as a waggon road. The Ontario Railway Commission has likewise under consideration an extension of the Charlton branch of the Temiscaming and Northern Ontario Railway, but this will not be made until such time as the district gives undoubted proofs of the importance and permanence of its mineral deposits.

By far the easier and more popular route, however, is up the Montreal river from Latchford, a small town situated at its crossing with the T. & N. O. Ry. Two lines of steamers plied on the route all last summer, but were quite inadequate for the service required of them, so that break downs and delays were frequent and unavoidable. The most pretentious service was carried on by small boats propelled by steam, and owned by the Upper Ontario Steamboat Company, while the opposition known as the Joy Line (so called after the name of the owner and manager) operated with smaller gasoline launches Starting from Latchford at from 7 to 9 o'clock in the morning, it was generally late in the evening and sometimes even midnight before the end of the journey was reached. The distance by this route is a little over 50 miles, but navigation is interrupted by three rapids known in ascending order as Pork, Flat and Mountain rapids. The following are the approximate distances intervening between these obstructions:—Latchford to Pork rapids, 9 miles; Pork to Flat rapids, 27 miles; Flat rapids to Mountain chute, 3 miles; Mountain chute to mouth of Bear river 11 miles.

Two rival towns, situated on either side of Elk lake (an expansion of the Montreal river), have already sprung into existence, the tents which formed the first residences having now given place to more substantial log structures. "Elk City," as the townsite on the northeast bank of the river has been called, already contains a comfortable hotel and several stores. On the opposite side of the stream, at the mouth of Bear river the Ontario Government have surveyed a town plot which they have named "Smyth." Last autumn the Hudson's Bay Company moved their store form Elk City into more commodious quarters alongside the post office at Smyth. It is stated to be the intention of the Government to move the Recorder's office, belonging to the Montreal River Mining Division, from Latchford to Smyth, thus avoiding the many inconveniences and delays necessitated by the long and tedious river journey.

The Maple mountain mining area is readily accessible by canoe in the summer months, disembarking from the Montreal river steamers at the Mattawapika (the outlet of Lady Evelyn lake), a short distance below "Mowats." Thence the route is to the south and west through Mattawapika and Lady Evelyn lakes, into the large bay on the west side of the latter lake. A portage about three quarters of a mile long, leaves the west side of this bay a short distance north of Willow Island falls; coming out near the south end of Emily lake, the largest of a chain of four small lakes before Anvil lake is reached. Thence the route follows northward through Hammer and Bergeron lake into Niccolite and Greenwater lakes. It is in this region, between Anvil and Greenwater lakes, that many of the most promising mining locations are situated. Another means of access is by way of Spring Creek, which flows into the Montreal river near the northeast corner of the township of Speight, but the portages are much longer and the route therefore more difficult and less frequented.

The Bloom lake area is likewise usually reached by canoe in the summer, the customary route leaving the Montreal river at a sharp bend in this stream about 2 miles below Indian chute (or

12 miles above Elk City). A portage starting from this point runs a little north of west for nearly two miles, reaching Stoney or Sydney Creek at an elbow, where this stream suddenly bends to the northward before emptying into the Montreal river several miles beyond. The route then continues in a direction a little south of west along this upper part of Stoney Creek, passing through a series of small lake-like expansions united by comparatively short though rapid discharging channels, thus necessitating frequent portaging. About 8 miles above the "Long Portage," at the northern end of Portage lake and within about three quarters of a mile of the East Branch of the Montreal river, the upward course of the stream again changes abruptly to a general direction a little east of south. This general course is followed through Portage, Birch and Pike lakes, for about three and a half miles until the outlet of Bloom lake is reached. Following this creek westward for about three quarters of a mile, in which two small portages have to be made, Bloom lake is reached about half a mile from the upper or northern end.

Bloom lake is the lowest of a chain of lakes of which Wigwam, Lost and Calcite lakes in ascending order form a part. The first mentioned is the largest, measuring about 3½ miles long with an average width of a little over a quarter of a mile, while the others vary from one to nearly two miles in length with an average width of less than a quarter of a mile. They all occupy a valley which has a direction very nearly north and south. The winter route to Bloom lake used during the past season, begins at the portage from the Montreal river into Hubert lake about 7 miles above Elk City. Thence in a prevailing direction a little south of west it crosses the southern part of the township of Farr through Hubert, Green, Grassy and High Bluff lakes reaching Pike lake a little south of the outlet from Bloom lake. The whole distance from the beginning of the portage to Bloom lake is about 15 miles. The whole of the territory included within the boundaries of these several mining areas, although undoubtedly picturesque, becomes somewhat monotonous. not only on account of the sameness, but also because of the want of any great accentuation of its hill features. The surface may be described for the most part as exceedingly rocky and uneven, although there are no very prominent mountains, and elevations of more than 300 feet are rather unusual. The only pronounced exception to this general statement is furnished by the Maple Mountain mining area, where the highest point of a ridge of quartzite, and one from which the district derives its name, rises to a height of about 1,100 feet above Lady Evelyn lake (2,033 feet above the sea). The valleys intervening between these rocky hills are occupied for the most part by swamps and lakes, and the size, number and disposition of these latter make travelling by means of canoe through much of this region comparatively easy and rapid. Much of the higher ground shows frequent and abundant outcrops of the underlying rock, but a very considerable proportion of the area, especially in the vicinity of the Montreal river, is drift covered, rendering prospecting difficult and expensive. Large areas in the valley of the Montreal river are quite flat and heavily drift covered, and could no doubt with advantage be cleared for farming purposes, especially if this region develops into a great mining area according to its present promise.

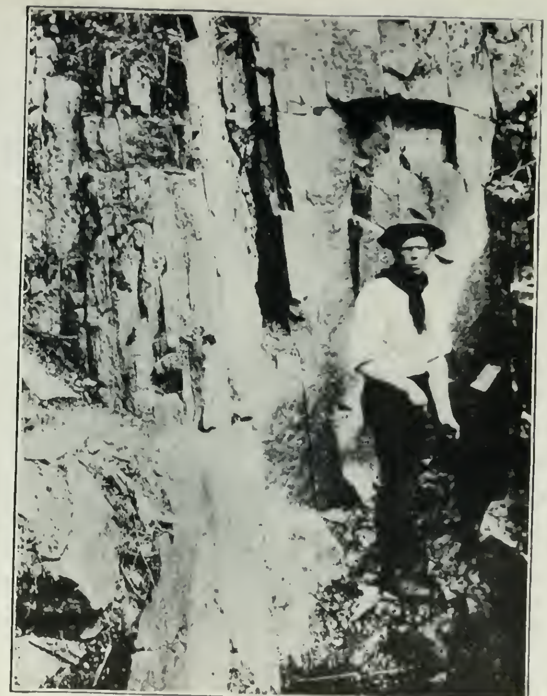
All of the ore bodies in the several mining areas mentioned occur in the form of veins cutting a quartz-diabase or gabbro. Most of the veins in James and surrounding townships occupy two sets of fissures, running approximately north and south and east and west respectively, and therefore nearly at right angles to one another. These fissures are regarded as contraction cracks formed by the cooling laccolith, which have been filled by later and more acid secretions of the same magma from which the accompanying diabase has solidified. The vein-filling must therefore be regarded as of pegmatitic origin, having the same genetic relationship to diabase that ordinary pegmatite does to granite. For purposes of discussion and correlation, it may therefore be referred to as diabase-pegmatite in preference to the term "aplite," by which the material in these veins or dykes is now known to the prospectors of the Montreal river district, for the latter would imply the formation of this material as a differentiation product of granite. As a rule these veins are more or less irregular, often curving, sometimes faulted, but surprisingly persistent over long distances. The fissures which they occupy vary from a fraction of an inch, or a mere crack, to two feet or even more in width. Very frequently, too, the same vein may show an equal variation in width both in its horizontal and vertical extension. The narrow veins, especially those from 4 to 8 inches in width, are more commonly met with and are as a rule more richly charged with the desirable metallic minerals. The wider veins usually contain these metallic minerals either in fairly uniform and continuous, though in comparatively narrow streaks or in wider and larger though more or less isolated patches. Many of these veins possess quite sharp and distinct boundaries, the gangue material showing very little if any connection with or transition into the wall rock. In some instances also the vein along either or both boundaries breaks easily and freely from the accompanying country rock, the ore body in such cases showing quite sharp and regular hanging and foot walls.

In other and quite frequent cases precisely similar veins show a distinct and, at times, perfect gradation or passage into the surrounding diabase, such a transition being characteristic of either or both walls. Examples are not lacking, especially in the wider occurrences, where there is a pronounced commingling of the material of the vein and the parent plutonic rock. In such cases the vein may contain certain vague greenish spots or masses, which have undoubtedly been derived from the diabase and are now in a more or less altered and disintegrated condition, while the diabase in the more immediate vicinity of the vein is relatively more acid in composition, with abundant quartz and patches and crystals of the same acid plagioclases characteristic of the vein. Moreover, the minerals, which together make up the diabase, show rather pronounced decomposition due to the same eruptive after actions as a result of which the accompanying veins have been formed. The plagioclase (labradorite) has been largely converted to a pale yellowish green saussurite, while the original pyroxene has been replaced by an aggregate or chlorite, epidote and calcite.

The gange of these veins, in the simplest form of their development, shows a fine to moderately coarse grained feldspathic material, varying in colour from a pale pink to deep flesh red. At first sight most of these veins are remarkable chiefly for the prevailing absence or scarcity of quartz, although examples are not lacking of veins, evidently very closely related, which contain this mineral as an abundant and occasionally predominant constituent. Dr. G. A. Young, of the Geological Survey, at the writer's suggestion, very kindly undertook to make a microscopical examination of this

German Development Co. Claim M.R. 202. 18 inch Vein; Native Silver, Smaltite, etc.

Northeast Corner post on a much disputed claim in James township.



" Big Bluff Vein "
Haibeck Claim, Tudhope township.

feldspathic material. In the thin sections examined by him, representing several of these veins from the western part of Tudhope and the central part of James township, by far the largest proportion at least was plagioclase varying in composition from albite through oligoclase to andesine. This diagnosis was corroborated in part by a separation of the mineral constituents by means of a heavy solution. The plagioclase thus separated varied in specific gravity from 2.609 to 2.635. Some of this plagioclase (albite) had distinct rectangular or lath-like outlines, showing twinning according to both the albite and pericline laws, which in certain cases produced a fine "cross-hatched" structure, usually considered characteristic of the appearance of microcline between crossed nicols. Most of these grains are quite turbid. Another species of plagioclase (oligoclase) occurs in irregular, untwinned and clear grains, thus resembling quartz; but unlike quartz this mineral is readily fusible. Some of these veins contain a considerable admixture of quartz, this mineral often forming graphic intergrowths with the feldspars. In certain of these cases, the feldspar has acted as the host, but in others, large grains of quartz were noticed containing only a few shred-like individuals of the plagioclase. Calcite is usually present and sometimes very abundant. This mineral frequently occurs in fairly large grains, or in granular aggregates made up of several individuals, disseminated through the more abundant feldspathic material. It also occurs in more or less continuous vein-like areas or masses, anastomosing between, and sometimes penetrating through, both simple and composite individuals of feldspar. Portions of the vein, where exposed to the action of the weather or percolating waters, frequently present a finely cavernous or sponge-like appearance, due to the etching and removal of the calcite, thereby leaving small and irregular shaped miarolitic cavities lined with minute tabular crystals of feldspar. Oxidation of the iron sulphides usually present, gives a prevailing pale brownish to an almost black colour to these portions of the vein. Not infrequently barite, usually pale pink in colour, and occasionally celestite occur with or replace altogether the calcite and feldspar. Some of these veins are, therefore, made up almost wholly of red feldspar, almost always a plagioclase near the acid end of the series, together with a very subordinate amount of calcite and a still smaller quantity of quartz. Other veins again are made up of an almost equal proportion of plagioclase and calcite and sometimes quartz, while still other veins present a finer grained feldspathic portion in the vicinity of the walls, with the whole mass of the interior made up of comparatively coarse grained calcite, with sometimes a small proportion of quartz. The stages represented completely by the vein occurrences in these districts show a perfect and practically uninterrupted continuity during their consolidation from an original condition of hydro-igneous fusion, characteristic of the magma from which the comparatively fine and even grained feldspathic material is believed to have resulted, to conditions of igneo-aqueous solution which must have obtained in the viscous mass from which the latest calcite or quartzose segregations had solidified.

Chalcopyrite is the most abundant and common of the metallic constituents, but bornite is also very frequently encountered; both of these sulphides often occurring side by side in the same vein. Covellite also occurs but much less frequently. Galena is also very common and usually carries silver in variable quantity. Many of the veins contain micaceous or specular iron ore (hematite) and some of them are entirely made up of this material, at least near the surface. Several veins were noticed made up of alternations of chalcopyrite and specular iron ore, while very frequently a vein containing specular iron ore is replaced at a depth sometimes of only a few feet by chalcopyrite, smaltite and native silver. In the Hubert lake area veins of magnetite have been found, similar to those of hematite in the township of James. Malachite and azurite are both common. The cobalt minerals, either smaltite or cobaltite are very prevalent, usually in association with more or less nicollite. Erythrite (cobalt bloom) and Annabergite (nickel bloom) are also frequently present as surface decomposition products. The smaltite-nicollite veins often contain the white bloom near the surface, which is formed by the reaction of these minerals upon one another when subject to weathering porcesses. Most of these veins will give assay values in silver varying from a fraction of an ounce to thirty ounces or even more per ton, although the material on which the trials were conducted showed no signs of the native metal. Silver is also of common occurrence in these veins, both in the native state and as argentite (sulphide of silver). As native silver it occurs in nuggets of various shapes and sizes as well as in fine flakes and scales disseminated through any of the various gangue minerals, feldspar, calcite, barite, or quartz. Beautiful fern-like skeleton crystals of native silver are frequently found in certain cavities in these veins from which the enclosing calcite has been removed as a result of weathering.

It would be unwise in this connection to give any detailed list of the many mining locations on which native silver has been discovered or to mention what are at present regarded as the more promising individual discoveries. It may be sufficient to say that several veins have been uncovered, varying in width from 4 to 8 inches, much of the material from which would average from 25 to 75 per cent. of native silver, while a large number of other veins have been proved to contain silver in such quantities as to merit further and quite extensive mining development work. The mode of occurrence and association of this silver in some of these veins bears a striking resemblance to that obtaining in the veins cutting the diabase in the vicinity of Kerr Lake near Cobalt. It seems, therefore, very reasonable to assume that many and possibly wider and richer veins will be revealed as a result of this season's mining operations, when conditions should be much more favourable for prospecting and development work.

The statement sometimes made that a greater or even a second Cobalt has been here discovered, is not warranted in the present state of our knowledge; but it may be well to mention, and even to emphasize, some of the points which should strengthen the opinion that the James township mineral area will become in the near future a permanent mining camp:

1. The wide extent of country over which these mineral veins have already been found.

2. The large number, width, continuity and well mineralized character of many of the veins so far located.

3. The very general presence of native silver in these veins.

4. The great richness of some of the ore already secured, some of which compares favourably with the best found in the veins of Cobalt. The region is certainly one of great promise and worthy of the most earnest and intelligent attention.

All of these veins occur in diabase or gabbro, a rock which represents the consolidation of a lava of basic composition, which has been intruded in the form of sills or laccoliths and dykes through rocks of Huronian, Keewatin, and Laurentian ages. The rocks representative of the Huronian are conglomerates, slates and arkoses or quartzites, very similar in structure and mineralogical composition, to rocks of the same geological age found in the neighbourhood of Cobalt. No rocks of Keewatin age have been found in James township, but extensive outcrops occur in the central and eastern portions of Tudhope township. The Keewatin is intruded by certain granites and gneisses which are usually referred to as Laurentian. These two rocks form an igneous complex lying unconformably beneath and furnishing pebbles and other debrital material of which the basal conglomerates of the Lower Huronian are composed. These gneisses and granites cover large areas in the central and northern portions of the township of Tudhope, almost the whole of the township of Smyth, and the northwest corner of James and thence west and northwest to Hubert Lake and beyond. Smaller patches of granite are also exposed as a result of denudation in the southern part of James township.

The diabase or silver bearing formation is the newest rock in the district as it is intruded through all the other series, cutting even the arkoses and quartzites which are at the summit of the sedimentaries. The distribution of these several formations is well shown on the map of the Montreal river and Temagami Forest Reserve, lately issued by the Bureau of Mines of Ontario, the necessary geological surveys having been made by Mr. Cyril W. Knight and his assistants during the past summer.

All of the veins of economic importance, so far discovered, appear to be confined to this diabase, which is essentially similar in mineralogical composition and geological age to that in which occur some of the most productive silver veins of the Cobalt district. Occasional fissures, some of them rather wide and continuous, were noticed in the conglomerate, filled with calcite, quartz and barite, and carrying galena, but the assay values of such material were disappointing. It is, however, reasonable to suppose that productive veins will yet be found in the conglomerate, although extensive outcrops of this rock usually show very little fissuring. Most of the hand specimens of the diabase, given to Dr. Young for microscopical examination, were collected in the vicinity of one or other of the mineral bearing veins and, therefore, doubtless show more advanced decomposition than would be the case had the material been secured from exposures farther removed from the influence of such eruptive after action.

The hand specimens usually show a dark green, more rarely greyish, medium to coarse grained rock, made up of irregular prisms or grains of a very dark green mineral and a dull, light greenish feldspar, showing only an occasional cleavage face. One of the least altered of these specimens was obtained from the Miller location in the western part of Tudhope. Under the microscope the rock proved to be a rather coarse diabase considerably altered, but with its typical mineralogical composition and structure still very distinct. Originally it appears to have been composed of nearly colourless pyroxene, occurring in large and small often twinned, but shapeless plates penetrated by laths of plagioclase. These individuals of feldspar are twinned according to the albite law, unaccompanied by carlsbad twining or zonal structures. They vary greatly in size, the interspaces being filled with irregular grains of quartz, which mineral forms no small proportion of the rock, a few flakes of deep brown, highly pleochroic biotite are also present. Much of the feldspar, often in the central part of the individuals is completely altered, apparently to epidote, while the pyroxene is associated with secondary minerals including a pale green somewhat fibrous hornblende. The rock shows no abnormal characters and may be described as a somewhat decomposed quartz diabase. Another specimen from a claim in the northwest corner of Tudhope appeared to represent a diabase, although the original pyroxene has been completely removed. The part of the rock represented by the slide is largely composed of tabular individuals of plagioclase sharply idiomorphic and with much interstitial quartz. The plagioclase shows prominent albite twinning sometimes accompanied by carlsbad twinning, and in two such cases the values of the extinction angles indicated an acid labradorite. The interstitial quartz in many instances almost seemed to be replacing the feldspar, isolated shreds of which sometimes lie in the quartz or form skeleton-like aggregates similarly orientated. Occasionally the relations are reversed, and the feldspar then includes a number of separate grains of quartz in optical continuity with one another. No evidence was afforded that the quartz was of more than one generation; and because of the general occurrence of this mineral in the unaltered diabase of the district it was concluded that the quartz was original. Besides this feldspar and quartz, calcite and chlorite compose a considerable proportion of the section. The chlorite occurs in small aggregates between, or distributed through, the feldspar. The calcite forms plates and granular aggregates. Both these minerals appear to replace the original pyroxene.

A specimen which probably represents the extreme phase of the decomposition of this diabase forms the wall rock enclosing the "Otisse vein" on the south shore of Hubert lake. The hand specimen is a medium grained very dark altered diabase, in which the small feldspar laths may be seen imbedded in a dull dark green matrix. The specimen also includes part of a vein of coarsely crystallized calcite at least half an inch wide. Occasional small scales and plates of native silver are disseminated through this diabase, the silver being more conspicuous and apparently more abundant in the wall rock than in the vein itself. The thin section shows under the microscope the typical ophitic structure consisting of numerous lath-shaped crystals of plagioclase lying in a ground-mass made up of calcite and chlorite in varying proportions, which minerals replace the original coloured constituent. The plagioclase laths are almost invariably twinned according to the albite law, and except where they interfere with one another are rather shapely idiomorphic and almost perfectly fresh, except that they often contain minute flakes of chlorite. The chlorite and calcite are about equally abundant and comprise a large part of the rock. The chlorite occurs in matted aggregates of somewhat fibrous forms. The calcite sometimes builds fairly large plate-like areas but more often is finely granular. The feldspar is as sharply idiomorphic against the calcite as against the chlorite. It seems probable that the abundant chlorite and calcite have been formed by the decomposition and thus at the expense of the original coloured constituent, Very little, if any lime, could have been furnished by the plagioclase as most of the individuals of this mineral are surprisingly fresh and unaltered.

SUMMARY OF CONCLUSIONS.

1. The diabase of the Maple Mountains, James township and Bloom lake areas is essentially and prevailingly a quartz-diabase. In many instances this quartz occurs as a granophyric or graphic intergrowth with the plagioclase, which is usually an acid labradorite. The presence and usual abundance of this original or primary quartz marks the rock as a rather exceptional type and distinct from ordinary diabase, which as a rule contains little or none of this mineral. Diabase and similar basic igneous rocks have been artifically reproduced in the laboratory from a state of simple dry fusion; but it is extremely doubtful whether any extensive intrusive process produced by natural causes is ever unaccompanied by a greater or less abundance of superheated water as an integral portion of the fused mass. This condition of dry fusion, however, is distinctly approached in a magma from which an ordinary diabase has been formed. During the intrusion and subsequent solidification of the diabase described in the present paper, however, there has been a very general superabundance of these heated waters and vapors, which not only accompanied the crystallization of the great mass of the ordinary parent plutonic, but were especially present and active in the formation of the pegmatitic mineral veins which represent the expiring efforts of this intrusion. The presence of the abundant original quartz, often in graphic intergrowth with the plagioclase and the breaking down and replacement of the original pyroxene by chlorite and calcite, is distinct evidence of the presence of superheated waters and steam present in and traversing the ordinary or finer grained phases of the diabase. The rock is, therefore, more highly quartzose than usual, which fact accounts in the main for the presence of the associated mineral-bearing veins.

2. The presence of these veins in the several mining districts mentioned is due primarily to a profound fissuring of the diabase itself, formed probably as a result of the contraction of the rock in cooling, the resultant cracks and cavities being occupied in many cases as fast as they were formed by the later, more acid and hydrated segregations from the same diabase magma.

3. The veins in their simplest forms of development are, therefore, essentially of pegmatitic type although some of the more complex types and those at the other extreme made up almost wholly of calcite or quartz show little or no evidence of such an origin.

4. The various stages in the formation of these veins are very completely represented in these several mining areas, showing a perfect and practically uninterrupted continuity during their formation from an original condition of hydro-igneous fusion characteristic of the magma from which the comparatively fine and even grained feldspathic material is believed to have resulted to conditions of ignes-aqueous solution which must have obtained in the viscous mass from which latest calcite and quartzose segregations have solidified.

5. The feldspar in this diabase-pegmatite is essentially a plagioclase near the acid end of the series, chiefly albite and oligoclase but sometimes andesine, in contradistinction to ordinary or granite-pegmatite which contains orthoclase, microcline and microperthite as the predominent and characteristic feldspar. Quartz is not essential and some of the more representative types of this diabase-pegmatite in these veins contain less than 5 per cent. of this mineral. Calcite is almost invariably present, and in extreme phases or those which have been formed as a result of very pronounced secondary action completely replaces the feldspar.

6. The age relations of the mineral constituents of the gangue is fairly simple, although the several minerals constantly overlap in their periods of generation. Plagioclase in the main, the oldest or first mineral to form, is succeeded by calcite and this in turn by quartz, although much of the calcite and even the quartz were formed simultaneously with or even before some of the plagioclase.

7. All of the gangue minerals, plagioclase, calcite, quartz, and even barite and celestite as well as the various metallic minerals, appear to have been derived from the surrounding diabase. The calcite has probably been derived from the decomposition of the original pyroxenic constituent as much of the plagioclase shows little or no signs of alteration. The native silver is not only present in association with all of the gangue minerals already mentioned, but is very commonly noticed and sometimes abundant in the diabase forming the wall rock.

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The Silver Lake Trail.
(Brulé country).

Photo A.M.C.

TOWN OF SMYTH.—(West side Elk lake, Montreal River).
July, 1907, showing Post Office in course of erection.

Photo A.M.C. Grand View Hotel, Elk City. (August, 1907).

Pioneer Store.

Photo A.M.C. H. B. Co., Elk City, August, 1907.

DISCUSSION.

Mr. Tyrrell:—Do you consider the diabase deposit in James Township the same as at Cobalt?

Dr. Barlow:—Yes. It is not a deposit, but a batholitic mass.

Dr. Miller:—I think the material in these dykes represents the end product of the diabase eruption. The cracks now occupied by pegmatites were evidently formed soon after the diabase had begun to cool, and the material now in them was below some place and came up. It contains the feldspar, silver and other materials which belonged, I think, to the same magma as the diabase.

As to the inspectors, to whom Dr. Barlow has referred, I had trouble last spring getting a corps of inspectors for that area. We had to get eight inspectors, who had to be technical graduates, men of experience and sense, and it took me a considerable time to get them together. If I had not gone to that trouble Dr. Barlow would not have his claims there now, as the whole country was blanketted in the winter. You must remember that the townships are six miles square and the mining location forty acres, or about five hundred to the township. The prospectors covered two or three townships on snowshoes and often ran three lines parallel, three men going abreast, cutting out lines, sometimes tieing their posts to trees where they were afraid to merely stick them up in the snow. That was the problem which faced us in the spring, if we did not intend to allow blanketting on a large scale. The inspectors tried to insist upon discovery, and Dr. Barlow, being a late comer, reaped the benefit of their work, as they threw open many blanketted claims.

ORIGIN OF COBALT-SILVER ORES OF NORTHERN ONTARIO.

By R. E. Hore,

University of Michigan, Ann Arbor, Mich.

The rapidly increasing proved area of silver and cobalt bearing rocks has disclosed new types of deposits, and has afforded additional information regarding the origin of the deposits and of the rocks containing them. It is the purpose of this paper to present some results of study in field and laboratory.

In Coleman Township.

The majority of shipping mines are located in the eastern half of this township, and are, therefore, within a few miles of the town of Cobalt. The producing veins occur in graywacké and feldspathic quartzites and conglomerates of Lower Huronian age, in metamorphosed fine grained green igneous rocks of Keewatin age, and in gray diabase-gabbro sills of Post Middle Huronian. In the Huronian sediments and in the diabase, the veins are nearly vertical, while in the Keewatin greenstones the inclination is irregular and the veins less well defined.

In his report* on the camp, Dr. W. G. Miller suggested that the fissures now occupied by the cobalt-silver ores in the Lower Huronian were probably formed by the disturbance which accompanied the eruption of the diabase and gabbro, and that the ores may have been deposited from highly heated mineral laden waters associated with the eruption. In a second edition of this report he has suggested that the ores were possibly leached from the Keewatin greenstones, or from the Laurentian granites.

Dr. Van Hise† also concludes that the diabase is the source of the ore, and believes that the Keewatin and the conglomerates

*W. G. Miller, Ann. Report Bureau of Mines, Ontario. Vol. V, 1905.
†C. R. Van Hise, Jour. of Canadian Mining Inst. Vol. X, 1907.

are the main source of the calcite of the gangue minerals. He suggests that the solutions bearing calcium carbonate were a factor in the precipitation of the metalliferous minerals.

A consideration of later discoveries seems to confirm the truth of these ideas in the main.

RECENT DISCOVERIES.

Cobalt is now known to occur in several areas including the following, which are classed according to the country rock:—

In Lower Huronian graywacke—

In Casey township, 15 miles north of Cobalt.

In diabase-gabbro—

In Pense and Ingram townships, 30 miles north of Cobalt.
In Whitson and adjoining townships, 25 miles west of Cobalt.
In James and adjoining townships, 15 miles north of Whitson.
In the vicinities of Portage Bay, of Trout Lake, and west of Anima Nipissing Lake.

In Keewatin—

South of Lorrain township, 16 miles south-east of Cobalt.

Of these localities, Casey tp., Whitson tp., James tp., and the area south of Lorrain show native silver in addition to cobalt minerals.

The following description applies to the rocks found over the large area including these deposits.

DIABASE-GABBRO.

The intimate connection of this rock with the ore deposits has been recognized by the prospectors for some time, and it is becoming more apparent as exploration advances.

It occurs in most cases in the form of large sills, a few hundred feet in thickness, lying nearly horizontal and parallel to the bedding of the Huronian sediments. The greater part of the sills is dark gray in colour and holocrystalline. The chief minerals are augite and plagioclase (labradorite to bytownite), while ilmenite is generally present and quartz is common. At the edge of the sheets the rock is very fine grained, and, though markedly ophitic in texture, is not readily distinguished from intruded slates. A few feet from the edge the grain becomes quite noticeable, and at some distance very coarse textures were often found. These coarser portions, often pink in colour, show a considerable percentage of quartz and pink feldspars, often in micrographic intergrowth. Barlow's description* of numerous occurrences of this rock in the area covered by the Nipissing and Temiscaming map sheets, indicates that they are all derivations of the same magma.

In petrographical character and in their relations to the Huronian sediments they are remarkably similar to diabase sills of the Lake Superior district, which are regarded as of Keweenawan† (being the plutonic equivalent of the surface flows of the copper district) or of Post-Keweenawan‡ age.

VEINS IN DIABASE-GABBRO.

Veins are not common in the diabase, and of these calcite are less numerous than quartz. Although quartz veins carrying cobalt ores are known, the silver is confined to veins having calcite gangue. In the rich deposits in Coleman tp., there is little gangue, the veins being seldom more than a few inches in width and often composed entirely of ore. In some cases native silver is the most abundant filling, forming thin films along the joint planes.

The quartz veins frequently carry small amounts of pyrite and chalcopyrite. West of Wakemika Lake there are several quartz veins, one to two feet in width, which carry argentiferous galena along with pyrite, chalcopyrite, and a later filling of pale pink calcite.

Some barite veins in James tp. are said to be argentiferous.

*A. E. Barlow, Geol. Sur. Canada. Ann. Rep. Vol. V., Part L, 1897.
†A. C. Lane, Geol. Sur. Michigan, Vol. VI, Part I, pp. 219, etc., 1898.
‡A. C. Lawson, Geol. Sur. Minnesota, Bull. No. 8, pp. 47, 1893.

Intrusives in Diabase-Gabbro.

There occur in the large sills small intrusions, some more, others less silicious than the main mass.

In Coleman tp. there are fine grained dark colored dikes of olivine diabase, while near Temagami there are small dikes of diabase porphyry.

More common and more interesting from an economic standpoint are the light coloured aplite veins. The width of most of these is to be measured in inches, and they are generally but a few hundred feet in length. They are fine grained and usually of a pink colour, being composed largely of quartz and feldspars. The proportions of quartz and feldspars vary considerably in the same vein. There is considerable chlorite in darker coloured portions, and calcite fills in the interstices. Small crystals of apatite and titanite are inconspicuous but characteristic constituents.

Most of these aplite veins carry some pyrite, chalcopyrite, or galena, and some carry cobalt and silver ores. It was noted in some cases in James tp. that the sulphides occur along fractures in the narrow veins and from this it is inferred that the metalliferous solutions followed the deposition of the aplite. It is also noted that the feldspars remain rather fresh, and that they were therefore inactive in precipitating the ore. The dark coloured silicate present, however, is chlorite, and is probably the result of the action of these solutions on pyroxene or amphibole, yielding at the same time lime for the formation of calcite when carbon dioxide was available.

Disseminated Ore in Diabase-Gabbro.

In the diabase which extends westwards from Anima-Nipissing Lake to Lady Evelyn Lake, there are several showings of cobalt minerals, both in calcite veins and as disseminated crystals in the diabase. There is generally little or no surface indication of the latter; but on breaking the rock traces of cobalt bloom are found.

One such deposit, west of Diabase Lake, is associated with an aplite vein. This vein is about one foot in width and is exposed for about 150 feet; it carries some pyrite and chalcopyrite, but little cobalt. Parallel to the vein and for a few feet from its walls, the diabase contains disseminated crystals of smaltite which are more abundant along the joint planes. The chief unaltered constituent of the ore-bearing rock is feldspar. The crystals of smaltite, accompanied by some small titanite crystals, are embedded in calcite and chlorite, and more rarely in the feldspars. In the latter case it is to be noted that there are many cracks, partly filled with calcite, which have evidently served as channels for the introduction of the smaltite.

Another cobaltiferous specimen, also chloritic, from the same region, shows some kernels of augite still undecomposed, and a high percentage of ilmenite.

ORIGIN OF DISSEMINATED ORE.

The detection by the naked eye of scattered smaltite crystals in the diabase, suggests the possibility of its being an original constituent in the rock. On the other hand, the association with aplite suggests that the ore had its origin in the solutions that accompanied these intrusions.

The microscopic examination outlined above shows that the smaltite is of secondary origin. It was at first thought that possibly the augite was cobaltiferous; but, on examination, a specimen of the rock containing kernels of this mineral was found to contain no trace of cobalt.

Accordingly the following conclusion may be drawn: (1) that the smaltite was introduced by solutions associated with the aplite intrusion; (2) that such solutions came after the crystallization of the aplite; (3) that the intrusion disturbed the diabase to such an extent that a zone was formed in the latter which was more permeable to the solutions than was the aplite itself; (4) that these solutions had little action on the feldspars, but found other silicates quite active chemically. Further conclusions may be deduced from a consideration of the origin of the aplite.

ORIGIN OF THE APLITE.

The most apparent difference between the aplite and the diabase is the colour. This is due to a higher percentage of quartz and pink feldspars, and a corresponding lower percentage of dark coloured silicates, so that the aplite is generally light pink in colour while the diabase is dark gray.

It has already been mentioned that portions of the diabase still at some distance from their edge are coarse in texture and sometimes pink in colour. Here again the difference in colour is due to a greater development of pink feldspars and quartz and less augite. The distance from the edge of the sheet, and the coarse texture show that these more silicious portions have crystallized later than the main mass. This shows that differentiation has taken place in such a way that the melt has become more silicious, possibly approaching a eutectic mixture. These pink coarse textured portions have a mineralogical composition intermediate between that of the gray portion and that of the more silicious aplite.

From the composition and the field relations it is thought therefore that the aplite is a later secretion from the further differentiated diabase magma.

The relations of the aplite to the diabase is very similar to that of "contemporaneous veins" in rocks described by Waller and Teal.* It is thought justifiable therefore to apply this term to the aplite occurrences.

ORIGIN OF THE METALLIFEROUS SOLUTIONS.

It has already been shown that the ores were deposited from solutions which followed the aplite intrusions.

The origin of these solutions cannot be proven, but the association with aplite suggests a genetic connection. It seems that, as the diabase magma cooled and crystallized, the melt was approaching a eutectic of predominating salic composition. If water and metallic sulphides and arsenides were being concentrated as the temperature fell, this was probably by the formation of a solution whose constituents were not soluble in all proportions in the fused silicate solution. The former solution was not miscible with the latter, and remained liquid or gaseous after temperatures had been reached at which the latter had solidified. When fractures in the diabase provided means of escape, part of

*J. J. H. Teall. British Petrography, London. 1888. p. 275.

the metalliferous solution doubtless accompanied the aplite solution, and, as has been shown above, part escaped subsequent to the aplite deposition.

That such a deposit is due to extreme differentiation in the igneous magma, is in harmony with the expressed views of J. E. Spurr* regarding the origin of most metalliferous deposits.

While no silver was found in the rock sections examined, the occurrence of native silver with cobalt minerals in aplite in James and adjoining townships, indicates a similar origin for the silver.

While it has been shown †that in the veins at Cobalt, silver solidified later than cobalt minerals, the occurrence in aplite indicates that there was no great time interval.

INFLUENCE OF KEEWATIN AND HURONIAN ROCKS.

Having concluded that the cobalt-silver bearing solutions are the result of differentiation in the diabase magma, we have now to consider the rôle of the intruded rocks in precipitating the ore.

Van Hise has stated "that the calcite gangue could not be derived from the diabase since it contains no carbonates, or so small a quantity that it is negligible. But one of the chief characteristics of the Keewatin rocks is the presence of carbonates, among which calcite is the most abundant. Also the conglomerate, being composed of debris from the Keewatin, contains much carbonate." He infers "that the Keewatin and the conglomerate are the main source of the calcite of the gangue minerals," and suggests "that the precipitation of the ores was produced by the mingling of solutions, some of which came from the diabase bearing the ores, and others of which came the conglomerate and Keewatin bringing precipitating agents;" but "the mere cooling of the solution may have been a factor in the process."

In the discussion following Van Hise's paper‡, Miller pointed out concerning the cobalt-silver veins west of Peterson Lake, that "in practically all cases the silver values disappear in passing

*J. E. Spurr. A Theory of Ore Deposition. Econ. Geol. Vol. II, pp. 781-795.

†Wm. Campbell and C. W. Knight. Econ. Geol. Vol. I. 1906.

‡Journal Canadian Mining Inst. Vol. X., 1907.

from the conglomerate to Keewatin, but the smaltite and niccolite continue below the contact." He suggests "that during a period of secondary disturbance the silver filled in the cracks through the smaltite or older minerals." But the older Keewatin "seems to have escaped the effects of this slight disturbance, hence there were no cracks in it, and the solutions could not get through the Keewatin."

A clearer idea of the part played by the intruded rocks, is to be obtained by a study of the character of the Keewatin and Huronian formations over the wide area in which cobaltiferous diabase is now known to occur.

THE KEEWATIN.

In Coleman township this formation is represented by igneous rocks only. Perhaps the most abundant type is a fine grained green rock in which there is considerable feldspar, chlorite and calcite, and still undecomposed remnants of augite. These rocks are apparently altered basalts. There are also intrusions of coarser textured rocks which appear to be altered gabbros, diabases, &c.

In Casey township there is an outcrop of a dark green, fine grained rock which appears to be an altered basalt, and in Tudhope township a coarse textured greenstone intruded by Laurentian granite was observed.

In other areas sedimentary rocks are associated with those of igneous character. At Larder Lake there are auriferous cherty carbonates, while at Temagami there are carbonates and cherty iron ores.

A study of Miller's map* shows that none of the ore producing veins are located more than a few hundred feet away from igneous Keewatin rocks. Equally significant is the fact that in areas in which the latter are not found, the cobalt-silver deposits are less extensive, and many cobaltiferous veins contain no native silver.

As Van Hise has indicated, these rocks contain a considerable percentage of calcite which furnished the gangue. It is also to be noted that there are present many relatively unstable minerals, e.g., pyroxene, hornblende, and biotite, which are readily acted

*W. G. Miller and C. W. Knight. Map of Cobalt Area. Bureau of Mines, Ontario, 1907.

on by percolating waters. These minerals are active chemical agents, and doubtless by their reactions with ore bearing solutions aided in the precipitation of the ores. From the field study it seems beyond doubt that such has been the case.

THE LOWER HURONIAN.

This formation is represented by graywacké slate, feldspathic quartzite or arkose, and graywacké conglomerate, in ascending order. The strata have, as a general rule, been but slightly disturbed from their original positions; but in some places are inclined as much as 45°. Their character has apparently been but little changed by igneous or dynamical agencies of metamorphism, except at the immediate border of the diabase where some hardening has taken place by a recrystallization of quartz.

In some areas, notably, Temagami, Cobalt, Casey tp., Wendigo Lake, and Larder Lake, the graywacké slate and conglomerate predominate over the arkose. In others, notably the region from James tp. to Lady Evelyn Lake, there is a greater thickness of the arkose.

From numerous petrographical descriptions by A. E. Barlow and G. H. Williams in Barlow's report, supplemented by the writer's examination of the rocks in the more immediate vicinity of the ore deposits, the arkose is known to be made up almost entirely of quartz, orthoclase, plagioclase, sericite, and chlorite. Quartz and orthoclase predominate, and of the plagioclases the more sodic varieties are most abundant. The grains are often subangular and much fractured, their size is that of a medium grained granite.

The graywacké, so far as can be determined, is made up of similar minerals more finely pulverized. The percentage of chlorite is higher; but there is an absence of fragments of primary ferro-magnesian minerals and the rock is therefore not a typical graywacké.

The pebbles in the conglomerate represent numerous types of Keewatin and Laurentian igneous rocks, and occasional cherty sediments. Light coloured granites, probably Laurentian, are the most abundant of the pebbles.

From the character and composition of the mineral fragments which constitute them, there can be little doubt that the arkoses were formed from the granitoid Laurentian rocks, and not from the metamorphosed greenstones of the Keewatin. It follows also that much of the graywacké is the finer material from the same source; but what percentage of the graywacké is made up of detritus of the Keewatin, cannot be determined.

Dr. A. P. Coleman* has shown that some pebbles in the conglomerate at Cobalt have suffered from glacial action. From the examination of numerous basal unconformities, however, one must conclude that they are not due to morainal deposition following the grinding action of glaciers. A photograph of one of these unconformities is shown in Miller's report.

The gradual transition from slate and arkose to the upper conglomerate bed shows that this latter is not of the common glacial type. The boulders of the upper bed, however, may be the erratic deposits of drifting ice; though glacial material is apparently a minor factor, if present at all.

Bell† describes the conglomerate as a volcanic breccia. Miller suggests that "some of the delicately banded graywacké slate may represent volcanic dust or fine grained pyroclastic material," but that the lower conglomerate is not pyroclastic and is made up of fragments of the adjacent older series.

The examination of thin sections of graywacké shows an absence of glass or mineral fragments so characteristic of volcanic dust. The chemical analysis shows it to be of a composition similar to an ordinary paleozoic shale.

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	FeO	CaO	MgO
A.......	60.15	16.45	4.04	.76	2.09	1.41	2.32
B.......	62.74	16.94	5.07	....	1.59	1.39	3.05

*A. P. Coleman. Jour. Geol., 1908.

†Dr. Robert Bell. The Cobalt Mining District. Jour. Can. Mining Inst. 1907. p. 64.

	Na_2O	K_2O	H_2O	CO_2	SO_3	C	BaO	P_2O_5
A.......	.. 1.01	3.60	4.71	1.46	.58	.88	.04	.15
B.......	6.07	....	3.56	....	......	......	......	......

(A) is a composite analysis of 51 palezoic shales, by F. N. Stokes of the U. S. Geological Survey.

(B) is the analysis of graywacké slate from the Little Silver Mine, made by A. G. Burrows of the Ontario Bureau of Mines.

The writer concludes, therefore, (1) that there was no volcanic activity contemporaneous with the Lower Huronian, (2) that these rocks were formed entirely of the detritus of the Laurentian and Keewatin formations, (3) that the arkoses, at least, are primarily of Laurentian origin.

INFLUENCE OF LOWER HURONIAN ROCKS.

Attention has already been drawn to the fact that the feldspars were but slightly, if at all, altered by the ore bearing solutions. Chlorite, sericite and quartz are well known to be stable minerals, and it therefore follows that the arkoses cannot have been active agents in depositing the ores.

The graywacké is made up of similar minerals with a larger percentage of secondary products. Calcite is sometimes present in very small amounts, and it is noteworthy that these rocks show a marked deficiency in lime, as compared with the Keewatin. It is thought therefore that while the Keewatin greenstones have probably, by virtue of their mineralogical composition, played an important role in the deposition of the ores, the graywacké, being composed of more stable minerals and low in calcite, played the same role in a minor way, if at all. The pebbles in the conglomerate contain numerous primary ferro-magnesian minerals which would be readily decomposed, and so the coarse conglomerate may have been more active than the graywacké slate.

Owing to their regular vertical jointing these sediments have afforded the most suitable place for the deposition of the ore, and so it happens that many of the most valuable veins have been found in them.

CONCLUSION.

It has been shown that cobalt ores have been deposited from solutions which followed the formation of a vein of aplite in the diabase.

Owing to the fact that in all the silver deposits in the district the silver minerals are intimately associated with cobalt minerals, the silver is believed to have the same origin.

It is suggested that the metallic sulphides and arsenides have been concentrated from the diabase magma by extreme differentiation.

The Keewatin igneous rocks have assisted in the ore deposition on account of their content of calcite and unstable minerals.

The Huronian sediments are composed for the most part of stable minerals with little calcite, and their chief function has been that of a recipient for the ores.

If these conclusions are correct, we may expect to find similar ore deposits where the diabase sills are associated with Keewatin igneous rocks, and especially valuable deposits where Huronian sediments are also present. The region from Lake Temiscaming to Lake Huron doubtless includes many such occurrences.

THE SAMPLING OF SILVER-COBALT ORES AT COPPER CLIFF, ONTARIO.

By Arthur A. Cole, M.A., B.Sc., Cobalt, Ont.

There are few ores that present greater difficulty in sampling than the silver-cobalt ores of the Cobalt Camp. The ore consists generally of cobalt and nickel arsenides and sulphides, but the trouble is caused by the occurrence of large amounts of metallics composed of native silver, or an alloy of silver and arsenic, which acts in the mill the same as native silver. With ores of this nature, frequently carrying extremely high values, the subject of sampling is of more than ordinary importance.

The ore leaves the mine in heavy jute sacks containing about 100 pounds each, and is shipped to Copper Cliff in (1) Railway Box-Cars under seal. In the case of very low grade material no bags are used, and the ore is shipped in bulk. From the car it is trucked to the (2) Weighing Scale, where it is weighed in lots of 10 sacks, and the first gross weight obtained. The sacks are then opened and the ore passed through a (3) Large Jaw Crusher, (Buchanan's Patent Rock and Ore Crusher). The empty sacks are tied up, weighed, and returned to the shipper. If the ore is dry it is shovelled directly into the (5) Ball Mill. If it is wet it is spread on (4) Steam Drying Plates until it is dry, and then it too goes to the ball mill.

As the ore comes from the jaw crusher a small shovelful from each sackful is set aside for a preliminary moisture sample, representing moisture contained in the ore as shipped.

This miosture sample is coned and quartered to about 100 pounds, after which it is taken to the sampling room, where it is passed through a small (15) Jaw Crusher, (Allis-Chalmers Laboratory Crusher). Then it is cut down to four samples of five kilos each, which are placed in pans in a (16) Steam Oven for about twenty hours, at a temperature of about 80 degrees centigrade. This material eventually returns to the crushing floor and goes through the ball mill.

The (5) Ball Mill (Plate I) is of Allis-Chalmers make and requires 25 H.P. to run it. It consists of a large metallic cylinder which revolves horizontally on its axis. It is lined with three sets of screens, the finest which is 20 mesh, being farthest from the centre. The grinding is done by a large number of hardened steel balls, of a total weight of 1¾ tons, which are carried up the side of the cylinder as it revolves, and then drop back on the ore. As the ore is ground to 20 mesh it is discharged below to an (6) Automatic Sampler. Screen tests show that 50% of the milled ore will pass a 100 mesh sieve, and 80% will pass a 50 mesh sieve. The capacity of the mill is about 1½ tons per hour.

The large metallics remain in the ball mill, and after the run is complete, they are removed, weighed, melted in a (14) Melting Furnace and run into bars of bullion. The speiss and the slag from this are combined and sampled together, while the bullion is sampled separately.

The (6) Automatic Sampler (Plate II), which is a 27 inch Snyder, cuts out one-tenth of the milled product. It consists merely of a circular casting shaped much like a miner's gold pan, having four openings in its sloping flange, and revolving on the end of a horizontal shaft. Two opposite openings are closed, thus leaving two cuts per revolution. The material to be sampled is directed by a spout so as to fall inside of the sloping flange of the sampler. The rejections slide off the flange and the sample drops through the openings as they pass under the spout. The sample makes 25 revolutions per minute, and this gives 3,000 cuts per hour for about 1½ tons of ore, or one cut for every pound of ore, or 60,000 cuts per car of 30 tons. A chain drive prevents slipping so that the cuts are regular.

The main part of the milled product (about 9/10 of the whole), is here weighed (7) and thence passes to the (8) Storage Bins of the smelter.

The sample is now removed from the (9) Sample Chamber and weighed (7) and this weight is added to that of the milled product

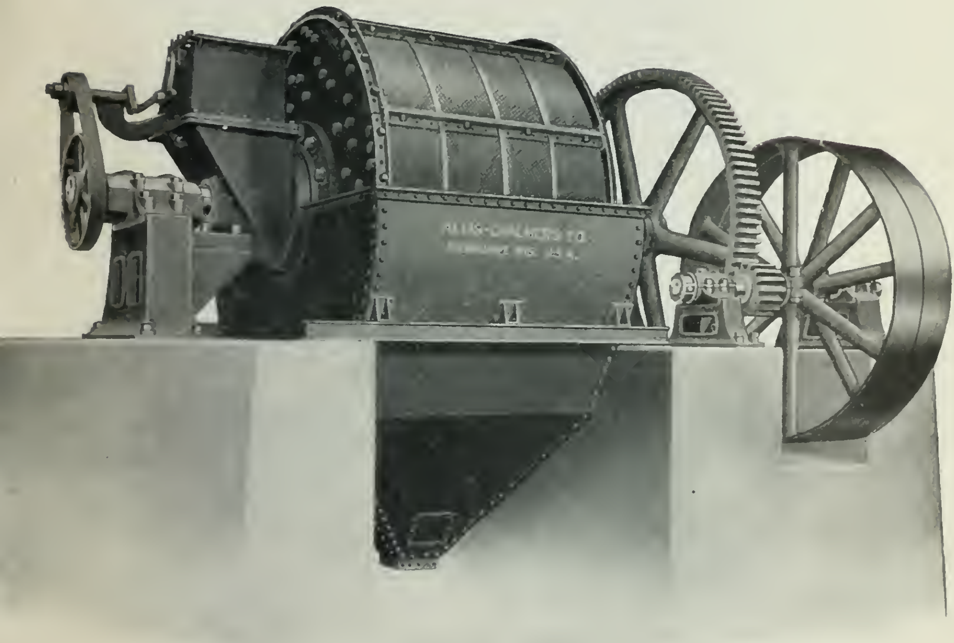


Plate I.—Allis-Chalmers Company, Ball Mill.

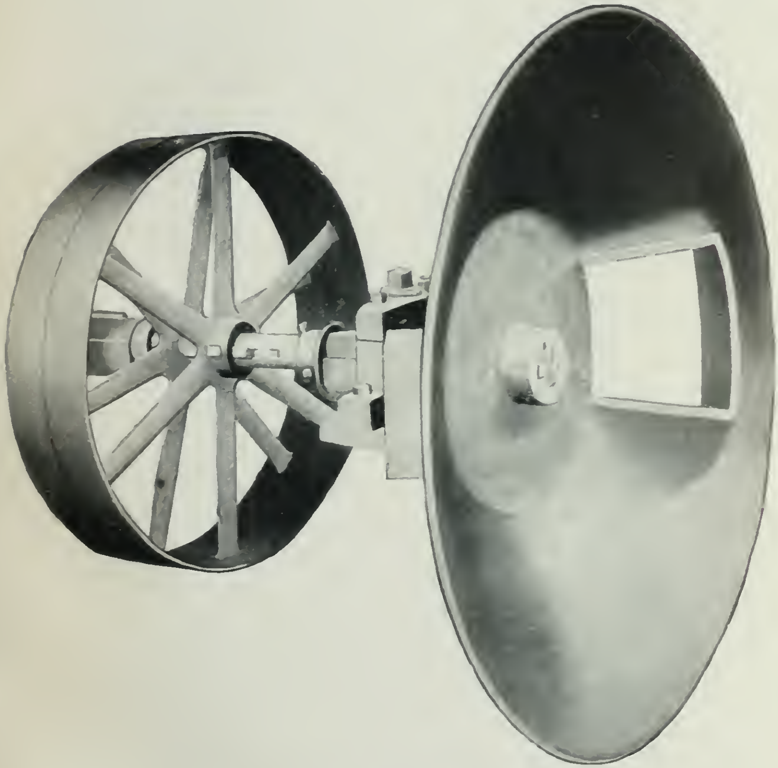


Plate II.—Snyder Automatic Ore Sampler.

above. Payment is made on these combined weights, less the moisture.

Two complete weighings of the shipment are thus made which should agree closely. This gives the shipper a check on his weights. Thus the gross weight of ore in sacks should be the same as the weight of:—

(a) Milled ore including sample.

(b) Sacks.

(c) Water lost on drying plates.

A sample for the final determination of moisture is taken by tube-sampler from each pailfull as it is removed from the sample-chamber. This moisture sample is cut down to three samples of three kilos. each. The result thus obtained is used in the calculation of dry weight. The weight of water lost on the drying plates can be calculated by taking the difference between this and the first moisture result.

The main sample is now thrown on the concrete floor of the sample-room, and after being shovelled over twice, is coned and quartered into two halves called Sample No. 1 and Sample No. 2. These samples are treated alike so that a description of one will suffice for both.

Sample No. 1 is (10) Coned and Quartered by shovelling on the concrete floor down to about 100 pounds, which will be four or five cuts according to the size of the original sample. Cutting down is continued by halving in a (11) Jones Sampler till two samples of approximately 20 pounds each are obtained. One of these is placed in a box and sealed by the shipper's agent for future reference, in case any accident should happen to the other samples. The other sample is now dried thoroughly and ground in a (12) Laboratory Disc Grinder, (Plate III) (Sturtevant Mill Company, Boston), till the fines pass through a (13) 100 Mesh Sieve leaving the metallic scales on the sieve bright and clean. Part of the final grinding is sometimes assisted by a Laboratory Pebble Mill (Plates IV and V) of the Abbé Engineering Company of New York, and sometimes by a Hance Drug Mill manufactured by Messrs. Hance Brothers & White, of Philadelphia.

The metallic scales and fines are weighed and sampled separately. The fines are placed in a pebble mill and mixed for an hour before sampling.

Sample No. 2 is handled as above excepting that no reference sample is retained.

The methods of sampling as described above are according to exceedingly good practice, and the final samples should be about as close to the truth as it is possible to get them. The first cut is made by an automatic sampler, so the possibility of introducing a personal error here is eliminated. The rest of the sampling is done by hand, but very carefully, as is proven by the following results shown in Tables 1 and 2. The sample is cut in two, and each half is sampled and assayed separately.

The following Table No. 1 shows the results in ounces of silver of 13 cars, being a complete month's run of the Copper Cliff Plant. The assays were made by the chemist at the works, and I am indebted to the courtesy of the Superintendent, Mr. D. L. Mackenzie, for these figures.

TABLE I.

Sample 1. Ozs.	Sample 2. Ozs.	Average. Ozs.	Difference. Ozs.	%
196.7	195.6	196.15	1.1	.56
313.6	312.4	313.00	1.2	.38
554.4	543.9	549.15	10.5	1.91
727.5	729.8	728.65	2.3	.31
1108.9	1107.3	1108.15	1.6	.14
1261.4	1265.7	1263.55	4.3	.34
1481.6	1477.5	1479.55	4.1	.27
2439.5	2451.0	2445.25	11.5	.47
2700.9	2683.2	2692.05	17.7	.65
2847.0	2839.9	2843.45	7.1	.25
3137.4	3137.4	3137.40	zero	zero
3572.4	3563.5	3567.95	8.9	.25
4407.0	4394.6	2200.80	12.4	.28

Table No. 2 shows six more shipments illustrating the same point. In this case the assays were made by Messrs. Ledoux & Company, of New York City.

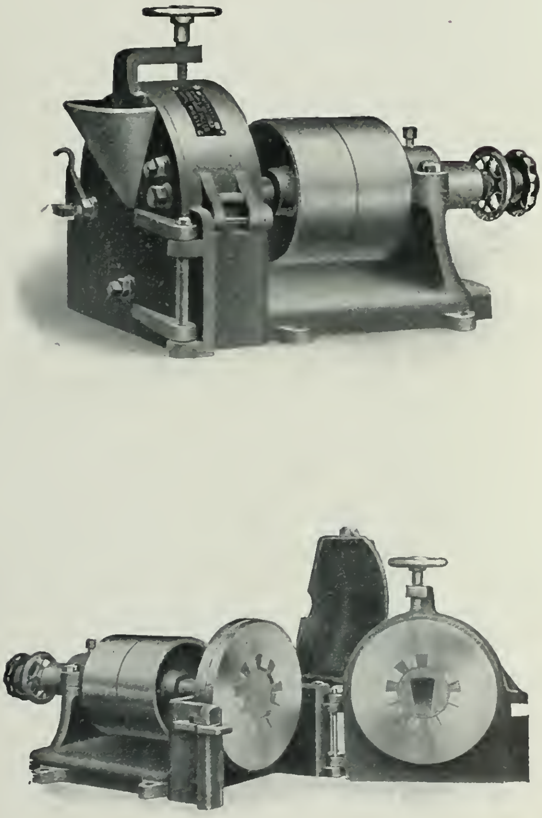


PLATE III.—Sturtevant Laboratory Disc Grinder.

TABLE 2.

Sample 1. Ozs.	Sample 2. Ozs.	Average. Ozs.	Difference. Ozs.	%
311.9	313.2	312.55	1.3	.42
402.1	393.7	397.90	8.4	2.11
449.2	449.0	449.10	.2	.04
552.9	547.3	550.10	5.6	1.02
2684.8	2610.6	2647.70	74.2	2.80
3115.9	3143.3	3129.60	27.4	.87

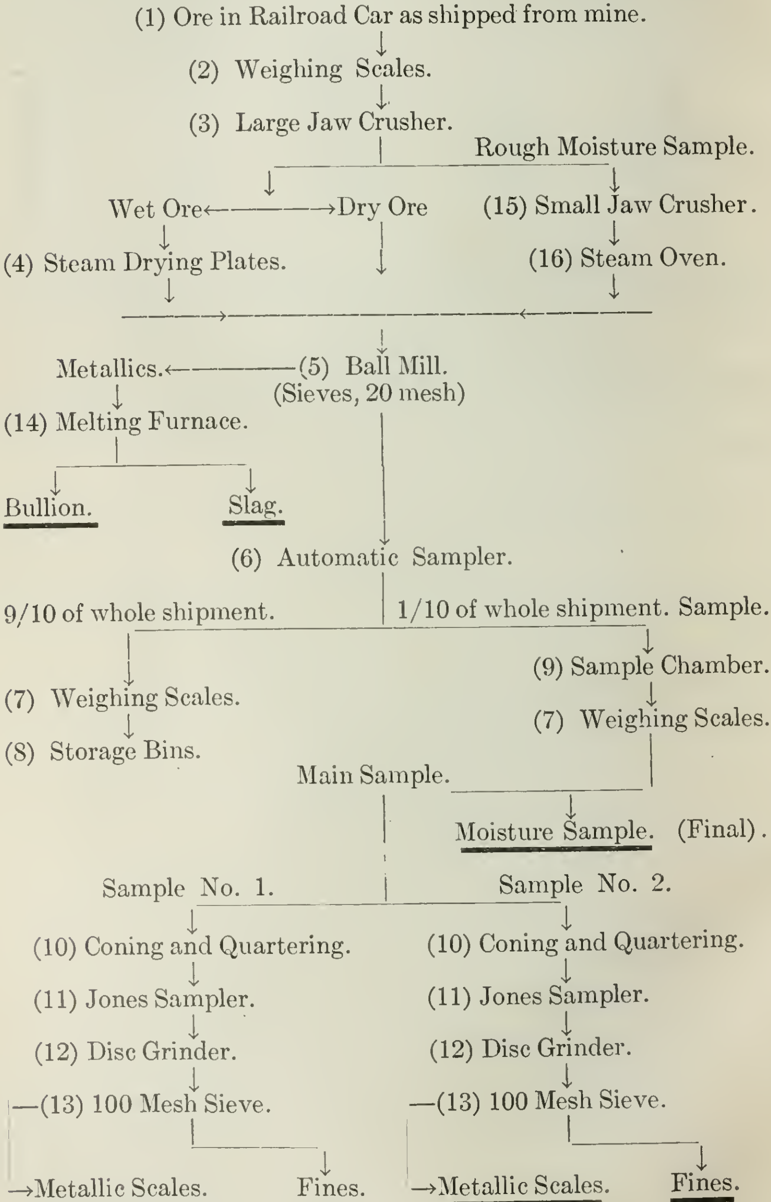
The average difference between Sample 1 and 2 on the above 19 shipments is .68%, which is remarkably small considering the grade of the ore and the amount of metallics contained.

The capacity of the smelting plant is determined by that of the crushing plant, which is about 15 tons per day.

It requires three days to complete the sampling of a thirty ton car.

TABLE 3.

GRAPHIC TABLE SHOWING THE SAMPLING OF SILVER-COBALT ORES BY THE CANADIAN COPPER COMPANY, AT COPPER CLIFF, ONT.



NOTE.—Final samples are underlined.

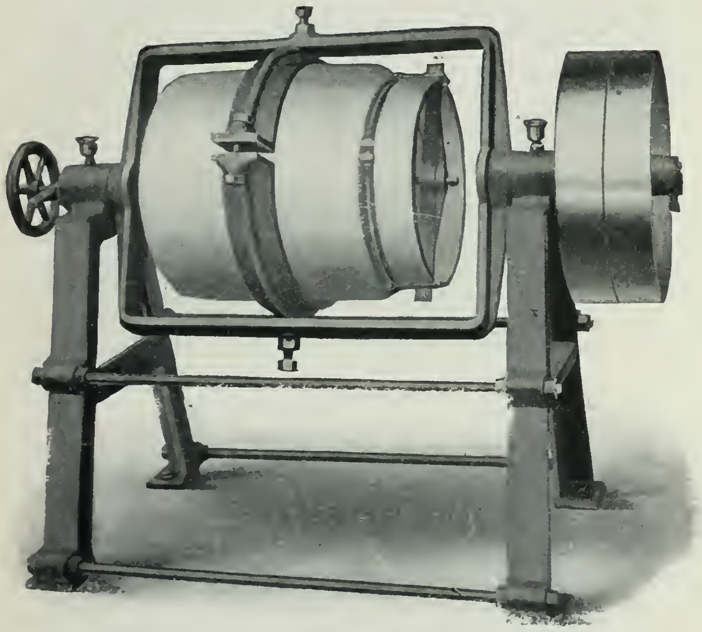


Plate IV.—Jar Pebble Mill

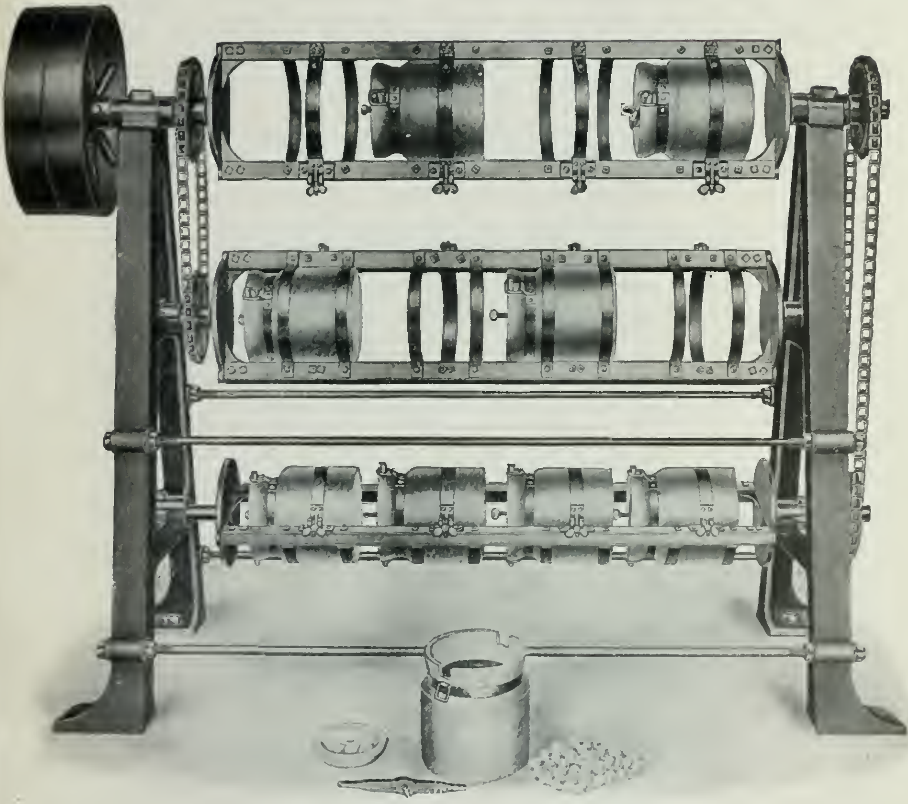


PLATE V.—Twelve Jar Laboratory Pebble Mill.

METALLURGICAL CONDITIONS AT COBALT, ONTARIO, CANADA, 1908.

By F. N. Flynn, Cobalt, Ont.

(Ottawa Meeting, March, 1908.)

In view of the fact that there exist, in the mines at Cobalt and its neighboring districts, a considerable quantity of low-grade silver ore or unmarketable cobalt ores, which have only a prospective value, it would appear as though a general discussion of the subject would be of value to the operators of the camp as well as to metallurgists in general. It would be very profitable to both if the metallurgists of foreign countries, who have treated ores of cobalt from this or other districts, would com-in closer touch with the Canadian district. In doing so it would not be expected that they would publish their guarded metale lurgical secrets of a generation; but should they do so, we would congratulate them on their more modern and more American way of doing business. On the other hand, the Canadian miners would be content to increase the business of both by selling them cobalt ores which they have treated successfully. The difficulty seems to be that there is no connecting link to facilitate business intercourse between the Canadian miner and the European metallurgist. Let us, therefore, interest these men in our problems by discussions and bring them to our assistance in marketing cobalt ores, of which we have more than any other country in the world. It is with this object in view and for *their special information* that the following general description of our conditions has been written.

With the discovery of the Cobalt camp, there were presented to mining and metallurgical engineers several problems, which made even the most capable and experienced experts pause before passing an opinion. These problems were unusually puzzling and out of the ordinary rut of every day engineering experiences. To this day many of these questions are as yet unanswered to the entire satisfaction of those who are developing the camp. The mining engineers were asked:—"Will these narrow veins go down through the changes in formation, and will their values continue in depth?" The metallurgists were asked:—"How can we get the most dollars from our ores?" The mining engineer has had three years of practical demonstration to prove his theories; but the metallurgist, aside from a select few engaged with the large custom smelters, has had little opportunity to put his ideas to the test. These conditions are now gradually changing and within the past few months several concentrating plants have commenced the solution of the primary problem. Primary, because it is always advisable to reduce the bulk of the material before attempting further separation of the values, and if concentration will accomplish this end, without too great a silver loss, the metallurgists will have cause for congratulation. The varying degrees of metallurgical success will depend largely on the physical constitution of the vein matter, the method of breaking down the ore in the vein, and the efficiency of sizing, hand sorting and cobbing.

THE FORMATION.

The veins are found in the Keewatin, Lower Huronian, Post Middle Huronian, Glacial and recent formations. Their pitch is nearly vertical. They open and close frequently, both vertically and horizontally. The Lower Huronian veins are the most constant, the Post Middle Huronian ranking a close second. The veins outcropping in the Keewatin cannot be referred to in a general way. They vary considerably. Some of the best veins are found in this formation. It is generally conceded that veins which are constant in the other formations, are apt to pinch out when they enter the Keewatin.

VEINS AND MINERALS.

The veins are narrow, all under 28 inches, probably averaging 4 inches in width, and according to the Provincial Geologists contain the following minerals:—

1. NATIVE ELEMENTS—

Native Silver, Native Bismuth, Graphite.

2. ARSENIDES—

Niccolite or Arsenide of Nickel ($NiAs$). Chloanthite or Diarsenide of Nickel ($NiAs_2$). Smaltite or Diarsenide of Cobalt ($CoAs_2$).

3. ARSENATES—

   Erythrite or Cobalt Bloom, $Co_3As_2O_8+8H_2O$.
   Annabergite or Nickel Bloom, $Ni_3As_2O_8+8H_2O$.

4. SULPHIDES—

   Argentite or Silver Sulphide, Ag2S.
   Millerite or Nickel Sulphide, NiS.

5. SULPH-ARSENIDES—

   Mispickel or Sulph-Arsenide of Iron, FeAsS.
   Cobaltite or Sulph-Arsenide of Cobalt, CoAsS.

6. ANTIMONIDE—

   Dyscrasite or Silver Antimonide, Ag6Sb.

7. SULPH-ANTIMONIDES—

   Pyrargyrite or dark red Silver ore, Ag3SbS3.
   Tetrahedrite or Sulph-Antimonide of Copper, CuSSb2S7.

VEIN CHARACTERISTICS.

(a) Some of the veins have all their ore concentrated in one seam, lying loosely between two perfect walls, the line of separation being distinctly marked, usually by a film of mud. Such veins, physically clean, can be stripped clean in mining, providing the width and grade justify stripping the gangue before taking down the ore. When stripping is the method followed, the wall rock material is usually of little value, and the ore very free from gangue.

(b) Another type of vein will have its ore "frozen" to one wall.

(c) A third type contains several "stringers" of ore entering and leaving the main vein, so as to leave several inches or feet of gangue rock between them. With these two types the walls are not always clearly defined, and it is usual to drive, in the ore that is, to cut behind the walls with the main drive, sufficient to take down the outside stringers. By keeping the drill holes away from the ore and loading them with just the right amount of dynamite, this method can be followed without an undue amount of "fines," but sufficient to make a fair grade of screenings. The ore from such veins requires considerable "cobbing" to clean it.

(d) A fourth type may have irregular walls and consist mainly of calcite and native silver, with sheets and flakes of silver penetrating the wall-rock at all angles from the main vein. The method of mining varies with the local condition. These veins produce a large quantity of "cobbings." In this refuse material the flake silver is quite visible before crushing, but is so thin as to produce little or no "metallics" after crushing, the gangue being very hard.

(e) Another similar type will contain the bulk of its wall-rock crevice values as argentite instead of native, or a mixture of both. These veins are not so frequently encountered as the preceding, but produce as large, or larger, tonnage of mill-rock than any in the district.

The five types mentioned are but a few of the many varieties, but serve to show that each vein or the wall-rock from each vein, may require a different method of mining and milling. The physical distinctions are of the utmost importance to milling operations, especially those having values in the wall-rock material.

SURFACE TREATMENT.

When several veins of different character, and possibly mined by different systems, are worked through one shaft, the complications which develop at the head-house become a matter of importance. There is hoisted:

(a) Clean ore from different veins, the composition of which varies widely and must be kept separate on account of the condition of the market.

(b) Clean waste from cross-cuts.

(c) Supposedly clean gangue rock from "stripping". Some of these veins carry values in the wall-rock.

(d) Mixed vein matter from driving in the vein, and from veins the ore from which must be kept separate.

The clean ores from the various veins are stored separately, and frequently each is sorted to two or more classes.

The clean waste must be kept in one dump to facilitate the grouping of mill dumps.

The gangue rock from "stripping" must be closely watched and kept in separate dumps, one as possibly worthless or doubtful, the other as a mill dump with values.

The mixed vein matter is treated on one or more bumping tables. These tables are frequently 4 ft. x 15 ft., hung by inclined bolts from overhead timbers. They have a fall of 1 foot in 15. The forward motion is about 4 inches, and is driven by a cam-shaft at varying speed. The floor of the table consists of two steel plates and one perforated plate; the latter is usually the centre plate. The material is fed from a bin at one end, and sprayed continuously with water from the mine pumps. The perforated plate has ¾″ holes, while the under screen has ⅛″ holes. This gives the sorters, washed rock ¾″ and larger, while the undersize ¾″ to ⅛″ and ⅛″ and water, along with the coarse waste from the end of the table, drop into their respective bins below. One table handles 50 tons per shift with six men including car-men. Each of these three waste products should be stored on separate dumps for future treatment, unless the fine screenings have a present market value. By arranging separate dumps for all these materials they can be more readily marketed, or treated by different processes, and may mean the recovery of dollars, as compared with cents if mixed together. The shipping ore is usually crushed to one inch and sewed in bags, the weights of which vary from 75 to 150 lbs.

ORE VALUES.

The following statement, from a paper* read by Dr. A. R. Ledoux at the Toronto Meeting, 1907, gives the only accurate published information of the average assays of Cobalt silver ores in car-load lots:—

				Per cent.
Over 6,000 ozs.		4	lots (say)	1
Between 5,000 ozs. and	6,000 ozs.	3	"	0.75
" 4,000 ozs. and	5,000 ozs.	12	"	3
" 3,000 ozs. and	4,000 ozs.	17	"	4.25
" 2,000 ozs. and	3,000 ozs.	30	"	10
" 1,000 ozs. and	2,000 ozs.	72	"	18.25
" 900 ozs. and	1,000 ozs.	11	"	2.75
" 800 ozs. and	900 ozs.	7	"	1.75
" 700 ozs. and	800 ozs.	12	"	3
" 600 ozs. and	700 ozs.	21	"	5.25
" 500 ozs. and	600 ozs.	10	"	2.5
" 400 ozs. and	500 ozs.	13	"	3.25
" 300 ozs. and	400 ozs.	20	"	5
" 200 ozs. and	300 ozs.	44	"	11.25
" 100 ozs. and	200 ozs.	66	"	17
Less than 100 ozs.		43	"	11

*"Richness of Cobalt Ores." Trans. C.M.I., 1907, p. 72.

"Silver, of course, in point of value, is the more important element. The highest percentage of cobalt found in any one shipment is 11.96 per cent., the average being 5.99 per cent. The highest assay for nickel in any car is 12.49 per cent., the average being 3.66 per cent. The highest percentage of arsenic is 59.32 per cent., the average 27.12."

The analyses of the graded ores from one mine working several veins are as follows:—

	Ins.	SiO_2	Fe.	CaO.	Al_2O_3	MgO	Ni.	Co.	As.	Ag. ozs.
"A"..........	5.75	4.51	2.34	9.05	1.42	6.22	6.62	7.11	29.88	4786.10
"B"..........	3.90	2.88	2.80	10.0	0.87	7.13	8.78	8.42	34.48	2014.01
"C"..........	18.48	14.30	4.80	12.82	4.45	8.84	5.06	4.55	22.14	262.20
"D"..........	8.8		3.7	9.3					42.3	183.66
"E"..........	8.2		2.8	8.7					37.0	52.00
"F"..........	40.8		6.2	11.9					6.1	72.33
"G"..........	69.0		7.0	3.0	15.0				0.5	71.27
"H".......	77.0		5.5	1.5					0.3	53.30

"A", "B" and "C" were averages for one year's shipments. The other grades carry cobalt and nickel proportionately to the relative arsenic contents. "G" and "H" are wall-rock ores, which carry values in the crevices. A complete analysis of two car-loads was found to contain:—

AFTER DRYING

Silica..	3.34%
Iron..	1.78%
Alumina..	0.27%
Lime..	5.85%
Magnesia..	4.63%
Copper..	0.09%
Nickel..	13.87%
Cobalt..	8.36%
Bismuth...	trace
Silver..	5.31%
Antimony..	1.46%
Arsenic...	42.46%
Carbonic Acid...	9.26%
Chlorine	0.08%
Sulphur...	1.89%
Combined water, alkalies and oxygen, by difference	1.35%

PRODUCTION.

The camp has produced:—

In 1904	158 tons.
" 1905	2,144 "
" 1906	5,129 "
" 1907	14,828 "
Total	22,259 tons.

The principal shippers in 1907 were:—

La Rose	2815.40 tons.
Nipissing	2538.26 "
Coniagas	2447.37 "
O'Brien	1475.44 "
Buffalo	1241.54 "
Trethewey	833.58 "
McKinley-Darragh	768.13 "
Silver Queen	456.57 "
Foster	345.13 "
Kerr Lake (Jacobs)	323.23 "
Nova Scotia	244.11 "
Temiskaming & Hudson Bay	180.41 "
Temiskaming	165.82 "
Cobalt Townsite	143.22 "
Right of Way	129.37 "
Drummond	104.13 "
13 other mines	416.95 "
Total	14828.66 tons.

MILLING METHODS.

For the moment at least, the main object in milling is to win more ore from the waste, cobbings, and screenings. The treatment of the wall-rock proper will be the second step. Take for example the $\frac{3}{4}''$ undersize from the bumping tables: this contains ore which is of too small a size to hand-pick. It is usually clean ore in separate particles from the gangue. If further sized, jigs and tables should do excellent work. Mixed material difficult to "cob" will undoubtedly add considerably to the output, but on account of its physical "make-up", and the fact that the ores of the district occur in the massive form (when they are crystallized the crystals are very small), the crushing will produce a considerable quantity of slimes. Stamp crushing should not be considered in concentration. Roll crushing, with a large slime-treating capacity, may serve for the present, but ample provision should be made for storing the slimes separately. If the concentration process is confined entirely to the recovery of the arsenides, the extraction, plus the recovery of slimes as such, should be quite satisfactory. On the other hand, should concentration be attempted on the wall-rock ores carrying values as native silver in very thin flakes and as argentite, the results cannot possibly prove a financial success, unless the tails are to be re-treated by another process. The native silver flakes and argentite ores must be treated chemically if milled, preferably by raw amalgamation for the native silver and cyanide for the argentite ores, whereas the slimes from concentration might be treated by the "oil process" or any number of processes. It is needless to say that the coarse silver can be concentrated. At present there are six new concentrators in the camp, three in operation and three nearly completed. One plant is designed to treat the tails by cyanide; the other by raw amalgamation. It is sincerely hoped that those in charge will make public the results of their operations. Whether they are successful or not, the knowledge of their results will be beneficial to the camp.

SAMPLING.

The bulk of the shipments from the camp have gone to the custom smelters of New Jersey, and as the ore is exceptionally rich, and special facilities are required in the sampling, it is almost invariably sampled at the public sampling works. Shovel sampling is preferred to mechanical samplers. Here in the presence of representatives from buyer and seller, the sacks are weighed in lots of ten, by a public "sworn weigher." The ore is crushed, rolled, and re-rolled, the nuggets of silver being picked out by hand between each handling. The nuggets are weighed and deductions made. These are usually sold to the custom refineries as a separate transaction. The finely-crushed and thoroughly-mixed material is now completely sampled four successive times. The smaller samples are screened, and the metallics are subjected to a further grinding in small pebble mills. The four samples vary widely in their values, in spite of all precautions.

Cobalt and nickel are not paid for by the custom smelters in the States. The ore carries no gold. Silver is the only determination necessary in most cases. This is determined by the combination method, wet and dry, on all ores carrying arsenic in quantity.

The nuggets are melted in large crucibles and cast into bars. The resulting slag and speiss are weighed, sampled and assayed as usual. The bars run from 700 to 875 fine.

The sampling of a mine dump at the mine, by the grab-sampling principle, is not worth the cost; the values are not homogeneously contained in the rock. The "fines" are invariably the richer. The values in the coarse rock are in the crevices; whereas the body of the rock, without cleavage planes, is barren, so that, in chipping pieces from the larger rocks, one invariably gets a greater proportion of crevice values than the whole rock contains. To determine the value of the dump, a large quantity in natural size should be crushed and finely ground before sampling is commenced.

MARKETS

Let us assume that concentration, followed by a chemical process in special cases, will solve all the low-grade ore problems. This means a larger output of arsenical ores to be smelted. In the earlier days of the camp a considerable tonnage of arsenical ore was shipped to Europe, where, in some cases, the four metals—silver, cobalt, nickel and arsenic—were paid for at very satisfactory prices. For various reasons, many of which are inexplainable at this end, the European metallurgists either declined to take any more shipments, or declined to pay for all four metals. Others later on declined to pay for nickel and arsenic, and at last only paid for the cobalt. The result is that those producing smaltite ores without silver values occasionally market a car in Europe. The silver mines have practically discontinued European shipments. The New York ore buyers paid for arsenic, silver, cobalt and nickel values as late as Aug., 1905, when they discontinued payments for the arsenic, cobalt and nickel. The new schedule, which came out at that time, by the New Jersey smelters, charged 6% of the silver, and later they imposed a treatment charge of $8.00 per ton. As the European market declined, the treatment charge was raised to from $9.00 to $15.00 per ton, with a silver deduction of 7%. Then followed the penalty for insoluble silica and arsenic. Later one half-a-cent an ounce was deducted from the price paid for the silver, and various other forms of deductions followed, until a period was at one time reached with one smelter, where, unless the mine owners would make a time contract at increased treatment charges, they declined to accept any more ore. Strange to say, the other smelters, including the European plants, were at this critical time "overstocked" with cobalt ores. After the mines had accepted the inevitable, the smelters broadened their field of operation, and allowed shipments to be made without restriction as to tonnage especially for wall-rock ores, which contained little or no arsenic. The new schedules still impose the heavy arsenic penalty on ores under 1,500 ozs. A comparison of European and American market conditions is best made by examples. In December, 1905, a car of ore was shipped from Cobalt to England direct. The liquidation shows:—

Weight—17 tons, 16 cwt., 3 qrs., 3 lbs.
Contents—Ag. 30,921.24 fine ozs.
Co. 4,275.0 lbs.
Ni. 2,496.9 "
As. 13, 679.0 lbs.

Liquidation:—

92% of silver contained=				£	s.	d.
30754.11 standard ozs. at 30.5187d. (average).............				3910	16	4
4275 lbs. Co. at 2/– per lb............................				427	10	–
2496.9 lbs. Ni. at 6d. per lb...........................				62	8	6
13679 lbs. As. at ¼d. per lb...........................				14	5	–
Total Credits........................				£4414	19	10
Freight, Cobalt to Liverpool, and Insurance	£51	3	2			
Ry. Exps. in England......................	38	2	7			
Paris Chgs. Nickel, etc........................	10	–	–			
Assaying...............................	35	–	6			
Silver Refining Expense....................	24	15	4			
Total Debits.........................				£159	1	7
Net Credits..........................				£4255	18	3

Expressing the above transaction in American terms, we have :—

Ag.	1547.68 ozs.	at 92%=1423.86 ozs. at 66⅔c...........	$949.24
Co.	10.70%	at 100%= 214.0 lbs. at 48½c...........	103.79
Ni.	6.25%	at 100%= 125.0 " at 12⅛c...........	15.16
As.	34.23%	at 100%= 684.6 " at ½c...........	3.43
		Gross Value per short ton.	$1,071.62
Freight, Treatment, and all other deductions		....	38.62
		Net per ton, F.O.B. Cobalt	$1,033.00

19.979 Tons......$20,638.30

A few of the old and new schedules follow:—

(2) New York Ore Buyers—1905.

Cobalt ores, at Ledoux & Co's plant, Bergen Junction, N.J.

Payments :—

Ag. 90% at N.Y. quotation.
As. 100% at ½c. per lb.
Ni. 100% at 12c. per lb.
Co. 100% at 65c. per lb.

(3) American Smelting and Refining Co., Maurer, N.J.—1908.

For ores under 1,500 ozs.

Pay for silver 93% of contents at N.Y. quotation, less ½c. per oz., at quotation 30 days after agreement of assays.

Charge for insoluble silica. . . . . .7c. per unit
" arsenic in excess of 5%. . .25c "
" treatment . . . .$9.00 per ton

For ores over 1,500 ozs.—These are not purchased outright. They are cupelled in their refinery and paid for as follows:—

Pay for bar silver recovered from cupellation at N.Y. quotation, less 1c. per oz., for 100% on date of agreement of assays.

Pay for the silver contained in the by-products from cupellation at N.Y. quotation, less ½c. per oz., for 98% of contents, at quotation 30 days after agreement of assays.

Charge for treatment, $125.00 per ton of ore.

(4) International Nickel Co., Copper Cliff, Ontario, 1908.

Ag. Pay 94%, when 4,000 ozs. or over.
" 93%, " 1,200 "
" 92%, " 800 "
" 90%, " 500 "
" 85%, " 300 "
" 80%, " 150 "

Co. Pay $30.00 per ton of ore for 12% or over.
" $20.00 " " 8% "
" $10.00 " " 6% "

No payment for less than 6% Cobalt, nor when the nickel contents is higher than that of Cobalt.

Payment is to be made in two instalments of 45 and 90 days respectively, after sampling the ore, and is based on the official value at New York on the first day of settlement. The purchaser reserves the right to pay in silver bullion delivered at New York in place of cash.

(5) Deloro Smelting and Refining Co., Marmora, Ontario, 1908:—

Ag. Pay	95%	when	2,000	ozs. or over.				
	"	94%	for	1,000	"	to 2,000 ozs.		
	"	93%	"	800	"	"	1,000	"
	"	91%	"	500	"	"	800	"
	"	90%	"	200	"	"	500	"
	"	85%	"	100	"	"	200	"

At N.Y. quotations 30 days after agreement of assays.

Co. Pay $20.00 per ton of ore for 10% or over.
" $10.00 " " 6% to 10% ore.
No payment for less than 6%.
As. Pay 1½c. per lb. for 30% or over.
" 1c " 10% to 30% ore.
Treatment, $10.00 per ton.

(6) 1907. The Swansea smelters bought low silver cobalt ores, without regard for silver contents, and without any deduction, F.O.B. cars Cobalt, as follows:—

8% to 10%	cobalt	..........30c.	per lb.
10.1% " 12%	"	..........35c.	"
12.1% " 14%	"	..........40c.	"
14.1% " 16%	"	..........45c.	"
16% or over	"	..........50c.	"

These prices give net returns of from $48.00 to $160.00 per ton.

1908. The Swansea smelters have raised their schedule of payment 5 cents per lb.

(7) Very recently, German buyers have entered the field, and have purchased certain classes of ores at figures which are satis-

factory to the Cobalt producers. They have bought several cars of ore on the following basis:—

> For ores containing not less than 10.5% of cobalt, and not less than 30 ozs. silver, per ton, there will be paid $81.82 per ton, on the following conditions:—
> F.O.B. cars, Cobalt. Purchaser pays freight. Sampling by Ledoux & Co., Bergen Junction, N.J. The cost of sampling to be divided. Ledoux & Co. assays will govern settlement.

This would net say $80.00 per ton.

Taking such an ore a comparison would be interesting however certain schedules would not apply in this case.

The ore:—Ag. 30 ozs.; Co. 10.5%; Ni. 4.5%; As. 50%; Insoluble 15%; Silver 55c. per oz.

Net F.O.B. Cobalt :—			Cr.
(1)	English Market	1905	$ 94.32
(2)	New York Ore Buyers	1905	155.95
(3)	A. S. & R. Co.,	1908	7.31
(4)	International Nickel Co.	1908	28.00
(5)	Deloro Smelting & Refining Co.	1908	32.02
(6)	Swansea Smelters	1907	73.50
	Swansea Smelters	1908	84.00
(7)	German Market	1908	80.00
	Difference between highest and lowest		$148.00

The most serious difficulty at the present time is the uncertainty of the cobalt market. The European buyers occasionally cable instructions to "ship 50 tons cobalt within one week," whereas the miner is not prepared to deliver in so short a time. It is not mined until a market is found for it. Should he ship, he might wait six months before receiving another offer.

In order to compare the schedules, on silver ores, we will take the shipment to England, previously referred to, with the same silver price for comparison:—

(2) New York Ore Buyers, 1905:—

Ag.	1547.68 ozs.	at 90%=1392.91 ozs.	at 66⅔c	$928.61
As.	34.23%	at 100%= 684.6 lbs.	at ½c	3.42
Ni.	6.25%	at 100%= 125.0 "	at 12c	15.00
Co.	10.70%	at 100%= 214.0 "	at 65c	139.10
	Total Credits			$1,086.13
Freight				11.20
	Net per ton			$1,074.93

(3) American Smelting and Refining Co., Maurer, N.J., plant. Schedule "A," present schedule, over 1,500 ozs. is cupelled direct.

Schedule "B," present schedule, under 1,500 ozs. will be used to illustrate this example:—

Ag. 1547.68 ozs. at 93% = 1,439.34 ozs., price 66⅝c. less ½c=66.17c		$952.41
Insoluble Silica (estimated for this example at 7%) at 7c.	$ 0.49	
As. 34.23% less 5% = 29.23% at 25c.	7.31	
Treatment	9.00	
Freight	11.20	
Total debits		28.00
Net per ton		$924.41

(4) International Nickel Co., Copper Cliff, Ontario;—

Ag. 1,547.68 ozs. at 93% = 1,439.34 ozs. at 66⅝c.	$959.56
Co. 10.70%	20.00
Total credits	979.56
Less freight	5.20
Net per ton	$974.36

(5) Deloro Smelting & Refining Co., Marmora, Ontario:—

Ag. 1,547.68 ozs. at 94% = 1,454.82 ozs. at 66⅝c.	$969.88	
As. 34.23% at 100% = 684.6 lbs. at 1½c.	10.27	
Co. 10.70%	20.00	
Total credits		$1,000.15
Freight	$ 7.00	
Treatment	10.00	
Total debits		17.00
Net per ton		$983.15

Summary of results:—

(1)	English Market	1905	$1,033.00
(2)	New York Ore Buyers	1905	1,074.93
(3)	A. S. & R. Co.	1908	924.41
(4)	International Nickel Co.	1908	974.36
(5)	Deloro Smelting & Refining Co.	1908	983.15
	Difference between highest and lowest		$150.52

Another type of ore, same silver price:—

The ore:— Ag. 776.28 ozs.
As. 44.26%
Ni. 11.09%
Co. 10.09%
Ins. 5.00%

(1)	English Market	1905	$566.69
(2)	New York Ore Buyers	1905	616.79
(3)	A. S. & R. Co.	1908	447.35
(4)	International Nickel Co.	1908	460.57
(5)	Deloro Smelting & Refining Co.	1908	487.22
	Difference between highest and lowest		169.44

It seems scarcely necessary to add that the market price of silver to-day—55 cents—would materially change these results, and that contracts for time or tonnage on the entire output of all classes of ores produced would result in slightly better terms.

Comparing the lead cupellation process with direct purchase, the advantage is that the many difficulties and uncertain results in sampling and assaying the rich crude ores are eliminated. The disadvantage is that the losses resulting from handling, flue dust, and volatilization falls on the seller. Roughly, about 60% of the silver is recovered in bars. The advantage of eliminating an uncertainty in sampling and assaying is as beneficial to the smelter as to the seller. On the other hand, the metallurgical losses are always borne by the seller. This loss, in addition to a treatment charge of $125.00 per ton and deductions from the percentage of silver paid for in by-products, as well as from the market price paid for the silver in both instances, and together with the fact that the seller is not at this late date paid for his cobalt, nickel and arsenic, by the New Jersey smelters, appears to the average miner as a condition wherein the term "Modern Metallurgy" is a delusion.

METALLURGY.

Market conditions are such as to compel the miner to study metallurgy. There are to-day at least a dozen prominent metallurgists who are endeavoring to overcome the smelting difficulties. Unfortunately, the good work which they are doing, in an experimental way, is underestimated and discounted by the average miner and investor, by the promises held out of high extraction, low costs, and good markets, by some of the earlier "Promoting Metallurgists." Many of these earlier "Metallurgists" were of the "patent-process presto-change" variety, whose special mission was to boom the camp indirectly, for the direct profit of others. Let us hope that this class have disappeared. When some new field of operation has sprung up, we are sure to find them again, for they make a specialty of booms.

The ores produced may be conveniently grouped under four classes:—

1.	Over	1,500	ozs. silver	and under	35%	arsenic
2.	Under	1,500	"	"	40%	"
3.	"	100	"	"	60%	"
4.	"	100	"	"	2%	"

The tonnage of No. 1 is very small. No. 2 may be considered the representative shipping tonnage of the camp. The tonnage shipped of No. 3 may be disregarded, because there is no profitable market for it. The number of veins of this character in the district and in the adjoining townships is greater than the silver veins. This ore is composed almost entirely of smaltite. If it could be marketed steadily, the tonnage would exceed all other classes combined. No. 4 is the wall-rock ore, and while it will be treated by the amalgamation and cyanide processes in considerable tonnage, it must nevertheless be counted on in local smelting as one of the slag-forming elements of the charge. If the other ores are to be smelted at a considerable distance, these may be disregarded. At present, the sentiments of the miner may be described as follows:—He is disposed to sell No. 1 classification to the refiners, but considers the conditions too severe. He is content to lose the other valuable metals on this grade of ore. On No. 2 classification—the larger tonnage he could console himself to the loss of the cobalt and nickel, if the smelters would not penalize for the arsenic. On No. 3 ore, he dreams of the future, when cobalt will be easily refined. On No. 4 ore, his former dreams are about to be realized in the mills. On the whole, he criticizes the custom smelters because they do not appear to be doing anything to relieve the situation. Metallurgists are frequently asked why it is that the miners do not smelt their own ore, even on a very small scale? The answer is well worth considering.

"We have no market for the speiss. This alone constitutes 95% of the reasons why we don't do it".

The smelting of the ore is not as difficult, metallurgically, as the average miner may have been led to believe. The trouble starts after smelting.

SMELTING

We know very little of the smelting of our ores, because we have had no opportunity to try it. The custom smelters have told us little about it, except that they have difficulty with the arsenic. In order to intelligently exchange ideas on this question, and to bring out criticisms, this issue will be discussed from the standpoint of a purely hypothetical question.

Suppose, for example, that all the custom smelters would refuse to buy any more of our ores. Instead the refiners would buy the furnace products therefrom, and in addition to the silver, would pay just sufficient for the cobalt and nickel in the resulting speiss to encourage us to mine and smelt the "cobalt" ores at a very small profit. They would not pay for arsenic in any form.

On the other hand, let us suppose that the arsenic market was sufficiently stable to justify us in entering the commercial market, if we so desired. How and where would we smelt?

A glance at our tonnage production for 1907 would convince us that any individual mine could not produce a sufficient tonnage of all classes of ores and concentrates to profitably keep one small furnace in blast. Every producing mine, and those that will produce in the future, would be compelled by necessity to join hands in a co-operative custom smelting industry. We would be confronted with the following questions:

(a) What classes of ore have we to smelt?

(b) What is the estimated annual tonnage of each class to be expected during the life of the district?

(c) Shall we enter the commercial markets with our arsenic by-products?

(d) What type of smelting should we adopt?

(e) What "base" will we use to collect the precious metals?
(f) What type of furnace?
(g) What fluxes would be required?
(h) Where should the plant be located?

(*a*) *Ore Classification.*

From a smelting point of view, three general classifications will suffice.

"Silver Ores."—Those ores carrying over 100 ozs. silver per ton. This silver is contained mainly as native silver. The composition of the ore may be described as consisting of equal parts of metallic arsenides and gangue, the principal arsenide being smaltite, the lesser arsenide as niccolite. The gangue is made up of calcite, with varying quantities of silicious gangue or wall-rock, and with small quantities of magnesia and very little iron, the latter as mispickel.

"Cobalt Ores."—Those ores containing less than 100 ozs. silver, per ton, and over 5% cobalt, averaging probably 7% cobalt, as smaltite, with a much smaller quantity of nickel as niccolite. The metallic arsenides and gangue rock being about equal, the gangue consisting mainly of wall-rock material, with a smaller quantity of calcite than the silver ores.

"Wall-Rock Ores."—An aluminium silicate, with "free" silica, and containing as high as 15% alumina, 5% lime, 7% iron, 5% magnesia, and 2% arsenic, carrying less than 100 ozs. silver, averaging probably 40 ozs.

(*b*) *Tonnage*

It would be impossible to form even an approximate idea of the life of the camp. A great deal would depend on the value of the smaltite ores low in silver. There being no ready market for such ores in the past, they have not been developed, and the tonnage is problematical. However, for the sake of argument, we will place the life of the camp at ten years, with an annual tonnage of ores and concentrates to be smelted at 12,000 tons. This might consist of 5,000 tons of "silver" ore, 5,000 tons of "cobalt" ore, and 2,000 tons of "wall-rock" ores, an average of 33 tons per day.

(c) *Commercial Arsenic*

The recovery of the arsenic, whether it be in a marketable condition or not, is a matter of great importance for many reasons. Whether we wish to recover or lose it, we will not meet with much success in either direction. If we decide to recover it by mechanically handling all of the gases at a short distance from the entrance to the dust chamber, the cost of doing so will probably exceed its market value, aside from the necessarily heavy cost of installation of plant. Unless we confine the gases in the smelting plant, the workmen's health will suffer. Unless we release the gases at a considerable distance from populated districts we will not be permitted to operate. If we roast the silver ores, the silver volatilization losses would probably put us in the hands of a receiver after the first clean up. Considerable difficulty will be experienced in roasting the arsenic below 14%. If we don't roast them, the quantity of speiss will be excessive, and its cobalt-nickel contents low.

After due consideration of the importance of all of these points, we would probably decide

(1) To roast the cobalt ores under 100 ozs. in silver.

(2) To smelt the silver ores, over 100 ozs. in silver, without roasting.

(3) To roast the speiss resulting from the smelting of both classes of ore.

(4) Not to install a plant for direct handling of the roasting or smelting gases.

(5) To construct a long dust chamber, which would convey the gases to a stack on higher ground and from one quarter to one half mile distant from the smelter, and in line with the prevailing air currents.

(6) At some later date, if conditions warranted, to install an arsenic refining plant, to treat the condensed arsenic vapors deposited naturally in the long dust chamber.

(7) To provide ample air pipes, connected with suction-fans, at all points around the works where arsenical dust or gases would be encountered by employees.

(8) In general, to forget the value of arsenic, and to prevent as far as possible the injury it might cause to the health of em-

ployees, and to locate the plant so as to do as little damage as possible to nearby vegetation, and populated districts.

(*d*) *Type of Smelting*

We have decided on smelting three classes of ore. One contains no arsenic to speak of. The silver ore is to be smelted raw. The cobalt ore is to be roasted. On account of the silver volatilization, it is not advisable to mix any more arsenic with the silver ores, even though that arsenic be partially in an oxidized form, such as the resulting product from the roasting of the cobalt ores. These two classes of ore should be smelted separately. The speiss from the treatment of both classes should be roasted and re-smelted, if necessary, until a point of enrichment was reached, wherein the cost of re-treating, plus the metallurgical losses, reached the point of economy under marketing conditions. Smelting methods may be classified, according to the prevailing atmosphere in the furnace, as neutral, oxidizing, or reducing.

Our "Silver Ores" should not be subjected to an oxidizing atmosphere, because of the resulting silver loss. A neutral condition might be acceptable under certain conditions for the lower grade silver ores, but for all grades the reducing atmosphere is ideal in so far as silver recovery is concerned.

The "Cobalt Ores", we have oxidized as far as practicable in the roasting furnace. The same conditions must be aimed at in smelting them, in order to eliminate the bulk of the arsenic, reducing the quantity of speiss formed, thereby enriching it in cobalt and nickel, and necessarily increasing its silver values. The aim of course being to keep the silver out of our marketable speiss, and to recover it in some other way.

Having decided that it would be advantageous to smelt one ore in a reducing, and the other in an oxidizing atmosphere, care should be exercised in selecting two furnaces in which to accomplish these reactions.

Reverberatory smelting furnaces are subject to slight changes in atmospheric conditions. At best they can only be controlled so as to produce a slightly reducing or slightly oxidizing condition, and are usually classified as "neutral atmosphere." Shaft furnaces are more under one's control in so far as the atmospheric conditions are concerned, and greater latitude is possible in securing highly oxidizing or strongly reducing conditions ; therefore, we would select a shaft furnace. The two principal subdivisions of shaft furnaces are those with or without a crucible. Before deciding this feature, we must know the "base" or "carrier" to be used in collecting the precious metals.

(e) *The Smelting Base*

In selecting a certain metallic substance as a collector for the precious metals, the selection should be carefully considered; none of our previous decisions are as important as this one. We are all more or less familiar with the bases used in smelting common types of ore, such as lead of the lead smelters, copper of the copper smelters, and the impure iron sulphide mattes of the pyritic smelters, but in our case we have not a type of ore commonly met with. Our ores do not contain any, or but fractional percentages of lead, copper, or iron sulphides. Therefore we cannot follow the examples set by others, without considerably modifying the conditions. Furthermore, in the nearby districts, there are either no great quantities of ores carrying lead or copper, or if in quantity, they have very small amounts of precious metals. It is true that in the province of Ontario we have all of those metals, but the province is large, and we cannot afford to haul low grade ores or fluxes across the province. To secure a furnace charge made up of such fluxes and carrier as would to a small degree pay their way through the furnace, we must consider moving the ores as well as the fluxes to the half-way point. On the other hand, if we smelt the ores locally, we would have to do so with fluxes carrying little or no precious metal values. The cost of producing and smelting barren fluxes would then be a direct charge to the smelting of the ore. It is necessary to consider the fluxes along with the base, because with certain bases a greater or less quantity of certain fluxes is necessary. Let us see what we have available. In Coleman Township, we have neither flux nor base, except such bases as are contained in our ores. On navigable waterways or railways we have, within a distance of:

5 miles:—Quarries of calcium-magnesium carbonates with 97% of those elements.

10 miles:—Quarries of calcium carbonate of 97%.

12 miles:—An ancient lead mine, described by the Provincial Geologist in part as follows:—

"Some of the rock here is conglomerate, associated "with which is porphyry. The latter is similar to rock in "Minnesota, which has been considered to be of doubtful "origin. The ore body lies in a zone of fracture which pene-"trates both of the rocks mentioned. Angular fragments of these "rocks, sometimes a foot or more in diameter, are cemented "together by calcite and galena. The pure galena has been "found to contain from 18 to 24 ozs. of silver to the ton of "2,000 lbs. Iron pyrites is found in small quantities "associated with the galena, and is thought to be the source "of the trace of gold usually present in the ore."

20 miles:—A six foot vein of clean pyrites, averaging 40% sulphur. Also, a pyrrhotite vein, touching the pyrite vein, which is also 6 feet wide. Samples of these veins shewed:—

	Au. $.	Ag. ozs.	Ni.%.	Cu.%.
Pyrites....................	$1.15	0.10	trace	0.15
Pyrrhotite	trace	trace	0.25	0.49

Also, in the same neighborhood, there are numerous smaller veins of pyrrhotite carrying up to 3% copper, but not developed. But these could be safely counted on as being capable of producing a very small steady tonnage. There are no other quantities of suitable fluxes along the line of the T. & N. O. Railway. This means that we would have to go much farther than 103 miles from Cobalt for other metals or fluxes. This would take us into Eastern Ontario for lead and copper ores, to Western or Southern Ontario for clean hematite ores, or to the Sudbury district for copper-nickel pyrrhotite ores.

Before going further, let us study the demands of our ores, with reference to the carrier and the fluxes.

We know that if we lead smelt the ores, as do the custom smelters in the States, while we may make a fair silver recovery, we will experience heavy lead losses. We will also have speiss troubles with the lead-well of the furnace. The lead bullion will be foul with arsenical impurities. The speiss will contain some lead, but it will be low in silver, and instead of lead-smelting, we will be speiss-smelting. This would be true to a greater extent than it is at the custom plants, because they have a large variety of ores with which to make up the smelting mixture. On the other hand, by lead-smelting, we would recover the silver values in an easily marketable product. Lead-smelting might be considered for our silver ores, but not for the cobalt ores. Copper-smelting, from a metallurgical view point, would appear to be a better method for the treatment of our cobalt ores, but it is not advisable on account of marketing conditions to mix quantities of copper with arsenic, nor is it advisable to mix cobalt or nickel with other valuable metals.

The difficulty of securing either copper or lead cheaply would probably decide us against using either metal if it could be avoided. Are they necessary? Suppose by adding a small quantity of hematite flux to our cobalt ores, they were melted; what would be the result? Clean slag and heavy speiss! Should the cobalt ores contain silver (the silver in nearly every instance is in the ore as native silver), we would find under the speiss a good percentage of the total silver contents as metallic silver. From this experiment we would conclude that lead and copper were in our case, luxuries, which we could not afford and did not need. The speiss will fulfil the mechanical actions of the "collector", without absorbing much silver. Therefore we would decide to smelt with speiss as a base.

(*f*) *The Furnace*

If we are not to use lead, then we do not need a lead furnace, with its deep crucible. We would decide on a shaft-furnace suitable for matting. Two of such furnaces would be required, one for oxidizing smelting the cobalt ores, the other for the reduction of the silver ores. Briefly, the main distinctions may be compared with standard lead and pyritic furnaces. The furnace for smelting the silver ores would be a lead furnace without a deep crucible, with good height of shaft, plenty of bosh, and with intermittent slag tap. It would be run with a high ore column, plenty of coke, and would discharge its liquid products at intervals into a suitable receiver. The volume of air would compare with lead-smelting practice. What is known as "cold blast" would be used, but in this cold climate, the thermometer reaching as low as 40° below zero, it would be advisable to warm the blast up to summer temperature. The furnace best suited for the cobalt ores and speiss smelting would be a matting furnace, similar to the pyritic furnaces. It would differ from the silver furnaces very materially. It would have a lower shaft, with less bosh, and a larger tuyer area. It would be run with a lower ore column, and with less coke. The volume of air would be very much greater, and would compare with the pyritic practice. A warmer blast would be used at all times to assist the burning of the arsenic. Each furnace would be provided with its separate blower and air line.

(*g*) *Flux*

For the silver ores, which contain a considerable quantity of calcite and a little magnesia and alumina, a small quantity of alkaline earths might be necessary. Calcium carbonate would be preferable to magnesia.

For the metallic oxide, oxides of iron or manganese must be secured. The quantity of metallic oxide used would have to be small on account of its cost, being brought in from a distance. The most important consideration, however, would be to aim to put the iron into the slag in preference to allowing the arsenic to draw large quantities of it into the speiss. Magnetite could be made use of, in small quantities, but its use is not to be recommended, on account of the difficulty experienced in making it enter the slag. In a strongly reducing atmosphere, its tendency is to reduce with the speiss or matte and form furnace "sows". Dead roasted iron ores or mattes would answer, but hematite or oxide of manganese is recommended, preferably manganese.

For the cobalt ores containing a smaller quantity of calcite and magnesia, with a larger quantity of silica and alumina, lime-rock would have to be used in quantity. A silicious lime slag would be our aim. With these ores, for the metallic oxide, economy must be considered.

(h) Locating the Smelter

In locating the plant, we would be influenced by many conditions. Among them might be mentioned the following:—

We have estimated the total output of the district at 120,000 tons of ore. When this tonnage was smelted, would the smelter be so situated that it could be made use of for treating custom ores from other districts? This question would be disposed of without further consideration, because of the fact that the cost of the plant would be wiped off by depreciation charges within ten years.

If the plant was centrally located in the Province, on account of the advantages derived from securing fluxing ores with metal values, in this way paying their own smelting costs, we would find ourselves buying ores in competition with larger custom smelters. We would also find that the mixing of our arsenides with large quantities of copper or lead ores was of no important advantage to our ores, and a detriment to the purchased ores.

It is not unlikely that oxidized iron ores may be found nearer to us than we now imagine. There are good reasons for expecting the hematite deposits on the east shores of Lake Temiskaming to more than supply our requirements.

There is now active work going on at Ragged Chutes, on the Montreal River, seven miles south of Cobalt, which will, within two years, develop 3,500 horse power, in the form of compressed air, by the Taylor Hydraulic System.

The Montreal River at low water, in the dry season, delivers over 1,000 cu. ft. of water per second.

At Hound Chutes, two miles farther up the river, is another dam-site, where it is proposed to install an electrical power plant.

These two power plants are in the centre of a timber berth reserved by the Provincial Government; both its surface and mineral rights are reserved. The area forms a square ten miles by ten, or approximately one hundred square miles. A smelter site near those two chutes could be reached by extending the railroad from Gillies station (four miles south of Cobalt), following the gradual fall of the river all the way, for a distance say of three to seven miles. Here, with numerous ideal sites, where the smoke would climb the surrounding hills, which are now traversed by the moose and the deer, there would be no law-suits from smoke damages. At least it would be expected of the Provincial Government that they would in some way continue to reserve this ground from settlement in order to encourage a home industry. Here, with very cheap power, an abundance of water, miles of cheap fuel wood, plenty of construction timber, seven miles from Cobalt, near to the proposed west shore extension of the Canadian Pacific Railway, is a smelter site beyond comparison.

CONCLUSIONS

We would produce bar silver which would contain probably 85% of silver, speiss with an uncertain amount of silver, the metal contents of which might vary according to market conditions and metallurgical difficulties, between 8 and 12% nickel, and from 15 to 25% cobalt. We have no desire to attempt to refine this material. The refining had preferably be done by those whose business it is. All we wish to do is to enrich our output, so that it can stand the expenses of shipment to distant markets. If we could improve the smelting conditions, or put the product in a more acceptable form for refining, it would be advantageous. Furthermore, if, after treating our products successfully, we could persuade the refiners to come to our district and establish their works in the field of production, the advantages would be incomprehensible. With these objects in view, let us make a further study of the metallurgical conditions involved.

To improve our roasting and smelting conditions, we must find ways and means of getting rid of more of the arsenic. We must also secure oxidized iron cheaply.

What means have we at hand for doing this in the simplest, cheapest, and best manner? Let us study the metallurgy of cobalt, nickel, arsenic and speiss, and see what effect other elements have upon them.

SULPHUR VS. ARSENIC

Let us study the effects produced by mixing sulphur with arsenic.

Consulting the second volume of Schnabel's "Metallurgy", we gather the following notes, at random and in part.

Arsenic.

Arsenic.—According to Conechy, arsenic volatilizes at a temperature of 449° to 450° C.

When heated with sulphur it forms sulphide of arsenic.

Arsenious oxide volatilizes when heated. The temperature at which it volatilizes is given by Wurtz at 200° C.

Arsenious Oxide is a Powerful Reducing Agent.—

Sulphides of Arsenic.—Arsenic forms three sulphides, arsenic disulphide As_2S_2, arsenic trisulphide As_2S_3, and arsenic pentasulphide As_2S_5.

The Extraction of Arsenic by the dry method.—When mispickel is distilled the arsenic is driven off and can be collected. The following equation shows theoretically the chemical change which takes place:—

$$2(FeAs_2FeS_2) = As_4 \quad 4\ FeS$$

When mispickel is treated in the way described above, sulphide of arsenic is volatilized at the beginning of the process and collects in the receiver (Freiberg).

The manufacture of Crude Arsenious Oxide.—Arsenical pyrites, mispickel, and native arsenic, either alone or mixed with other ores, are the special sources of arsenious oxide. The changes which occur when these are roasted are the following:—

Mispickel ($FeS_2 \quad FeAs_2$). Below red heat it evolves arsenic sulphide vapor. At higher temperatures it is converted into a mixture of ferric oxide, ferric sulphate, and ferric arseniate, sulphurous acid and arsenious oxide being at the same time liberated.

At Deloro, in Canada, mispickel which contained gold was formerly worked. The ore contained 42 per cent. of arsenic and 20 per cent. sulphur.

The production of Red Arsenic Glass or Realgcr.—It is not essential, in order to obtain a good product, that the sulphur and arsenic should be employed in the correct molecular proportions. The best proportions for a product of any particular shade are discovered by trial.

NICKEL.

Nickelous Oxide NiO.—If this oxide is heated with iron sulphide or arsenide, we get ferrous oxide and nickel sulphide or arsenide. Nickelous oxide and copper sulphide do not react.

Nickel Monosulphide.—Nickel sulphide is decomposed by copper with the separation of metallic nickel. When the sulphide is melted with an acid iron silicate, a very small quantity of nickel passes into the slag. If cobalt sulphide is present a considerably greater quantity thereof passes into the slag.

If nickelous and cobaltous oxides and cupric oxide are fused with silica and iron arsenide, containing sufficient arsenic, a nickel-cobalt-copper speiss is produced, while the iron forms a ferrous silicate.

According to Badoureau, when nickelous and cobaltous oxides are fused with arsenic or arsenical pyrites, almost the whole of the nickel and only part of the cobalt pass into the speiss.

If a nickel-iron speiss is fused, and air passed over it, the iron is oxidized first and converted into slag by the addition of silica. The nickel is oxidized only after the removal of the iron. The process can be so conducted that only the iron is removed, the nickel being left as arsenide. If cobalt is present in this speiss, it is oxidized and passes into slag after iron, but before nickel. The appearance of cobalt in the slag is detected by its blue colour. Therefore if it is desired to keep the cobalt in the speiss, the the process of oxidation must be stopped as soon as the blue colour appears in the slag. As a certain quantity of nickel goes with the cobalt, the blue coloration shows also the presence of some nickel in the slag.

If heavy spar, instead of quartz, is added during this fusion, the iron may be completely separated, for heavy spar and iron arsenide react, forming iron arseniate and barium sulphide, both of which are taken into the slag. Any copper present is converted into sulphide by the barium sulphide, and separates as a matte if in considerable quantity.

Silicates of Nickel.—When the silicate is smelted with iron pyrites, with copper pyrites, or with sulphides of the alkalies or alkaline earths, nickel is reduced, and forms a matte or mixture of matte and metal.

If it is smelted with arsenic or arsenical pyrites, it is very incompletely converted into nickel speiss.

Smelting of the roasted ore to produce coarse nickel matte. Antimoniates or arsenides are reduced to metal and partly volatilize as such. In the presence of undecomposed pyrites part of the arsenic is volatilized as sulphide. The remaining arsenic and antimony, if they are only in small quantities, pass into the matte; otherwise they form a speiss, combined chiefly with nickel and cobalt.

Extraction of nickel from the Silicate (*Garnierite*).—At present all the ore raised in New Caledonia is exported. The greater part comes to Europe, and there is smelted into a matte in blast furnaces with the addition of materials containing sulphur.

Extraction of Nickel from Arsenical Ores.—Roasting the Ores. When the ores are free from sulphur, the roasting should be regulated so that the arsenic is brought down to the quantity sufficient to combine with the whole of the nickel to form Ni_2As as the main product of the subsequent smelting. If the roasting is carried too far, and the quantity of arsenic is less than this, nickel will pass into the slag. When sulphur is present, the roasting should remove it as completely as possible, unless there is also copper enough to be worth extracting. In this case sulphur should be retained in such quantity that a copper matte is formed during smelting, and separates from the speiss.

During the roasting arsenic is converted partly into arsenic trioxide, partly into pentoxide. The iron and the nickel arsenides lose arsenic and become converted into oxides. The higher compound of arsenic is formed by the oxidation of the trioxide where it is contact with red-hot masses of ore, and the red-hot furnace walls; it combines partly with the iron and nickel oxides (with cobalt oxide and with silver also if present). Further, part of this arsenic pentoxide is reduced again to trioxide by contact with undecomposed arsenides, and with the lower metallic oxides, if any should be present. Arseniate of nickel is much more easily produced than the corresponding salt of iron. The arseniates are fairly stable at a high temperature, as they are not readily decomposable by heat alone. If it is desired to remove the arsenic from them, powdered coal or carbonaceous matter is added. By these means iron arseniate is somewhat readily converted into ferric oxide, while the acid radicle is converted into arsenic trioxide and suboxide, with the formation of carbon dioxide. Arseniates of cobalt and nickel are converted into arsenides, which, in a current of air, are converted into oxides and basic arseniates, with a loss of some arsenic as trioxide. The product of the roasting is accordingly a mixture of undecomposed arsenides, oxides and basic arseniates.

If metallic sulphides are present in the ores they are oxidized to sulphates. Vapours of sulphur trioxide are formed from sulphur dioxide by contact action, or from the decomposition of sulphates, and *exert an oxidizing action on arsenides,* which are partly converted into arseniates. Any arsenical pyrites (iron sulphide and arsenide) present in the ore, gives off fumes of sulphide of arsenic; at a red heat it is converted into a mixture of ferric oxide, sulphate and arseniate, setting free sulphur dioxide and arsenic trioxide.

Carbonates of iron and calcium, which are frequently present in nickel ores, are changed into arseniates of those metals, or into a mixture of sulphates and arseniates if sulphides are present. During this heating the heat must not be carried so high that any silica present forms silicate with nickel monoxide, because this nickel silicate is but imperfectly decomposed again, in the subsequent smelting, with the formation of arsenide of nickel. Thus, if sulphides are present in the ore, the product of roasting is a mixture of metallic sulphides, arsenides, oxides, sulphates and arseniates.

The roasting may be performed in heaps, stalls, reverberatory or shaft furnaces, or muffles. Since the complete removal of the arsenic is not really necessary, the ores are roasted in stalls in most works, these stalls allowing of the collection of arsenic trioxide in the chambers attached.

The Smelting of Nickel Ore into coarse Speiss.—The smelting is conducted so that a monosilicate containing at least 30 per cent. of ferrous oxide is formed. An acid slag will contain nickel. (According to Badoureau, when nickel and cobalt arsenides are smelted together with a slag containing 30 per cent. of ferrous oxide, the two former metals are practically absent from it).

The Dead Roasting of refined Nickel Speiss.—Apart from roasting, arsenic may be removed also by smelting the speiss with saltpetre and soda, or smelting it with soda and sulphur, and washing out the salts formed; or it can be removed in the form of sulphide of arsenic by heating the speiss with sulphur in absence of air.

COBALT.

The Extraction of Cobalt Oxide.—The matte from the Sesia Works at Oberschlema, in Saxony, is similarly treated. It contains 16% Ni, 14% Co, 50% Cu, and 20% S.

In "Hoffmann's Metallurgy of Lead" we find:—

To treat speiss so as to extract the silver, gold and copper economically has always been a difficult problem. With large quantities the cheapest way is to roast it in a heap of about 50 tons, which burns from two to four weeks. The imperfectly roasted speiss is sorted out, crushed and roasted in a calcining furnace. The whole is then smelted in the blast furnace with pyrite or matte. The result will be base bullion and a matte rich in copper and silver, and perhaps a small amount of speiss, in which any nickel and cobalt will be concentrated. This second speiss goes to a new heap of first speiss, as nickel and cobalt occur in such small quantities as not to call for any further attention.

With the small amount formed to-day, the simplest way is to crush it and roast it with sulphurets in the proportion of 1.10, in the reverberatory furnace, when the sulphur trioxide set free will decompose the arsenides and arsenates, converting them into sulphates.

In Peters' "Modern Copper Smelting" we find:—

Speiss, as ordinarily understood, is a basic arsenide, or antimonide of iron, often with nickel, cobalt, lead, bismuth, copper, etc., having a metallic luster, high specific gravity, and a strong tendency toward crystallization. It takes up gold with avidity, but has a less affinity for silver than copper matte has.

It has always seemed to me that here is a field that has not been sufficiently exploited. Especially since bessemerizing and pyritic smelting are becoming so important, it is worth while to consider to what degree, and with what advantages, speiss may be used to replace sulphides under favorable conditions.

We have several instances where it has been used to collect silver, gold or copper. A late notable example in the Transvaal, South Africa, of which, I regret to say, I have no personal knowledge, is described by Mr. W. Bettel in the Chemical News of June 26, 1891. He describes the production of an argentiferous, antimonial copper speiss of the following composition, from smelting oxidized, ferruginous ores, containing much antimonate of iron, and 4 per cent. of copper in the shape of carbonates, and 36 ounces silver per ton (0.123 per cent.).

Copper	52,50
Antimony	38.00
Arsenic	2.00
Sulphur	2.06
Iron	3.60
Silver	1.59
Lead	0.25
	100.00

The ore is smelted in reverberatory furnaces, and some 91 per cent. of the silver and copper is collected in the speiss. The concentration averages 16.4 tons into one.

In Lang's "Matte Smelting" we find:—

How Mattes are classified.—The classification under which I prefer for the present purpose to place both the mattes and speisses is as sulphide mattes, arsenide mattes, and antimonide mattes. Examples of each will be found in their appropriate places in the Table of Smelting Products accompanying this article.

The Composition of Mattes.—Of the various elements which enter into the composition of certain mattes, I quote the highest percentages and the lowest which are found therein:

	Highest	Lowest		Highest	Lowest
Iron	70.47	0.136	Platinum	0.0018	0.
Copper	80.	0.	Bismuth	1.26	0.
Lead	73.	0.	Molybdenum	2.31	0.
Zinc	11.5	0.	Calcium	7.	0.
Nickel	55.	0.	Barium	22.	0.
Cobalt	54.	0.	Sulphur	44.	trace
Manganese	3.	0.	Arsenic	52.	0.
Silver	5.	0.	Antimony	60.	0.
Gold	0.11	0.			

Arsenic and Antimony as Matte Formers.—Given molten metallic arsenides with access of air, and contact with silicious material, and silicates of metals result. Pursuing the dependant train of reasoning toward its logical conclusion, and carrying out the processes indicated, we are led to an application of the pyritic smelting and bessemerizing principles, and experiments actually show that under the influence of the air-blast the arsenides are decomposed with ease, more readily in fact than the sulphides to which those principles have been heretofore adapted. Experiments made by the writer on mixtures of fused sulphides and arsenides show conclusively the greater facility with which the latter are decomposed, and how the elimination of arsenic takes place before that of the sulphur, and with what high heat it is accompanied.

Conditions Governing the Absorption of Metals.—The useful result of the matting fusion in the presence of sulphur and arsenic is the saving of the valuable metals about in this order, beginning with that one which is found to be extracted most completely: gold, copper, nickel, cobalt, silver, lead. These, with iron, which is always present, constitute the metallic portion of the matte.

Treatment of Molten Mattes.—The most interesting of the arsenide mattes are those containing cobalt and nickel, metals which have a strong affinity for arsenic—an affinity which is taken advantage of sometimes in the beneficiation of their ores when these metals are sought in the presence of substances which exercise an opposing influence. It has been found advisable under some circumstances to make such an addition of arsenic bearing materials to cobalt or nickel ore as serves to bring about the formation of cobalt or nickel arsenide, while other heavy metals in the mixture separate therefrom as sulphides. In this manner it is possible to effect a useful separation of the two, even from very complex and difficult combinations.

Specific Gravity of Mattes.—The arrangement is as follows:—

Group 1. (Substances having a specific gravity not greater than 4.7). The sulphides of zinc, molybdenum, calcium and manganese.

Group 2. (Specific gravity between 4.7 and 5.5). The sulphides of barium, iron, cadmium, nickel, cobalt and copper, and the magnetic oxide of iron.

Group 3. (Specific gravities ranging from 6 to 9). The sulphides of silver, lead and bismuth; the arsenides and antimonides, and the sulpharsenides and sulphantimonides of silver, copper, bismuth, lead, iron, cobalt and nickel, and metallic lead, iron and copper.

Losses from Volatilization.—It is my impression that neither copper nor gold suffers loss from volatilization while undergoing the pyritic treatment; and in the absence of all testimony upon the matter we may allowably assume from the known characteristics of nickel and cobalt that they also do not. It would appear then that, so far as losses by volatilization are concerned, the pyritic process is better adapted to ores of gold, copper, and proably nickel and cobalt, than to those of silver. And better to silver than to lead.

In "Lead and Copper Smelting" by Hixon we find: At Leadville, Colo., Hixon altered a lead furnace for copper matting. He was producing 10% of matte with 15 to 40% copper. To the copper charge he added roasted speiss from the lead furnace, which contained 15 to 20% of arsenic with about the same amount of sulphur. He roasted one part of speiss to two parts of sulphide ore, and at times the roasting charge contained as high as 50% speiss. He smelted 3,000 tons of speiss in this way. In conclusion he states:

"It would naturally be expected that smelting with so much speiss on the charge a considerable quantity of speiss would be produced and would separate from the resulting matte. But such was not the case. When the furnaces were tapped it would frequently spark in the way which is characteristic of speiss, but after cooling there would be no line of separation in the pots, and upon being crushed and roasted and resmelted the product was a matte of very clean appearance with 40 to 50 per cent. copper, the arsenic contents of which did not exceed 5 per cent."

In "Pyritic Smelting" Dr. E. D. Peters, writing under the heading "Degree of Desulphurization Attainable," refers to Lang's results as follows:

A few years ago Lang made a run on the ores of the Blue Dick mine, near Prescott, Arizona, and obtained such remarkable results in the removal of sulphur and arsenic by an oxidizing smelting in the blast furnace, that it will be instructive to refer to it in this review. I take the facts from his letter published in the *Mining and Scientific Press* of March 29, 1902.

The ore is a mixture of quartz and mispickel, containing a little pyrite, chalcopyrite, tetrahedrite, galena, barite and spathic iron. The values are in gold and silver. As it was received at the furnace, its approximate composition was: Silica 45 per cent.; iron, 17; arsenic, 17; sulphur, 17; and copper, 0.5 per cent. It was necessary to add about 50 per cent. limestone to form the required slag. The circular trial-furnace was 36 in. in diameter at the tuyeres, and the cast-iron water jackets were only 30 in. high, the brick shaft extending to the charge door, which was 11 ft. above the tuyeres. The blast was cold, and the pressure only 9 oz. per sq. in. The resulting slag contained: Silica, 40 to 45 per cent.; ferrous oxide, 24 to 27; and lime, 20 to 24 per cent. Fifty tons of charge were smelted per 24 hours, being over 7 tons per sq. ft. of hearth area; a most extraordinary record for a small furnace run with cold blast, light pressure, and an acid slag; and due, in great part, to the unusual proportion of volatile constituents in the stock. The rate of concentration was still more remarkable when one recollects that the ore contained 34 per cent. sulphur and arsenic, being 27 tons of ore (ore in italics) into one ton of matte; and this matte was free from arsenic, though not sufficient in quantity to entirely cleanse the slags from silver.

Mr. Lang himself was evidently surprised at this unique result. He says: "As one-half of the ore consists of combustible matters (the iron sulpho-arsenides and sulphides) it appears that the decomposition was very extensive. Nearly 90 per cent. of the iron was oxidized and slagged off. Fifteen-sixteenths of the sulphur went up the chimney or into the slag; while all the arsenic was volatilized in some form or other. Vast quantities of deep yellow or red sulphide of arsenic presumably orpiment, passed out of the smoke-stack, succeeded by thick masses of pearl gray fumes containing arsenious oxide, etc. A good deal of metallic arsenic also is sublimed, but this speedily becomes oxidized, and permeates the atmosphere as gray smoke. Not a single particle of speiss or any other indication of arsenic appeared at the bottom of the furnace. The matte presents no peculiarities except its brittleness, arising, I presume, from the absence of metallic iron, due to the highly oxidizing action of the blast. It carries about 10 per cent. copper, which is not enough for a clean saving of the silver. Measures are being taken to procure a quantity of copper-bearing ores for admixture, so as to bring the copper contents of the matte up to 25 or 30 per cent., which will produce a cleaner separation of the silver".

Lang does not ascribe these results entirely to the oxidizing effects of the smelting, but believes that there happened to be a peculiarly favorable ratio between the proportions of sulphur and arsenic in the ore, which induced the extensive sublimation of these volatile substances, leaving the iron a prey to the oxygen of the blast. Such reactions as these furnish food for reflection and further experimentation.

SMELTING SMALTITE WITH PYRITES

We have gathered sufficient evidence of the advantages of eliminating arsenic by treating it with sulphur to decide us to take advantage of it. In doing so we not only simplify the metallurgical conditions, but we have remaining after using pyrites an oxidized iron flux, thus avoiding the necessity of buying hematite. Instead, we must buy pyrites.

Twenty miles distant by the railroad, from the proposed smelter, is situated the Pyrite Mine previously referred to. Nearby are other promising properties. There are less important deposits of an impure pyrite in the immediate neighborhood of the smelter site. The larger pyrite deposit is very clean, running 40% sulphur. A very small quantity of this would answer our requirements. We could take the fines, which are not so readily marketed, to the sulphuric acid burners. These would be mixed with the cobalt ores and the speiss, and roasted with them. Sulphide of arsenic would be driven off in the roasting furnace. The undecomposed sulphides and sulphates remaining in the roasted mixture, when smelted in the pyritic blast furnace, would have another opportunity to volatilize as sulphide of arsenic. The aim would be to leave only a small excess of arsenic in the speiss produced after the cobalt and nickel had been satisfied, in this way keeping the iron in the speiss low, and producing a high-grade cobalt-nickel speiss for marketing.

METALLURGICAL MANIPULATIONS.

In our previous calculations, smelting the ore with hematite, we had planned to make a large quantity of free metallic silver in the silver furnace. If the charge of cobalt, ores going to the cobalt furnace was close to 100 ozs. silver, we would expect to have made a very small quantity of free metallic silver to separate out. On the other hand, if the silver contents of the cobalt charge contained very little silver, we would expect it not to liquate from the speiss, but to be mechanically mixed with it, and therefore requiring a further separation in order to recover it. Now that we have decided to use pyrite on our cobalt charge, we would modify the resulting product from the pyritic furnace treating these ores. We would eliminate the annoyance caused by small quantities of silver separating from the speiss, by recovering in a matte all of this silver and a good percentage of the silver which the speiss would otherwise contain. Pure iron matte is not a good absorbent for silver, but our matte would not be pure. It would contain most of the bismuth in the charge. The ores contain fractional percentages of bismuth and of copper Some of the ores contain a considerable quantity of bismuth. The bismuth and copper, if in large enough quantities, would recover the silver in this impure iron matte. We would make sure of this by purchasing small quantities of copper pyrrhotite, which can be obtained near by.

As modified, the pyritic furnace would now produce clean slag, a cobalt-nickel speiss with much smaller silver contents, and an impure iron matte containing the greater part of the silver contents of the charge. This impure matte, in its crude state, would be resmelted in the same furnace a second or third time. On each occasion its retained sulphur would volatilize more arsenic. Its copper-bismuth contents would lessen the demand for fresh copper ores. Its silver contents would increase. When the silver reached a given assay, the matte would be crushed and roasted. If necessary the roasted matte would be ground finer and roasted a second time, to insure a dead roast. The desulphurized matte containing 1% or less of sulphur, and with less than 10% copper and some bismuth, would then go to the silver furnace, where its silver would be recovered, and the iron oxide slagged.

On account of small amounts of sulphur going to the silver furnace, we would now have to decide whether or not we would aim to recover the silver in its metallic form as previously described, or as silver-copper matte. Under normal conditions the silver furnace will produce an excessive quantity of speiss, on account of raw smelting; so much speiss that it would not be advisable to make matters worse by burdening the furnace with any quantity of matte.

If we recovered the silver in copper matte, we would have to market that product. We would then have to buy quantities of copper ores, and would be copper smelting. We cannot do either. We must stand by our original decision to produce metallic silver and speiss in the silver furnace. The speiss produced will be low grade and must be roasted and concentrated in the cobalt furnace. It matters not whether the speiss contains copper matte. All we are concerned about is to keep the quantity small, and to see that it does not bring with it too much silver to the cobalt furnace. What silver it would bring would be subject to further smelting losses, though the remainder would eventually come out of the silver furnace in time.

In considering the copper question, we must remember that the matte produced from the cobalt furnace will always contain less than 10% copper. There will be a considerable quantity of this iron-copper matte, and its gravity will be so much less than the speiss that a separation will take place.

When this roasted matte is fed to the silver furnace, there will not be sufficient sulphur in the charge to combine with the copper, therefore the copper must combine with the arsenic and enter the speiss. However, should it happen that our silver ores would contain more sulphur than is usual, and there would be sufficient sulphur to make matte, we would expect it to be a high grade copper matte, small in quantity, so small and heavy that it would not separate from the speiss. If a greater excess of sulphur was present, a larger quantity of lower grade copper-iron matte would separate from the speiss, and would have to be treated in some other way. Under such conditions we would not make any free silver in the silver furnace. It is doubtful if an average sulphur on our ores would exceed half of one per cent. The furnace will get rid of some sulphur. We have every reason to expect the copper to enter the speiss as arsenide. Therefore, we would make copper arsenide in the silver furnace, and copper sulphide in the cobalt furnace, and never have any copper to sell. We would buy a copper stock, and then an amount equivalent to the metal loss. Such details as these present themselves in every line of smelting. The question of successfully handling this copper matte can be met and conquered. Approximately, the metallurgical problem would resolve itself into the following system:—

SMELTING SYSTEM

To Roasting Stalls.

Lump speiss from silver furnace—"1st Speiss"
Lump speiss from cobalt furnace—"2nd Speiss"

To Mechanical Roasters.

(1) Crushed "1st Speiss" from stall roasters.
(2) " "2nd Speiss" " "
(3) "Ore Mixture"—Cobalt ores with pyrites.
(4) "2nd Matte" from cobalt furnace.

To Cobalt Furnace	*Products*
1st Smelting—	
Roasted Ore Mixture Roasted 1st Speiss Copper Pyrrhotite Ores Lime-rock	Clean slag 2nd Speiss 1st Matte
2nd Smelting—	
Roasted Ore Mixture Roasted 2nd Speiss Raw 1st Matte Wall-rock Ores Lime-rock	Clean slag 3rd Speiss (shipping product) 2nd Matte

To Silver Furnace	*Products*
Silver Ores Roasted 2nd Matte Wall-rock Ores Lime-rock Foul slag	Some foul slag 1st Speiss (containing copper as sulphide or arsenide) Silver Bullion

SULPHURIC ACID

The output of the Pyrites property referred to now goes to Buffalo for sulphuric acid manufacture. Its distance by rail from the proposed smelter site would be about 20 miles. With the cheap compressed air power at Ragged Chutes, there is no reason why acid could not be made cheaper there than in Buffalo. There may or may not be commercial reasons for not wishing to manufacture it in this district, but judging from the new manufacturing industries which are being developed along the lines of our northern railways it would appear to be advantageous to have it nearer to North Bay than to Buffalo. We could afford to give the new plant a little encouragement to locate near our smelter, by buying a small portion of their refuse cinder as a flux for our ores.

REFINING

All these things accomplished, we would then go to the "Refiners" with the following appeal:—

We are smelting 33 tons per day of cobalt-nickel ores, in addition to a small tonnage of custom ore from the neighboring districts of Cobalt.

We are producing——ounces of silver bullion containing approximately 85% silver, with bismuth and other impurities.

We are producing——tons of cobalt-nickel speiss containing ——ounces of silver, with approximately 50% of cobalt and nickel combined. The other 50% is made up chiefly of combined arsenic and of iron arsenides, free from lead, and with fractional percentages of other impurities.

We are producing large quantities of arsenical dust, which can be easily refined and sold direct to the trade.

Our plant is located in the centre of a large tract of land reserved by the Provincial Government, with whom we arranged, before building, to continue to reserve from public settlement for at least ten years, for the special purpose of fostering industrial enterprises of public importance.

Our ore supply from Coleman Township will last ten years. We have every reason to believe that, at the expiration of that time, the mining districts tributary to the Montreal River will be producing an equal tonnage of ore of somewhat similar character, and a much larger tonnage of copper ores, with precious metal values

The Canadian Pacific Railway will shortly extend their line north, along the west shore of Lake Temiskaming, and within the Reserve.

We are supplied with compressed air power at $—— per horse power per annum.

Electrical power will be worth $——

Sulphuric acid can be delivered for $——per ton.

Other chemicals can be obtained at reasonable prices in the Niagara Falls region.

We are producers, not refiners. We are in need of a refinery near our smelter. If satisfactory terms can be arranged, we will contract to sell, for a period of ——years, all our output, consisting of valuable metals in various furnace products.

GENERAL SUMMARY

The possible success of the smelting process outlined will depend upon certain metallurgical problems. These problems should form an interesting discussion. Given the two furnace charges and conditions as outlined:—

(1) Approximately what percentage of silver should be recovered in the cobalt furnace

(a) In matte?
(b) In speiss?

(2) Approximately what percentage of silver should be recovered in the silver furnace

(a) In matte?
(b) In speiss?
(c) In metal?

(3) Given a certain percentage of silver extracted in the silver furnace as metal, and another percentage in the cobalt-nickel speiss,

How much additional silver will be absorbed by the speiss if copper were added to the furnace charge?

(4) Is the process as outlined feasible?

Personally the writer is not at present prepared to say, but the important issues at stake would, at least, seem to justify further research and experiment.

MINING AT COBALT.

By Frank C. Loring, Mining Engineer, Toronto, Ont.

(Ottawa Meeting, 1908.)

This is an effort to consider the Cobalt silver mining district from the standpoint of the miner and mine operator. No attempt is made to discuss geology and its relation to the probable future of ore bodies. Able men have examined and reported upon the geology of the district as indicated by surface exposure, and have furnished valuable and accurate information. As to future probabilities in depth, I shall not express an opinion.

It is common knowledge that during the first two years of mining at Cobalt, but one object was in view, namely, to extract the rich ore found at the surface as quickly and with as little expense as possible. This was done so easily that extreme extravagance in mining and sorting ore was practised, the result being that many thousand dollars worth of silver lie buried in dumps, often covered with waste, which, had more economic methods been adopted, would have largely increased the output of the district. Many of the mines were discovered and operated by men entirely inexperienced in mining, whose sole object appeared to be to secure as much of their easily won fortune with the minimum of effort and without in any way providing for future contingencies or reverses. Often, little or no assaying was done. If the silver could not be recognised, the ore was not saved. Not until recently has any especial effort been made toward operation in a miner-like, scientific manner or toward provision for future development and regular, lasting production.

To near the close of 1906 the total value of machinery in the camp probably did not exceed $100,000, and the number of feet of cross-cuts, shafts, and like work of a strictly prospecting character was probably less than a thousand. With two or three exceptions, there was not a shaft in the district exceeding 100 feet in depth. Ore extraction by means of open cuts and underhand stoping was almost the universal practice, nor do I pretend to say but what, under the circumstances, this was advisable. There were no adequate sorting facilities, the ore being almost universally sorted either where shot down, or, without washing, at dump; all the fine material and ore not easily recognised being thrown upon the waste dump and often mixed with, or covered by, barren country rock.

So crude was the method adopted, that the report of one mining company, while showing the cost of production to be less than 10% of the value of ore extracted, made no reference to the fact that no dead work had been done and no attempt made to provide ore reserves. The natural inevitable result of the policy of this company, as well as of others, was that although a considerable tonnage had been extracted, practically no ore was blocked out in the mine, there were no reserves, and future probabilities became more than usual an uncertain quantity.

Since that time a radical change has slowly but surely taken place. Machinery for power, hoisting, pumping, and other purposes, amounting in value to possibly one million dollars has been installed. Adequate buildings have been erected at a majority of the mines for the accommodation of men and staff. Considerable surface and subterranean exploration has been done for the purpose of developing veins already known, and blocking out ore thereon; searching for other veins and obtaining knowledge as to probability of continuance of ore bodies longitudinally and at depth; the result being that in mines already in operation, many additional veins have been discovered at the surface, and many blind leads have been cut underground. The former practice was, that as soon as an ore body pinched or became lean, it was immediately dropped and another was picked up and mined to the same condition; the result being an impression which still exists with many, that ore bodies are but superficial and that veins have no lasting qualities. Where so many rich veins of little width exist, it is but reasonable to assume that a majority have slight extent; but there was little positive evidence to show whether or not veins continued further than the workings indicated, and whether or not at some other depth, pay ore recurred. All information was negative in this regard.

Many assumed, and some probably still maintain, that the veins consist solely of the rich pay streaks, that these are the only evidence of fissuring, and that, with their disappearance, the entire vein ceases. In many cases this assumption is correct, but it does not follow that there are no, possibly many, exceptions. Usually no comparison has been made between the history of the Cobalt district and that of other mining districts. Had there been, the fact that the same prediction has been made of nearly every other mining district in the world might have modified the positive opinion expressed. Thus to particularize this same doubt was expressed in the case of the deep gold quartz veins of Colorado and California, now developed in some instances to more than two thousand feet in depth; and it was repeated in the history of Leadville, New South Wales, British Columbia, and notably, Cripple Creek and Goldfield. There is no more common error than the assumption that an unqualified negation is indicative of conservatism. True conservatism, while often admitting lack of knowledge, is prepared to weigh any evidence, and to take any reasonable chance to obtain definite information.

During the new era, the limits of the producing area have been considerably extended; extensive and deeper explorations have been made; and although the quantity of silver sold in 1907 is about double that sold in 1906, the amount of ore available for future extraction has increased enormously, attributable to the fact that underhand stoping and open cut work have been largely supplanted by sinking shafts, driving levels, and adopting those methods of mining generally employed elsewhere. There are also notable instances of discovery of rich ore-chutes not coming to the surface, as in the case of the Temiskaming, McKinley-Darragh, Nova Scotia, Silver Queen, Foster, O'Brien, Coniagas, Trethewey, City of Cobalt, and probably other properties; sometimes in the same rock existing at the surface, and again with change in formation.

Nevertheless, astonishingly slight effort has been made toward deep exploration. There are often probably excellent economic reasons why this has not been done, but the fact remains that there is no mining region in the world approaching the production of the Cobalt district, where—with two or three notable exceptions—such slight depth has been explored and where so little effort has been made to attain positive knowledge as to the continuation of veins and recurrence of ore bodies to depth, and where less prospecting by means of cross-cuts has been done.

On one property, which has been in operation from the earliest history of the camp, one of the largest producers, upon which a considerable number of veins containing rich ore have been discovered, the greatest depth attained by any workings does not exceed 140 feet, and this, notwithstanding the fact that upon this property are some of the strongest evidences of deep fissuring to be seen in the district. It would seem that even a large amount expended in sinking at least one deep shaft and driving cross-cuts at various points therefrom, even though the work should result in discovering nothing of value, would be money well expended because of the information obtained.

None claims positive knowledge as to the nature or extent of the geological formation below the surface. The geology of that region is acknowledged as exceedingly complex. Deep exploration either by means of shafts or by borings, might, to some extent, solve this problem and might result in the admission that there is at least a fighting chance that pay ore would recur at various horizons, or with change in country rock.

Some of the veins show a width of region of movement or fracturing of several feet with comparatively well defined walls; and although between these walls, material is usually largely the same as that of the country rock, there is often a series of parallel faces or cracks, distinguishing it from the structure of the country rock. In these veins the streaks of calcite and ore are simply a secondary and minor incident. Occasionally the entire material between walls is silver shot, containing leaves of silver both vertical and horizontal, there being no silver found beyond the extreme walls. These fissures sometimes extend to a considerable distance, and are probably deep, and are known to maintain their strength in some instances through varying formations. If they are followed, probably at some point, either with change of formation or perhaps in the same formation, pay ore will be encountered. There are also a number of zones of weakness and faulting which contain more than one of these veins and often many minor cracks. On the Nipissing is a zone upon which exist a number of its principal ore producing veins, and which is known for more than a mile in length. The La Rose-Cobalt Lake-McKinley-Darragh system of veins is probably a second. Another exists on the Coniagas, Trethewey, and adjoining Nipissing and Amalgamated Cobalt territory. The north-easterly, south-westerly veins on the Lawson, Foster and University are on another zone, and there are undoubtedly a number of others in the district. These are worthy of deep exploration with a probability of success, but so long as the common policy holds of dissipating available funds in dividends, rather than as elsewhere, providing for development, Cobalt will never attain its true position as a permanent producer.

The average value of ore marketed is something over 600 ounces silver per ton. There are great extremes of value, ranging from six thousand ounces or even more in carload lots, down to less than one hundred ounces a ton, but the margin of profit on the lower grade ore is so small on account of expense of transportation and treatment that to attempt to dispose of it at present would be injudicious and extravagant.

Aside from ore marketed, there are in the dumps, many times as many tons carrying from 20 to 100 ounces silver, which are not a present source of revenue.

During the past six months, three concentrating plants have been erected, and are now, it is reported, in successful operation. Two other plants—for custom work—are being erected, while other mines also are considering the adoption of concentration. Undoubtedly nearly all of the principal mines will eventually employ concentration as a necessary factor in operation. Partially successful effort has been made to find markets for cobalt. Arsenic may in time be another source of profit. These metals should eventually materially add to the revenue of the district.

With proper attention given to systematic development and provision for the future, with concentration adopted when possible, with a market for all of the metals mined, and with the cost of transportation and reduction reduced to a minimum, there is a strong probability that Cobalt will enjoy a long and prosperous era of production.

METHODS OF CONCENTRATION AT COBALT, ONTARIO.

By Geo. E. Sancton.

(Cobalt Branch Meeting, May, 1908.)

At the present time there are three concentrators in active operation in the Cobalt Camp; namely, those at the Buffalo, the Cobalt Central and Coniagas Mines. In addition has been established an experimental mill at the McKinley-Darragh-Savage Mines of Cobalt, not at present in use, and the Muggley concentrator, a customs mill, which is not yet in readiness for operation. All of these plants are wet concentrators, in contradistinction to those in which the ore is concentrated in a perfectly dry state. Of this latter class of mill there is one in the camp—a custom concentrator which has not yet been put into service.

In a great many respects all of the three first mentioned mills employ the same method of treating the ores from the mines. The veins in the camp being comparatively narrow, none of the mines are able to so mine their ore that the underground work is done in vein matter only. At the mines in which the concentrators are installed, it is the custom to make in the mine a rough separation of the high grade ore from the rest of the material. This high grade ore is hoisted to the surface and sacked, as on account of its richness it needs no concentration. The remainder of the material is composed of a mixture of high grade ore, rock and ore of low values, and is hoisted and sent to the mill without any further picking or sorting. From this point the methods of treatment vary slightly in the different mills. The following is an outline of the manner in which the ores are concentrated in the three mills which are now working, and of the proposed method of treatment at the Muggley concentrator.

THE BUFFALO MINE

The ore to be concentrated is lifted from the underground working to a trestle, from which it is trammed directly in, over the main ore bin, at the highest point in the mill, and dumped over a 1″ space grizzly, which removes some of the fine material, which it is unnecessary to pass through the coarse crusher. Passing through the main crusher, which is a 6 x 20 Blake set to reduce ore to about ⅞″ size, the ore is elevated to a revolving trommel fitted with three sets of screens. These screens are of perforated metal with ⅝, ½ and ¼″ holes respectively. Oversize from the ⅝ screen and the product of the 1″ grizzly pass on to the fine rolls, which are spring rolls 20″ dia. by 20″ face. The material under ⅝ and over ½″ and the material under ½″ and over ¼″ is treated separately on 3 compartment Hartz jigs. The material under ¼″ passes over an impact screen fitted with 20 mesh wire screen, the product over the screen going to a third Hartz jig and the fines through the screen going to cone settler and thence to a Wilfley table. The middlings from this Wilfley table are returned to the table; the tailings are split up, the coarser portion being treated on a Deister slime table.

The tailings from all the jigs feed into a six foot Chilian mill and are reduced so as to pass through a 20 mesh slotted screen. The product of the Chilian mill passes over an impact screen fitted with 80 mesh wire screen, which removes the greater portion of the slimes, to be treated on a Deister slime table. The material which passes over the 80 mesh screen is fed on to four Deister tables, the tails from which, being of low value, go to the dump. These tails may later on be further treated by the cyanide process if sufficient silver remains in them to warrant it. At the present time about 40–50 tons of ore are being treated per twenty-four hours, the capacity of the mill being limited by the fine rolls. With fine rolls of greater capacity the mill would handle over 75 tons per twenty-four hours, provided more concentrating tables were installed also. The amount of ore treated in a given time varies greatly, as ores from some parts of the mine will go through the mill much more quickly than ores from other parts. A Corliss engine of 150 h.p. is used in driving the machinery.

THE COBALT CENTRAL MINE

The ore is trammed directly from the mouth of the shaft to a large bin from which the main crusher, a 10″ x 20″ Blake, is fed, the crusher discharging directly into the mill bin. From the mill bin the ore is fed by a plunger feeder to the roughing rolls, 42″ diameter by 14″ face, from which the ore is elevated to a 2 mesh trommel. The oversize from this trommel is returned to an oversize bin. When a sufficient quantity of oversize accumulates in this bin, the feed from the mill bin is shut off and the material from the oversize bin is fed into the large roughing rolls. The material passing through the 2 mesh trommel goes on to a No. 1 centripact screen fitted with 8 mesh screen cloth. The oversize from No. 1 centripact screen is treated on two Hartz jigs; the tails from the first are dewatered and reground by 10″ x 32″ finishing rolls, and the tails from the second are recrushed by 14″ x 30″ rolls, the products of the two sets of rolls uniting and being carried by a 7 x 12 elevator to the No. 2 centripact screen fitted with six mesh wire screens. This product, previous to being elevated, passes through dewatering screens to remove excess of water. The oversize from No. 3 centripact screen passes to one of these dewatering screens previous to being reground by the 14″ x 30″ rolls. The undersize from both the No. 1 centripact and the No. 2 centripacts feed on to No. 3 centripact screen, which is fitted with No. 16 wire screening. The oversize from this screen is reground in the 10″ x 32″ rolls, the material under 16 mesh meets the water from the dewatering screens and goes to two 20″ hydraulic classifiers and the sands from these classifiers are treated on four James tables. The overflow is settled in two Callow settlers and the thickened pulp is treated on two other James tables. The overflow from the Callow settlers, being practically clear water, goes to waste. The middlings from all six James tables are re-treated on the 7th James table; the tails from which, being of low value, go to the dump.

The mill, with average ore, is capable of handling about 50-60 tons per twenty-four hours. Of the values extracted about 70% are recovered by the jigs. In this mill all the fine grinding is done by rolls, the 10″ x 32″ rolls being set to crush to not over 16 mesh. The James tables are designed to also handle any slimes settling on a section of the table, which is left smooth and practically flat.

On this section of the table most of the values in the slimes are extracted. There is, however, very little work for this part of the table to do and the quantity saved on it is not great. On the average the tails from the James table run not over four to five ounces per ton. This mill is also driven by a 125 h.p. Corliss engine.

THE CONIAGAS MINE

The ore will eventually be raised from the mine in a skip and dumped directly into the mill storage bin through a long chute. Ore is first crushed in a 10 x 16 crusher, elevated, passed over a grizzly, recrushed by a 7 x 13 crusher and discharged into a storage bin. From this storage bin the ore is reduced to ¾″ by No. 1 rolls and elevated to No. 1 trommel, which has ¾″ and 5/16″ perforated steel screens. The oversize is returned to No. 1 rolls, which are 10 x 30; the oversize from the 5/16 and under ¾″ goes to two sets of Hartz jigs, the tailings from which are recrushed in No. 2 rolls. The undersize from the 5/16 screen goes to No. 3 trommel fitted with 3 millimeter screens. The oversize from this trommel goes to fine jigs, the tails from which go to a 5′ Huntington mill fitted with about 20 mesh slotted screens. The product from the 3 m.m. trommel, less than 3 m.m., is classified, the sands being treated on a Wilfley table and the slimes on a Frue vanner. The tails from the vanner also go to the Huntington mill. The tailings from the coarse jigs, after being recrushed in the No. 2 rolls, which are also 10 x 30, are elevated to No. 2 trommel, which is fitted with ½″ and ¼″ perforated metal screens. The oversize returns to No. 2 rolls; the product over ¼″ and under ½″ is ground in a ball mill fitted with about 20 mesh screen. The product from the trommel, which is under ¼″, goes to the No. 3 trommel previously mentioned. The materials from the Huntington mill and from the ball mill, crushed to 20 mesh and finer, unite and go to a classifier, the coarser product from which is treated on four No. 2 Deister tables. The tailings from the Deisters go to waste, the middlings being re-treated on a Wilfley table. The overflow from the classifier goes to a Callow settling tank and the thickened pulp is treated on a Frue vanner. This mill is driven by a Robb engine of about 100 h.p. capacity.

THE MUGGLEY CONCENTRATOR.

Ore to be concentrated will be taken up the incline tramway to the top of the mill and fed into a No. 4 style K. Gates crusher. From the crusher the ore will be fed into a set of Gates economic rolls, which crush to $\frac{3}{4}''$ and under. The ore will then pass over a screen with $1\frac{1}{8}''$ openings and go to a two compartment bull jig. The tails from the bull jig will be elevated and discharged by a belt elevator to the ore bins from which they will be fed by Challenge feeders to twenty 1,250 pound stamps. The mortars will be fitted with screens approx. of 20 mesh and the stamped material will be elevated to Richards annular vortex classifiers. The spigot product will be treated on four Wilfley tables, the overflow going to two 8′ callow tanks. The tails from the Wilfleys will be re-treated if found of sufficient value. The thickened material from the callow tanks will be treated on corrugated belt vanners, the tails from which will unite with the middlings from the Wilfley tables and go to 8′ settling tanks. The sands from the settling tanks will go to 8′ amalgam pans and to four 8′ settlers. The amalgam will be retorted and the tails let go to waste. It is estimated that the complete cost of treating ores in this mill will be from $4.00 to $12.00 per ton. It may be found necessary to roast the ore previous to amalgamation, and if this is done it will likely reduce the cost of treatment.

When the subject of the treatment of Cobalt ores was first considered, the main difficulty was thought to lie in the prevention of the crushed material from sliming, the general opinion being that the ore would slime to such an extent that the loss of values in the slimes would be very excessive, while the actual process of reducing the ore to a fine state was not considered as being a very important one. But as a matter of fact this order has been practically reversed, as there appears to be no great trouble in getting a good extraction, though the actual fine grinding of the material has proved a problem of great importance. The coarser reductions give little trouble, as the material breaks along its fractures and, furthermore, accurate crushing to size is not altogether important. When it comes to the fine grinding, the rock is particularly difficult to reduce. The small particles seem to be exceptionally hard and the wear on the rolls shells, or Chilian mill tyres, as the case may be, is very great, grooving taking place to such an extent that the capacity of the machines in the case of the Chilian mills and the capability to give a fine product in the case of the rolls is greatly reduced.

In connection with the fine grinding there is one mill, the erection of which is contemplated, in which it is proposed to use stamps. This method has much to recommend it. The cost per ton of ore crushed would not likely exceed 30 to 40 cents per ton, and this we do not think can be bettered by either fine grinding with a series of rolls or with Chilian or Huntington mills. To drive either of these machines a much greater horse power is required and the upkeep is more expensive both for parts and the amount of labour required to keep the machines in order. Half a day's work on a small stamp battery putting in new liners and refitting with new shoes and dies will make the battery practically as good as new. To overhaul a Chilian or Huntington mill thoroughly would probably take over a week at the least. Some silver would no doubt accumulate in the mortar boxes, but this would be no serious disadvantage as it could be easily and quickly cleared out as often as was found necessary.

The assertion has been made recently by one of the mine operators in Cobalt that stamps have no place in a concentrator. This statement, in the writer's opinion, is very broad and possibly rash in view of the number of stamps working with apparent success in many parts of the world. His statement, it is understood, covered milling in general and not only the reduction of Cobalt ores. The success of stamps in general as a crushing medium has been well shown at the Michigan Copper Company and other properties in the Lake Country. For the fine crushing in connection with the treatment of the jig tailings on tables, we think that stamps will ultimately prove to be the best device.

The treatment of the tailings from the concentrating tables from the various mills by the cyanide process is a matter which is open to a large amount of discussion. In Mexico this has certainly proved a success, but the conditions in that country are much more favourable than those in this district. Unless the tailings carry much higher values than is said to be the case, it will require very cheap treatment to justify the installation of the cyanide plants for the treatment of tailings solely. In Mexico the climatic conditions are more suitable, and the cheapness of labour also bears a strong influence on the success of the process. There the operations are largely in the hands of mining engineers from the Rand, who, having seen the great success of cyaniding in South Africa, have carried their ideas to Mexico, and introduced them there in the treatment of silver ores.

In the Republic Camp, in Washington, they are treating an ore in which the values of silver and gold are about the same. It is found that the gold is easily leached out, but that the recovery of the silver is a matter of three or four days.

The actual extraction that would ultimately be made on the tailings here in Cobalt by the cyanide process is not questioned, but it will be at the expense of a large consumption of cyanide and the leaching out will be very slow on account of the comparatively large pieces of silver—large by comparison with the minute state in which gold is disseminated through the low grade ores in the Rand—which will require to be dissolved. At a great many of the mines in Cobalt, chalcopyrite is found to some extent and it would all mix with the ore going to the mills. This, when it finally reached the cyanide tanks, would tend to increase the consumption of cyanide. The question, however, of the actual success of the cyanide treatment here will largely depend on whether the tailings are sufficiently rich to stand the cost of treatment.

In connection with the primary crushing of the rock in most of the mills now running, and in most of the mills whose erection is contemplated, the Blake type of crusher seems to be preferred in preference to the gyratory crusher. In the Blake crusher the wear is practically confined to two points, that is to say, at the lower ends of the jaw and wearing plates. For this reason the plates must be frequently renewed. In the gyratory crusher the wear is distributed over a far greater surface and the renewal of the concaves and the mantles is not necessary to the same degree. For a given amount of ore crushed the power taken is less; and, furthermore, the crusher head having a circular motion in contrast to the reciprocating motion of the jaw in the jaw crusher, the strain on the supports for the gyratory is not nearly so great; and in case where the crusher is located in the upper part of the mill building the shaking and vibration due to the crusher is far less. This would enable the upper portion of a mill building to be made lighter, as it would not have to be so strongly braced to hold the crusher from oscillating.

For treating the Cobalt ores the simplest form of mill would first crush the ore to about $\frac{7}{8}''$ size in a Gates crusher. This product would then be passed over a bull jig, which to a great extent would displace the need of hand sorting. These tailings would then be crushed with rolls, roughly sized and treated on two jigs. The tailings from these jigs would then go to the stamps, so arranged that any of the tailings which were not of sufficient value to treat could be run directly to waste. The silver which accumulates in the mortars could be removed periodically, and the product after leaving the stamps, treated on Wilfley or other suitable tables and corrugated belt vanners. As the actual tonnage of concentrates produced would be comparatively small, it might be found profitable to treat these concentrates in amalgamating pans fitted with mullers for grinding. This would amalgamate a large amount of the native silver and the amalgam could be retorted and the bullion shipped. The concentrates from which most of native silver would be removed could then be shipped to the smelters and their treatment would cost far less than if the original concentrates had been shipped.

In this scheme very little mechanical screening is used, only a coarse sizing for the jigs being made. No fine jigging would be attempted on account of the leanness of the material; it would be better to allow the finer material to go direct to the stamps. Attrition of the small pieces might also be an objection to fine jigging. The extensive use of trommels, screens and other mechanical sizers, would add greatly to the costs of the upkeep of the mill as there is usually a great amount of wear attached to machines of this class. On account of the hardness of the ore milled, the best and heaviest machinery on the market would be, there can be no doubt, the cheapest in the end.

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MINERALS AND ORES OF NORTHERN CANADA.

By J. B. Tyrrell, Toronto, Ontario.

(Ottawa Meeting, March, 1908.)

About twenty-one years ago the late Dr. George M. Dawson published a paper in the Annual Report of the Geological Survey of Canada for 1886, entitled "Notes to accompany a Geological Map of the northern portion of the Dominion of Canada, east of the Rocky Mountains," which contained a synopsis of the information at that time available on the geology and mineral resources of northern Canada. Attached to the paper is a coloured geological map depicting in graphic form the information collected together in the "Notes."

In the summer of 1897, nearly eleven years ago, I read a paper at the Toronto Meeting of the British Association, on the "Natural Resources of the Barren Lands of Canada," in which, among other things, a summary was given of the information then at hand of the known deposits of valuable or useful minerals in the more remote and inaccessible parts of the Dominion, west of Hudson Bay.

The time may not be inopportune to again review our knowledge of the mineral resources of northern Canada, including under that designation, not only the *Barren Lands*, but in a general way all those parts of the country which are north of, and remote from, the main lines of transportation.

It is thought that such a review may be interesting and useful to the mining men of Canada, and may form a useful record in the Journal of the Canadian Mining Institute.

No attempt at originality is here made. Many of the statements offered have already been recorded in the two papers above mentioned, but some additional information, which has been obtained in the past ten years has been added.

In such a review it is not necessary to include the gold fields of the Klondike, or the silver mines of the Cobalt district of Northern Ontario, as those have already been very fully discussed

No. 1. Red Conglomerate on the shore of Dubawnt Lake.

No. 2. Cliff of red Conglomerate on the shore of Dubawnt Lake.

in other places, and besides they do not come under the head of undeveloped minerals and ores which are here alone referred to, although there may be large areas in their vicinity in which future development will produce good rich mines.

Northern Canada, as here roughly understood and designated, is very largely underlain by rocks belonging to the very old geological formations, most of which were included under what has been known as the Archæan Complex, a mixture of igneous rocks and highly altered sediments melted and folded together in a very intricate manner. Underlying these more or less crystalline rocks are, in places, much less altered and often nearly horizontal Cambrian, Cambro-Silurian and Devonian sediments, while in the Arctic Islands the Carboniferous rocks, with thick beds of coal, are conspicuous and widely distributed.

The recent separation of the Keewatin and Huronian rocks throughout the northern United States and the better known parts of southern Canada, has not been carried out or attempted for northern Canada, and therefore with some few exceptions these formations will be considered together.

Dr. G. M. Dawson, in referring to the Huronian (including Keewatin) formation writes as follows:

"The distribution of the Huronian is important from an economic point of view, on account of its generally metalliferous character, which may eventually give value to tracts of country in which the rigorous nature of the climate entirely precludes the possibility of agriculture."*

And also "There can now be very little doubt that every square mile of the Huronian formation of Canada will sooner or later become an object of interest to the prospector, and that industries of considerable importance may yet be planted upon this formation in districts far to the north, or for other reasons at present regarded as barren and useless."†

GOLD.

It may not be generally known that gold mining is one of the first, if it is not actually the first industry started in Canada.

In 1576, a quarter of a century before Samuel de Champlain

*Geol. S.C. vol. 2. p. 7 R.
†G.S.C., vol. 8, p. 18 A.

first saw the St.Lawrence River, Martin Frobisher, one of the great navigators of the Elizabethan era, sailed north-westward from London, in search of a north-west passage to Cathay, and discovered Frobisher Bay on the east side of Baffin Island, north of Hudson Strait.

The account of Frobisher's three voyages to Frobisher Bay is given by Sir John Barrow in "A Chronological History of Voyages into the Arctic Regions, London, 1818," and a few extracts from this book will indicate something of the work then done, and the success or failure which attended it.

Among the various articles which Frobisher brought back to England was a piece of stone "much like to a sea cole in colour." "A piece of this black stone being given to one of the adventurers' wives, by chance she threw it into the fire; and whether from accident or curiosity, having quenched it while hot with vinegar, it glistened with a bright marquesset of gold. The noise of this incident was soon spread abroad, and the stone was assayed by the 'gold finers of London,' who reported that it contained a considerable quantity of gold. A new voyage was immediately set on foot for the following year, in which 'the captaine was specially directed by commission for the searching of more of this gold ore than for the searching any further discovery of the passage.'"*

"Frobisher was now openly countenanced by Queen Elizabeth, and on taking leave had the honour of kissing her Majesty's hand, who dismissed him 'with gracious countenance and comfortable words.' He was, besides, furnished with one 'toll ship of her Majesty's, named the *Ayde*, of nine-score tunnes or thereabouts; and two other little barkes likewise, the one called the *Gabriel*, and the other the *Michael*,' these two vessels were about thirty tons each. On the 27th of May, (1577) having received the sacrament, and prepared themselves 'as good christians toward God, and resolute men for all fortunes, they left Gravesend.

"They arrived off the north foreland, otherwise *Hall's* Island, so called after the man who had picked up the golden ore, and who was now master of the Gabriel.

"They proceeded some distance up the strait, when, on the

*A Chron. Hist. of Voyages into the Arctic Regions, by (Sir) John Barrow, London, 1818, p. 84.

18th of July, the general taking the gold-finers with him, landed near the spot where the ore had been picked up, but could not find in the whole island 'a piece so bigge as a walnut.' But all the neighbouring islands are stated to have good store of the ore. They then landed on Hall's greater island, where they also found a great quantity of the ore.

"They now stood over to the southern shore of Frobisher's Strait (Bay) and landed on a small island with the gold finers to search for ore; and 'here all the sands and cliffs did so glisten and had so bright a marquesite that it seemed all to be gold, but upon tryall made it proved no better than black-lead, and verified the proverbe—all is not gold that glisteneth.'

"Another small island, which they named Smith's Island, they found a mine of silver, and four sorts of ore 'to holde gold in good quantitie.'

"As the season was far advanced, and the general's commission directed him to search for gold ore, and to defer the further discovery of the passage till another time, they set about the loading of the ships, and in the space of twenty days, with the help of a few gentlemen and soldiers, got on board about two hundred tons of ore. On the 22nd of August, after making bonfire on the highest summit on this island, and firing a volley for a farewell 'in honour of the right Honourable Lady Anne, Countess of Warwicke, whose name it beareth,' they set sail homewards, and after a stormy passage, they all arrived safe in different ports of Great Britain, with the loss only of one man by sickness and another who was washed overboard.

"With respect to the ore brought in the *Ayde* and *Gabriel* it was ordered (by Queen Elizabeth) that this should be stored in Bristol Castle; and that it should be carefully weighed and placed under four locks, the four keys whereof were to be given in charge, one each, to the Mayor of Bristol, Sir Richard Barkley, Martin Frobisher and Michael Lock. The ore brought in the *Michael* was in like manner stored in the Tower of London, the keys in this instance being given in charge to the Warden of the Mint, the Workmaster of the Mint, Martin Frobisher and Michael Lock. The Queen also appointed Special Commissions to take in hand the examination of the ore and report on the value of the same.*

* Life of Sir Martin Frobisher, by Frank Jones, London, 1878, p. 19.

"Portions of the ore were from time to time charily and carefully dealt out by the Commissioners, under certificate, and official returns began to be furnished.*

But the assayers and "gold finers" squabbled and fought over its value; one Jonas Shutz, who had been with Frobisher on his second voyage, and who had directed the mining, claimed that, if properly treated and coaxed, it would yield £40 to the ton, while the goldsmiths of London said that they could not find any gold at all in it.

But most of the people interested believed firmly in the richness of the ore and "The Queen and her court were so highly delighted in 'finding that the matter of the gold ore had appearance and made show of great riches and profit, and the hope of the passage to Cathaia by this last voyage greatly increased,' that after a minute examination by the commissioners specially appointed, it was determined that the voyage was highly worthy of being followed up. The Queen gave the name *Meta incognito* to the newly discovered country, on which it was resolved to establish a colony. For this purpose a fleet of fifteen ships was got ready, and one hundred persons appointed to form the settlement, and remain there the whole year, keeping with them three to the ships; the other twelve were to bring back cargoes of gold ore. Frobisher was constituted admiral and general, and on taking leave, received from the Queen (Elizabeth) a gold chain, and the rest of the captains had the honour of kissing her Majesty's hand."

"The fleet sailed from Harwich on the 31st May, 1578." On the way "the bark *Dennis*, of one hundred tons, received such a blow with a rock of ice, that she sunk instantly in sight of the whole fleet, but the people were all saved. Unfortunately, however, she had on board part of the house which was intended to be erected for the winter settlers.

"At length, after many perils from storms, fogs and floating ice, the general and part of the fleet assembled in the *Countess of Warwick's Sound* in Frobisher's Bay, when a council was held on the 1st of August, at which it was determined to send all persons and things on shore upon Countess of Warick's Island; and on the 2nd August orders were proclaimed by sound of trumpet for

(*ibid, p. 93.)

No. 3.—Rapids above the Forks, Telgoa River, in Lat. 64° 25′.

No. 4.—Kewenawan, traps on Dubawnt River.

the guidance of the company during their abode thereon. It was determined in council that no habitation should be there this year.'

"Captain Best of the *Ann Francis* discovered 'a great black island,' where such plenty of black ore was found 'as might reasonably suffice all the gold gluttons of the world,' which island for cause of his good luck,' the captain called after his own name, *Best's Blessing*. He also ascended a high hill called *Hatton's Headland*, where he erected a column or cross of stone in token of Christian possession; 'here also he found plentie of black ore, and divers pretie stones.'" (Ibid, pp. 84–93.)

The work of loading the ships went on all through the month of August, and towards the end of the month two of them at least were fully loaded and ready to sail back to England, and doubtless most of the other ships had taken on some of the ore.

While the ore was being mined and loaded "the mason and carpenters, who had been brought over to put up the intended fort, had been for some time engaged in constructing a small house of lime and stone upon the Countess' Island. Within the house was built an oven, and to indicate the use of it, some baked bread was placed in the inside. They buried the remaining timbers of the intended fort, together with many barrels of meal, peas, grist, etc., being the provision intended for the colony."*

On the last day of August the ships set sail for England, where they arrived about the first of October, and as nothing more is heard of the ore which they brought back with them, it may be assumed to have been of no value. Certainly the Company of Cathay, which undertook this enterprise, met financial disaster,

Such is a brief account of the first prospecting expedition undertaken into Canada. Whether there was ever any reason, however slight, for this first stampede is not known, but the known occurrence of the crystalline limestones of the Grenville series in that region would indicate the possibility of the occurrence of ore of such kinds as are found in Eastern Ontario.

The scene of Frobisher's mining operations were unvisited and practically unknown for nearly three hundred years, and it remained for Captain C. F. Hall, in 1861 and 1862, while exploring

*The Life of Sir Martin Frobisher, Rev. Frank Jones, London, 1878, p. 146.

in Frobisher's Bay, to rediscover all that was left of Frobisher's stone house, and of the pits dug by him in his mining operations. Unfortunately, Hall seems to have known very little of mineralogy or geology, and the specimens of rocks brought back by him, were merely different varieties of mica schist.*

There could be very few summer journeys more interesting and instructive to the wealthy yachtsman than a visit to this part of Arctic Canada, and perhaps now that attention is drawn to the matter some yachtsman will visit the Countess of Warwick's Sound, and bring back an account with photographs of what mining was done there, and of the exact character of the rocks in which this mining was undertaken.

Dr. A. P. Low has drawn attention to the extent of the beds of sands and gravels on Baffin Land, and to the possibility of finding gold bearing placer deposits in them. The existence of these gravels should furnish an additional incentive to a thorough investigation of the mineral resources of that enormous island, either by the Government of Canada, or by private individuals.

In most parts of northern Canada, except in the Yukon Territory, prospecting for gold is difficult and uncertain work. The Klondike district was not overrun by the vast glaciers of the Glacial Period, and therefore beds of gravel have there been accumulating since Tertiary times at all events, and any gold that these gravels may have contained, has been the result of slow concentration from the surrounding rocks for a very long time, rather than of rapid concentration from rich gold-bearing lode in a short time.† The Continental portion of northern Canada, east of the Rocky Mountains was, as far as known, completely covered by ice during the Glacial Period, and all or nearly all of the surface deposits that had accumulated up to that time were removed and carried away by it to form the till or boulder-clay of the country further south, and consequently gold cannot be easily traced to its parent rock or vein by following particles of float gold up the streams. If gold should be found in any of the northern streams it would be more likely to have been derived immediately from the boulder-clay on the banks, than from veins in the neighbouring rock. If, there-

*Life with the Esquimaux, by Captain C. F. Hall, London, 1864.

†Concentration of Gold in the Klondike, by J. B. Tyrrell, Econ. Geol., Vol. 2, No. 4, 1897, pp. 343–9.

fore, it was desired to trace the gold to its origin in the rocks it would be necessary to follow back the course of the glacier, rather than the river or stream, to the place where it passed over these rocks. In practice, however, this is exceedingly difficult to do on account of the many changes in direction which it has undergone at different stages of its development. There is therefore no rational method of prospecting in that country but to search for the veins or lodes themselves, almost irrespective of float, and this is necessarily very tedious and laborious work.

Most of the gravel deposits of northern Canada, east of the Yukon Territory, are of recent origin, and could not be expected to be rich in gold unless they had been derived from rocks containing very rich gold-bearing lodes.

Dr. John Rae has recorded the occurrence of gold-bearing quartz veins in Wager Inlet, west of Roe's Welcome, and north of the north-west portion of Hudson Bay.

Gold also occurs in the sands of the Athabasca, Peace, McLeod and other rivers flowing from the east side of the Rocky Mountains, having probably been derived from the wearing down of the Laramie sandstones which form the river banks.

SILVER.

Silver is very rarely seen by the ordinary traveller or prospector when passing along the waterways or over the portages throughout the country. It has few highly coloured salts or ores, and is usually associated with a soft gangue which will be found in hollows and depressions in the general surface, and which consequently will in most cases be covered over with clay, sand or debris of some kind. The veins must therefore be uncovered with pick and shovel before their true nature can be determined. The discovery in this way of such a large number of silver-bearing veins in the Cobalt and Elk Lake districts of Ontario has been quite a revelation in this respect, and points confidently to the hope that many other areas of Huronian rocks, when correctly prospected for silver, will also afford satisfactory results. When it is remembered that probably much less than one per cent. of the surface even of the rocky country is naturally exposed to view, and that it is in the hollows that the silver is to be found, the improbability of finding silver veins can be easily understood.

On the east coast of Hudson Bay, between Little Whale River and Richmond Gulf, silver bearing galena occurs in a band of Magnesian limestone. Drs. Bell and Low record this galena as assaying from 5 to 12 oz. to the ton.

Copper.

The presence of copper is much more easily recognized than either gold or silver, for many of its salts or ores are highly coloured, bright green being very prevalent, and many of its ores are associated with harder rock or vein material, so that they may often be found on salient points or distinct elevations of the surface.

Bornite has been recorded by C. F. Hall as occurring in Frobisher Bay, and copper ore is spoken of by Sir John Ross as occurring at Agnew River.

On the north-west side of Hudson Bay, between Baker's Foreland and Cape Eskimo, the Keewatin greenstone has disseminated through it a quantity of copper pyrite. No large deposit was seen, but where the mineral is as freely distributed through the mass of the rock, it is not at all improbable that large deposits may be found in favourable situations, especially near contacts with later intrusions.

Dr. Robert Bell records the occurrence of copper ore on Great Slave Lake as follows "On the north-west side of McLeod Bay small interrupted gash veins and stringers of calc-spar are found in the primitive gneiss and granite, and some of them contain nuggets of chalcopyrite.

Dr. J. M. Bell speaks of numerous interrupted stringers of calc-spar containing chalcopyrite in the greenstones east of McTavish Bay, Great Slave Lake.

Chalcopyrite was found by the writer in a dike of diabase on an island in Pipstone Lake, Nelson River.

In the Yukon Territory the copper-bearing belt at Whitehorse would appear to extend westward towards Rainy Hollow. At this latter place lodes of bornite and chalcopyrite have been located, and from what can be learned of them from others, they only await reasonable facilities for transportation, in order to be capable of being developed into mines.

On the White and Copper Rivers, near the Boundary between Yukon Territory and Alaska, native copper occurs. This copper is found loose in the gravel of the river bed, and it has been proposed to work some of these gravel beds as copper placers, similar in most respects to the gold placers, except in the character of the metallic contents.

But the most interesting, and probably the most extensive copper deposits in Canada are contained in the Keweenawan traps and sandstones which extend along south of the Arctic coast from Coppermine River eastward to Bathurst Inlet.

The occurrence of native copper in that country has been known to the Indians, and Eskimos from time immemorial, and the metal has been commonly used by them to make knives and other implements. The first journey that was made by a white man into the northern country, 137 years ago, was made in search for this "mine" of copper.

The Copper Mountains, near the Coppermine River, were visited by Sir John Richardson in 1821, and again in 1826, but there is no record that they have been visited by any one capable of describing them since that date.

His description of them is as follows: "The Copper Mountains consist principally of trap rocks. The great mass of the rock in the mountains seems to consist of felspar in various conditions; some times in the form of felspar rock or claystone, but most generally in the form of dark reddish brown amygdaloid. The amygdaloidal masses contained in the amygdaloid are either entirely pistacite (epidote), or pistacite enclosing calc-spar. Scales of native copper are very generally disseminated through this rock, through a species of trap tuff which nearly resembles it, and also through a reddish sandstone on which it appears to rest. The rough and in general rounded and more elevated parts of the mountain are composed of the amygdaloid, but between the eminences there occur many narrow and deep valleys, which are bounded by perpendicular mural precipices of greenstone. It is in these valleys, among the loose soil, that the Indians search for copper. Among the specimens we picked up in these valleys were plates of native copper; masses of pistacite containing native copper; of trap rock with associated native copper; green malachite, copper glance, or variegated copper ore, and of greenish gray prehnite in trap with disseminated native copper; the copper in some specimens was crystallized in rhomboidal dodecahedrons. We also found some large tabular fragments, evidently portions of a vein consisting of prehnite, associated with calcareous spar and native copper. The Indians dig wherever they observe the prehnite lying on the soil, experience having taught them that the largest pieces of copper are found associated with it. We did not observe the vein in its original repository, nor does it appear that the Indians have found it, but judging from the specimens just mentioned, it most probably traverses felspathose trap. We also picked up some fragment of a greenish grey coloured rock, apparently sandstone, with disseminated variegated copper ore and copper glance; likewise rhomboidal fragments of white calcareous spar, and some rock crystals. The Indians report that they have found copper in every part of this range, which they have examined for thirty or forty miles to the N.W., and that the Esquimaux come hither to search for that metal. We afterwards found some ice chisels in the possession of the latter people, twelve or fourteen inches long, and half an inch in diameter, formed of pure copper.*

In 1902, Mr. David Hanbury travelled from Chesterfield Inlet to Great Bear Lake, passing on the way along the shore of the Arctic Ocean, and up the Coppermine River, though he did not visit the Copper Mountains.

He describes the Rocks of Bathurst Inlet and the neighbouring parts of the Arctic Coast as follows:—

"On the 16th (June, 1902) we reached Barry Island, which one of my Eskimo had described as the best place for copper. He now said copper was more plentiful on an island six or eight miles north of Fowler Bay. However, two pieces of native copper were found in the evening.

"The main rock of the island is a fine-grained basalt". It is in this rock that the native copper occurs. The copper is plentiful, for the quantity we obtained was found after but a brief search, and on a neighbouring island, Kun-nu-Yuk, a mass of copper had just been found so large that a man could hardly lift it. There, also, copper is often found in the tide-way. The whole of the lower levels on Barry Island are covered with debris from the basalt, and when the rock has been distinguished by

* Narrative of a Journey to the Shores of the Polar Sea, by Capt. J. Franklin, London, 4to., 1823, p. 528.

weathering, copper has fallen out, so that flakes of the metal may be found along the sea shore."

Seven days later he says "We passed a small basaltic island, on which two pieces of copper ore were picked up. It seems as if copper is to be found wherever this basalt occurs."

On the 25th June he camped on Lewis Island. "This Island is formed of the same partly decomposed basalt as Barry Island. Although we did not find so much copper here, the green marks on the rocks were more numerous, but we did not spend an hour altogether in the search. One of our Eskimo knew of a large mass of copper on the south-west shore of the island, which he stated to be as much as five feet in length, and three inches thick, it protruded from the rocks under the water, it was said, but there was too much ice for us to find the copper. A piece of quartz with copper ore and native copper was picked up on the sea shore.

"On the 27th we rested at the north-west point of Lewis Island, where we again found the copper-bearing basalt, and accordingly we commenced a search that resulted in our collecting about two pounds weight of copper. The metal appeared to be very persistent in its occurrence in the partly decomposed basalt, of which the islands we passed that day consisted. The flakes of copper seemed to be always vertical when in their rock matrix."*

In writing of his journey up the Coppermine River, he says:— "While tracking, Sandy was nearly tripped up by a chunk of native copper on the shore. It weighed about twelve pounds."†

During my exploration of the Dubawnt River in 1893, the Keweenawan rocks, similar to those of the Coppermine, were met with about the middle of the west shore of Dubawnt Lake, whence they were found to extend north-north-eastward for 125 miles to the Forks of the Dubawnt River, and from there they were traced eastward for 175 miles to the outlet of Baker Lake. In 1900, James W. Tyrrell traced the same rocks westward up the Thelon River for about 125 miles.

While native copper was nowhere found in the rock formations on the Dubawnt River, this great extension of the Keweenawan series indicates the possibility of its occurrence throughout a very extensive tract of that northern country, and when

*Sport and Travel in the Northland of Canada, by D. Hanbury, p. 265-6.
†96 id, p. 206.

Hudson Bay becomes easily accessible by a railway to Fort Churchill, these copper-bearing rocks should prove an attractive field to prospectors.

LEAD.

Veins of galena have been noticed at a few places.

Drs. Bell and Low record the occurrence of a vein of galena on the east side of Hudson Bay, near Richmond Gulf. A number of years ago the Hudson's Bay Co. attempted mining here for a short time, but apparently without much success.

Sir John Richardson mentions the occurrence of a "narrow vein of pure galena" cutting gneissic rock at Galena Point, 14 miles south of Cape Barrow, on Bathurst Inlet (on the Arctic Coast).

Dr. Robert Bell speaks of the occurrence of galena in the Devonian limestone south-east of Great Slave Lake.

In describing the resources of the valley of Mackenzie River, Mr. Von Hammerstein makes the following statement: "At Black Bay on Lake Athabasca there is a first-class galena, none better. It carries gold, silver and copper. Assays $6 or $7 in gold. "There is a big seam near Black Bay, and you can follow it right along till you come to an island."

IRON.

In the Labrador Peninsula, and in the District of Ungava, vast deposits of hematite and magnetite have been outlined by Dr. Low as extending from near Hamilton Inlet northward to Ungava Bay, but here, as in most other parts of Northern Canada iron ore would not as yet stand the cost of transportation.

On the Nastapoka Islands, which extend along the east side of Hudson Bay for a hundred miles north of Little Whale River, are also very extensive beds of banded iron ores. For a description of these deposits I would refer to "The Cruise of the Neptune," by A. P. Low, Ottawa, Govt., 1906, pp. 239–245.

On the Great Fish River, Mr. Warburton Pike speaks of the ironstone, of dark fissile slates and schists, as extending down the river from Musk Ox Lake to Beechey Lake, a distance of 75 miles.

No. 5.—Exploring the shore of Hudson Bay.

No. 6.—Cliffs of Keewatin greenstones, Rankin Inlet, Hudson Bay.

Captain Dawson is reported to have found specular iron ore in the vicinity of Great Slave Lake.

On the north shore of Athabasca Lake I found what seemed seemed to be a large body of iron ore, but the necessity of rapid travel prevented its exploration.

COBALT.

Great Bear Lake.—In the greenstones, East of MacTavish Bay, occur numerous interrupted stringers of calc-spar, and the steep rocky shores which here present themselves to the lake are often stained with cobalt bloom. (J. M. Bell).

Great Slave Lake.—On the north shore of the bay west of the Narrows between Christie and McLeod Bays, cobalt bloom was seen in the cracks in the greenstone. (R. Bell).

NICKEL.

Norite on Upper Weenisk River, similar to the norite at Sudbury, though no nickel has yet been found in it. (McInnis).

On the north bank of Stone River east of Lake Athabasca, there is also a high ridge of norite, which should be well worth careful exploration.

Pyrrhotite on the east coast of Hudson Bay was found to contain small quantities of nickel. (Low).

ANTIMONY.

During the past two years some important discoveries of high grade stibnite have been made in the Wheaton district in the Yukon Territory, south-west of the town of Whitehorse. The veins are reported to be large and some very nice specimens of ore have been seen from them, and doubtless some of them will be developed before long.

BISMUTH.

Nuggets of native bismuth have been found occurring with gold in the placers of the Duncan Creek District, Yukon Territory.

TIN.

Cassiterite or Stream-tin is found in small quantities in some of the placers in the Klondike District, Yukon Territory.

TUNGSTEN.

Scheelite has also been found in the gold-bearing sands of the Duncan Creek District, Yukon Territory.

COAL.

Coals varying in character from excellent bituminous coals to low grade lignites are found in the vast northern wilderness.

Bituminous coals of Carboniferous age occur in many of the Arctic Islands. For a short but succinct account of their distribution reference may be made to *The Cruise of the Neptune*, by A. P. Low, pp. 222 to 229 and 247.

Similar coal, though in this case of Cretaceous age, has recently been traced northward from the Bow River Basin in the Rocky Mountain Range, and the northern limit of these beds is as yet quite indefinite.

An interesting possibility of the existence of beds of bituminous coal of Carboniferous age in Manitoba and the provinces to the north and west was suggested by the writer some years ago. In Iowa, about 400 miles south of Manitoba, the geological formations extend upwards in orderly and conformable series overlapping each other from east to west, from the Cambro-Silurian up through the Silurian and Devonian to the Carboniferous. The latter terrain contains extensive beds of coal from which millions of tons are mined every year. North of the State of Iowa in Minnesota these Paleozoic formations are very largely covered and hidden by sandstones and shales of Cretaceous age which overlie them unconformably. In Manitoba the lower portion of the Palaeozoic series is again exposed, and the rocks can be followed upwards from the Cambro-Silurian through the Silurian to the Devonian, but at this point they are again covered unconformably by Cretaceous sandstones and shales. In Northwestern Manitoba the Upper Devonian limestones can be seen close to the edge of the underlying Cretaceous beds.

Whether the Carboniferous Formation, which should follow the Devonian in ascending order, is present under these Cretaceous beds or not is not known. It is possible, though hardly probable, that it may have never been deposited in that region, or if it was deposited it may have been removed, partly or entirely, by erosion in the long period between the close of the Carboniferous age and the beginning of the Cretaceous. But on the contrary it is not improbable that the Carboniferous formation may be present, overlying the Devonian in regular sequence, beneath the covering of Cretaceous shales. If such should be found to be the case, and that the formation here, as in so many other places, should be found to be rich in beds of coal, the question of fuel for a large portion of central Canada would be solved for many years to come. The possibility of the existence of such an adequate supply of fuel, when it is so much needed, should be thoroughly investigated in the very near future.

Lignites of Cretaceous age are known to outcrop in many places from the great plains northward down the valley of the Mackenzie River.

NATURAL TAR.

Tar or maltha occurs in the sandstones at the base of the Cretaceous formation for long distances down the Athabasca River, though the problem of how it can be utilized in its present form is as yet unsolved. The hope is still strong and prevalent that liquid oil may be found near where these "Tar Sands" are now known to outcrop.

Other minerals are known to occur in the north, but it is not necessary to enumerate them here as they would not bear long inland transportation and could only be developed as the country itself becomes populated.

With regard to the possibility of living and making a home in even the most inhospitable parts of northern Canada, I wish to emphasize what I have already said in a paper written eleven years ago, that no part of that country is as cold and inhospitable as many inhabited parts of Siberia. The mean summer (3 months) temperature determines the limit of the forest, and the possibility of the growth of trees and cereals. Mr. Stupart, Director of the Meteorological Service of Canada, places the summer isotherm of 57.5° as the northern limit of the successful growth of wheat, and this is the mean summer temperature of Dawson, Yukon Territory. On the contrary the mean winter, or perhaps the mean January temperature would probably determine the habitability of the country for human beings. Now Fort Good Hope, on the Mackenzie river, is the coldest known place in Canada, with a mean January temperature of –28° F., and Dawson is not far behind it with a January mean of –23.6° F., while Yakutsk, a town of about five thousand inhabitants, in Siberia, has a mean January temperature of –40.4° F., and many other places in northern Asia are still colder, one town having a mean January temperature of –56.2° F.

It is thus seen that inhabitants of the old world live and thrive in a much more rigorous climate than is found even in the coldest parts of northern Canada, and that therefore the climate does not offer any insuperable objection to settlement if minerals or ores are anywhere found in paying quantities.

DISCUSSION.

MR. CAMPBELL:—Did you see any coal in that north country?

MR. TYRRELL:—The coal in the interior is all lignitic. But there is good coal in the Arctic Islands. I have never seen it, but the coal has been used by some of the whalers. I understand it is bituminous coal.

DR. GOODWIN:—I would like to ask how the conditions of mining would compare with those in the mining districts of Siberia. Would life be as endurable there, and are there any railway possibilities?

MR. TYRRELL:—The conditions of life up to the Arctic circle in Canada are fairly easy. Much of the country is what we know as "barren lands," treeless country, but bright with flowers and abundant grass in summer. The growth of vegetation in a country depends upon the warmth of the summer, not on the coldness of the winter. One of the coldest parts of North America in the winter is the Klondyke; but it is warm in summer, so that there is abundant growth of trees, and no one there suffers any particular hardship, except from isolation. In the Great Slave Lake or Great Bear Lake districts the winter is no colder than in the Klondyke. The conditions that make life hard for people are not nearly as bad in the very coldest parts of Canada as in many parts of Siberia. One city in Siberia has a mean January temperature of 56 deg. below zero. There is no such mean monthly temperature known in North America at all. If a mining industry were to start in our far north country, there would be no particular difficulty in establishing a standard of comfort equal to that enjoyed in many parts of the great plains.

With regard to railways, a road could be built from Churchill to Athabasca Lake far more easily than in many parts of Ontario. The distance from Churchill to the Athabasca River could probably be built for little more than half the cost per mile of building the Temiskaming and Northern Ontario railway. It is an easier country to build through, so that if there is ever any object in building such a railway the factor of cost will not be very great, though, possibly, the suitability of a country for human habitation may depend on its winter temperature.

DR. GOODWIN:—We are glad to hear this from so experienced an explorer as Mr. Tyrrell, because if the Russians could exploit the mineral riches of Siberia and build cities there, surely Canadians could take advantage of our northern country to which Mr. Tyrrell has so interestingly alluded.

THE OCCURRENCE OF TUNGSTEN ORES IN CANADA

By T. L. Walker, University of Toronto.

(Ottawa Meeting, March, 1908)

In 1904 the Geological Survey of Canada issued a bulletin on the occurrence of molybdenum and tungsten (1) in Canada. At that time the known occurrences were the following: Inverness and Queens Counties, N.S., Beauce County, P.Q., and a reported occurrence of wolframite in a boulder on Chief's Island, Lake Coutchiching, Ontario. More recently (2) Mr. R. A. A. Johnston, curator of the Geological survey's Museum, has recognized scheelite in the heavy sands from gold washings in the Yukon, while wolframite, scheelite and hubernite have been found in the tin deposit near New Ross, Lunenburg Co., N. S.

Since the appearance of this bulletin several discoveries of tungsten minerals have been recorded. It is my object in the present statement to bring together the information regarding recently recorded discoveries of tungsten, and to briefly describe some occurrences not hitherto published.

Occurrences Already Recorded.

Slocan district.—In the reports of the Minister of Mines for British Columbia several localities have been indicated. The report for 1903 (3) mentions the discovery of masses of scheelite occurring in vein quartz in the form of lenses at the Meteor Mine in the Slocan District. The lenses vary in length from one to three feet, a total of 500 pounds being saved after the identification of the mineral.

(1) Molybdenum and Tungsten by R. A. A. Johnston and C. W. Willmott, 1904.

(2) Summary Report, Geol. Survey of Canada, 1907, p. 82.

(3) Report of the Minister of Mines, 1903, p. 138.

In the subsequent reports of the Minister of Mines no reference is made to the production of scheelite in this district. The occurrence of scheelite or of other tungsten minerals in silver lead veins is unusual.

Cariboo District.—In 1904 an important discovery of scheelite was made on Hardscrabble Creek in the Cariboo District. Mr. Akin first discovered this mineral in the black sands obtained in gold washing and later succeeded in locating the scheelite in place. He describes the geological occurrence as follows: [1]

"This consists of highly altered country rock, the scheelite being scattered through it in small patches, but it is in the quartz stringers that most of the mineral is found. Some of these, varying from one inch to four inches wide, contain about one-third scheelite, with a little galena, and products of decomposition of iron pyrites. This zone appears to be from 12 to 20 feet wide, as determined by work done up to July, 1904, and gives every promise of turning out a valuable deposit."

After experimenting on the concentration of the scheelite by washing, a quantity was sent to Chicago to be tested and as a result of these tests was stated to be worth $460 per ton at the prices then current.

Promising as this first report seemed it does not appear from the later reports of the Minister of Mines to have been followed by active development.

OCCURRENCES NOT PREVIOUSLY REPORTED.

Wolframite—Sheep Creek, B. C.—In the vicinity of Salmo in British Columbia some of the gold quartz veins carry considerable proportions of wolframite, specimens of which were collected recently by the writer from mines on Sheep Creek. The wolframite on examination in the laboratory was found to have a specific gravity of 7.137. With it are associated ferruginous quartz and wherever the mineral has been exposed to secondary action, yellow more or less powdery tungstite occurs. On chemical examination the following result was obtained:

(1) Report of the Minister of Mines, 1904.

WO_3	74.90
FeO	17.75
MnO	2.75
CaO	1.52
MgO	2.66
SiO_2	1.02
Total	100.60

So far as I am aware no economic use has been made of this material. I had not an opportunity of examining the mode of occurrence personally, the material being given me as coming from the Kootenay Belle Mine, though its nature and value appear to have been unknown at the time.

Tungstite and scheelite—Sheep Creek.—The writer has elsewhere (1) described in detail the occurrence of masses of hydrated oxide of tungsten in the gold quartz veins of the Kootenay Belle Mine. The tungstite appears in more or less reniform concretionary masses in the vein associated with wolframite and scheelite, from which it was derived by alteration. In the tungstite specks of native gold may be observed. It was as gold ore that this auriferous tungstite along with the accompanying gold quartz was shipped. I have reason to believe that in the subsequent metallurgical treatment the tungsten values were not recovered even when they were very much more valuable than the gold contents.

From an analysis of the tungstite-wolframite-scheelite ore in the laboratory the following results were obtained:—

WO_3	86.20%
FeO	1.20%
CaO	.54%
Fe_2O_3	4.14%
Water	7.72%
Total	99.81%

The tungstite is golden yellow in colour and very heavy—pure tungstite 5.517 and of some of the ore specimens nearly as heavy.

St. Mary's River, B.C.—Recently Mr. E. Walter Widdowson, assayer of Nelson, B.C., showed me a very fine specimen of crystallised wolframite from the St. Mary's River north of Cranbrook. I do not know anything of the quantity of this mineral available and am unable to say whether it be an economic deposit or not.

(1) American Journal of Science, 1908.

Scheelite from Victoria Mines, Sudbury District, Ontario.—At the Victoria Mines of the Mond Nickel Company in 1904 Mr. T. M. Paris, assayer for the company, presented to me a few small fragments which he had determined as scheelite. I do not know anything as to the mode of occurrence, but so far as I know this is the only place in the Sudbury district where any tungsten mineral has been found. The general studies of the genesis of the Sudbury ore deposits do not lead us to anticipate the occurrence of such minerals as scheelite.

The mineral is quite white and of very vitreous lustre; specific gravity 6.167. On the fragments in my possession no crystal surfaces are visible, but from the continuous cleavage surfaces it is probable that they are crystal fragments.

A chemical analysis showed that the mineral is exceedingly pure.

WO_3	79.36%
CaO	19.96%
Total	99.32%

Conclusion.—The ever increasing importance of tungsten in the industries calls for an examination of these various Canadian occurrences with a view to determining their possible economic value. Within the past year the government of the United States has appointed an officer to examine and report on such occurrences within their borders. In Canada we know of tungsten minerals only as specimens and curiosities and as those engaged in developing properties do not know these minerals or their value, such an appointment might be beneficial in many ways.

DISCUSSION.

MR. HAULTAIN (Toronto):—Dr. Walker has cleared up a problem which has been irritating me for some years. In panning samples for gold in the neighbourhood of Salmo I was troubled with a tail which looked like gold and yet did not look altogether like gold and what it was I did not determine. It is very evident it was this yellow mineral and it is more like gold in a pan than anything I have ever seen. It is the only thing that would justify a man in thinking twice whether it was gold. I know several men who have mistaken this tail for gold. I know we have come to the conclusion by panning that a rock would go five or six dollars when only a trace of gold could be found in it by assay, and I see now it was this yellow mineral tungstite.

Mr. J. C. Murray:—In Langland, in Ungava, we had the same occurrence; we had a yellow tail in the pan that we could not explain.

Mr. Gibson:—Has Dr. Walker a specimen of the boulder containing wolfamite that was found at Couiching in Ontario?

Mr. Walker:—No.

Mr. Gibson:—Was the origin of that boulder ever ascertained?

Dr. Walker:—I do not think so.

TOPOGRAPHICAL METHODS USED FOR THE SPECIAL MAP OF ROSSLAND, B.C.

By W. H. Boyd, Ottawa.

(Ottawa Meeting, 1908.)

The special map of Rossland, on the scale of 400 feet to an inch, with 20-foot contours, is a special detailed mining map.

The scale, 400 feet, was chosen as being the most convenient to show the area mapped, and as admitting all the features being shown in detail without appearing too small or crowded, and at the same time allowing the geology, veins, etc., to be laid down with a greater degree of accuracy, thus adding largely to the working value of the map.

In making a topographical map of this nature, as in any other topographical map, the methods employed depend upon the scale, the instrumental work applicable to conditions and locality, what the map is to be used for, and what is required to be shown; these last two conditions directly control the scale, which must be so chosen as to show all the necessary features desired in the map. Another important item is the systematic recording of field notes.

The area covered by the special map is about 1.9 square miles ($1\frac{1}{2}$ miles x $1\frac{1}{4}$ miles), and embraces the city of Rossland, and the principal mines. All railways, roads, buildings, shaft-houses, shafts, tunnels, prospects over 6 feet deep, mine dumps, tramways, flumes, streams, marshes, etc., are shown, and, as stated, contours are represented with 20-foot intervals.

On this map are shown 2,100 buildings, 50 shafts, 14 shaft houses, 33 tunnels, 200 prospects, $7\frac{1}{2}$ miles of railway and 15 miles of road outside of the city proper. The extreme vertical relief is 2,000 feet.

The amount of control is shown in the accompanying illustration which is a rough plot of the triangulation and also the traverse stations and traverse lines.

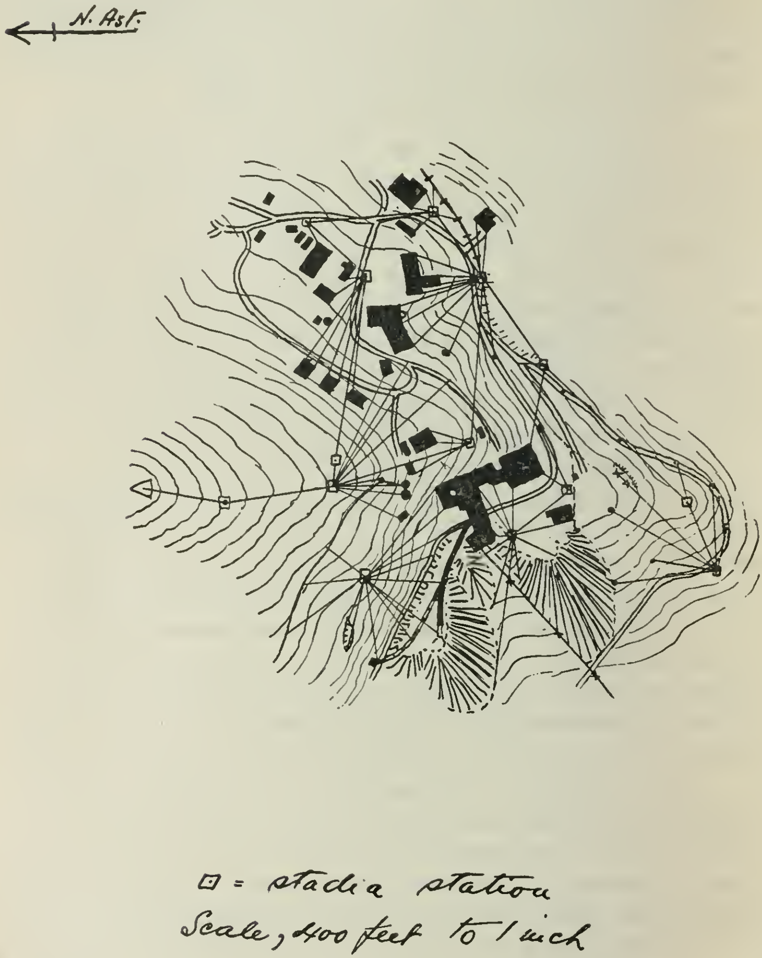
All the work in connection with the surveying and plotting of this map was attempted to be carried out with a degree of accuracy which would prevent errors of appreciable magnitude appearing on a finished map of the scale used.

A triangulation formed the main control of the sheet. Between the triangulation stations, transit-stadia traverses were run along railways, roads and across country; between these traverses, branch traverses were run until the whole area was covered by a network of traverses all tied on to one another (see Control Sheet). While these traverses were being carried along, side shots to locate all objects and for contour points were taken. The plane table with stadia was also used over a large part of the area. Elevations of the triangulation stations were obtained by vertical angulation. On the traverses the elevations were carried along by means of the stadia, and were checked at all tie points.

The district was first looked over and a suitable locality for a base line selected, also the best points for the triangulation stations were determined upon. On these stations, signals were erected, consisting of an upright pole carrying a white flag, supported by three other shorter poles in the form of a tripod. On the uprights, targets of white cotton were fastened, the bottom of the target being placed 5 feet above the ground. Vertical angles between the stations, for elevation, were measured to the bottom of these targets. Care was taken in setting the signals to have the upright perpendicularly over the point on the ground.

The triangulation was carried over the district embraced by the general sheet, which is on a scale of 1,200 feet to an inch and is not published yet. The special map forms about one-half the area covered by the general sheet. Nine of the triangulation stations are within the 400-foot sheet and form its main control.

Second Avenue was chosen as the best site for a base line on account of its giving the longest stretch that was fairly level. The base was first staked out with the aid of a transit, and large hubs driven in every 300 feet. The line was laid out along the side of the road so that the operations in connection with the measuring, etc., would not interfere with the traffic and also that


N. Ast.
⊡ = stadia station
Scale, 400 feet to 1 inch

the hubs would be preserved. When the base was completely staked out, the final measurements were made with a 300-foot steel tape, between the hubs set, using a uniform pull of 16 pounds applied at one end of the tape with a tension handle. Three measurements were made of the whole length of the base and the three results for the total length were found to differ by such a very slight amount that it was not considered in this work. A line of levels was run over the hubs; with the difference in elevation between each hub thus found, each 300-foot section was reduced to the horizontal. The total horizontal length of the base was 2,405.7 feet. The difference in elevation between the two ends was 27.2 feet. A very short line of levels was also run from the base line to the Great Northern railway track opposite the station house, and the elevation of this point was used as the datum. The bench mark on the Bank of Montreal was taken from the same datum, and is the bench mark used by the mines.

The transit used in the triangulation was an 8-inch Gurley Engineer's Transit, divided to quarter-degrees with vernier reading to one minute; telescope 11 inches, with fixed stadia-hairs, magnifying power 24 diameters; vertical circle 4½ inches diameter, with vernier reading to single minutes.

The triangulation was carried out in the usual way, by occupying each station and measuring all the angles of the triangles. The angles were measured by pointing to each signal in turn with telescope direct, and then a second time after reversing the telescope and shifting the plates about 60°. At the end of each set the telescope was directed around again to the first signal sighted and the instrument read to see that the instrument had not moved during the operation. Vertical angles were also read at each pointing, direct and reverse. On leaving a station the signal was carefully set back in its proper position.

The triangulation when completed in the field was immediately worked out in the office; the length of the sides and their azimuths computed, as well as the elevations of each station, before any traverse work was started. Observations for azimuth were taken on the sun at both ends of the base line and at one of the stations. The triangulation stations were afterwards plotted by means of their total latitudes and departures from one end of the base line.

The accuracy with which the triangulation was done is shown by the following:—The Station L was one of the farthest points to which the triangulation was carried, and lies in the south-east corner of the 1,200 ft. sheet. The Station D is near the base line and lies in the north-east corner of the 1,200-ft. sheet. The length of the side D L, as determined from three different triangles, gave the following results—10,626.9 feet, 10,625.5 feet and 10,625.7 feet, the greatest difference in length being 1.4 feet; thus the Station L is located much closer than it could be plotted on the map.

The degree of accuracy obtained for the elevations by vertical angulation is shown by the following:—

Elev. of Sta. D from Sta. A base—4050′.2 distance 3820.7 ft.
Elev. of Sta. D from Sta. B base—4050′.6 distance 5489.2 ft.
Elev. of Sta. D from Sta. C base—4050′.6 distance 3197.8 ft.

Elev. of Sta. F from Sta. D—4210′.2 distance 11162.8 feet
Elev. of Sta. F from Sta. B—4208′.8 distance 5853.0 feet
Elev. of Sta. F from Sta. A—4209′.6 distance 7455.0 feet
Elev. of Sta. F from Sta. E—4209′.1 distance 8857.9 feet
Average of the four gives Elev. as 4209′.4.

As the elevations were determined with just sufficient accuracy to meet the requirements of the work, no permanent bench marks were left. If bench marks were to have been left, a line of instrumental levels would have been run to control the elevations.

The transit with which the traverses were run was the same as used for the triangulation. The requirements of a transit for stadia work are that it should have a good telescope with a flat field, good illumination and a fair magnifying power. The transit used was found to meet very satisfactorily these requirements. The stadia wires in the telescope were fixed and included 1 foot on the rod at a distance of 100 feet plus the instrument constant.

The rods used were the telescopic English self-reading levelling rods. Each rod was provided with a circular rod level to insure the rod always being held in a vertical position. In traversing two rod men were used, one for the front, the other for the rear.

The traverses were first started from a triangulation station; the instrument oriented by sighting to another triangulation station after setting the plates at the azimuth to that station. In this way true azimuths were carried throughout all the traverses.

In setting hubs and sighting on them, the rod was held with its edge towards the instrument, and then, after a signal from the transit man, was turned with its face to the instrument for the rod reading. In taking side shots the face of the rod was kept towards the instrument, both for direction and distance.

The transit was always set on a back-sight by setting the plates at the back-azimuth of the line and then sighting to the edge of the rod held at the back station; in this way the instrument was always used in the same position throughout the work. The rod reading and vertical angle were always taken on the back-sight, in order to check the fore-sight readings; if any difference was found the mean of the two readings was used.

All traverses were tied either to triangulation stations or to stadia stations already set, and the azimuth checked on the spot by sighting to another triangulation station, or stadia station, as the case demanded. If the azimuth agreed within two or three minutes on a two-mile (or over) traverse, it was considered close enough for this work. Where the azimuth, on closing a traverse, was found in error above the allowable amount, the traverse stations were quickly run over again, neglecting the rod readings for distance, simply to locate the error.

The height of instrument was always noted (a light rod graduated to feet and tenths of a foot being carried for this purpose), and in reading vertical angles the cross-hairs in the telescope were directed to a point on the rod at the same height above ground as the instrument.

While carrying on a traverse, the rodmen, after giving the sights to the hubs, would go about in all directions giving the side shots to the various objects to be located, as well as side shots for contours. The side shots were taken to the bends of roads, road crossings and road forks, road crossing streams, stream bends, corners of buildings, prospects, shafts, tunnels, along the tops and at the bottoms of mine dumps, tramways, etc., etc., in short to everything that was to be shown on the map.

For contour points, shots were taken to points along the tops of ridges, the bottoms of ravines, at changes of slope, on tops and around the bottoms of knolls, or any other irregularity in the features of the ground that would show on the map scale.

In locating buildings, the rodmen would give two adjacent corners and then measure up the shape of the building with their rods; keeping a diagram with measurements of the same on a small pad provided for the purpose. These diagrams were handed to the transitman before moving to the next station, and were incorporated in his notes.

In all of this work where so many features were taken, a system of signals between the rodmen and transitman was used, in order that the transitman could tell where the rod was being held, when the distance was too great to call out.

The error of the stadia is generally given as being 1 in 600. With a good telescope, having good illumination and magnification, the rod can be read fairly easily at 800 feet, provided the atmosphere is not too tremulous owing to the heat. The best days for stadia work were found to be the cloudy days with a clear air; bright sunlight is hard, especially if the light is behind the rod, then it is sometimes impossible to get a rod reading at a fair distance. Taking every kind of day into consideration, the stadia gives excellent results for work of this nature.

The limit to which the rods used could be accurately read was tried on the base line. It was found that up to 600 ft. the stadia gave the same results; at 907 feet the stadia gave 905. A better idea of the work done by the stadia may be obtained from the following example:—Traverse from Sta. A to Sta. K.—total distance 2½ miles—azimuth checked to within 2 minutes.

From A to K by triangulation	South	6,722′.8	and West	2,001′.5
From A to K by traverse	South	6,728′.3	and West	1,998′.3
	Total Error........	5′.5	and...... ..	3′.2

Elevation of K by triangulation........................	3,409′.8
Elevation of K by traverse............................	3,408′.4
Difference	1′.5

Longest rod reading on the traverse was 845 ft. This traverse was run on a rather hot day, partly along a railway track where

Point	Azimuth	Rod Read.	Vert. Angle	Hor Dist	Diff Elev.	Elevation
At □D4a	H.I. =	4.1,	mean diff Elev		= 66.69	3824.93
To □ D4	93° 35'	3.48	-11° 12'			
End Tramway	140° 50'	3.86	-17° 17'	353	-109.8	3715.1
S.W. Cor. house	5° 36'	0.66	+9° 30'	65	+10.9	3835.8
N.W. Cor "	348° 30'	1.10	+9° 00'	108	+17.2	3842.1
C.P.	327° 51'	1.29	+7° 47'	128	+17.5	3842.4
To □ D4b	341° 28'	3.03	+12° 28'	290	+64.14	
At □ D4b	H.I. =	4.6,	mean diff. Elev		= 64.09	3889.02
To □ D4a	161° 28'	3.03	-12° 27'	290	-64.05	
End flume	168° 23'	1.00	-15° 14'	94	-25.7	3863.3
Centre Water tank, change S	184° 24'	1.42	-19° 30'	127	-45.1	3843.9
C.P. change slope	350° 49'	2.20	+20° 37	193	+72.5	3961.5
To □ D4c	250° 21'	2.01	-15° 31'	188	-52.13	
At □ D4c	H.I. =	4.8,	mean diff. Elev		= 52.29	3836.73
To □ D4b	70° 21'	2.02	+15° 32'	189	+52.45	
bend in flume	37° 27'	0.95	+19° 53'	85	+30.8	3867.5
End dump by shaft house	169° 00'	3.13	-9° 43'	305	-52.3	3784.4
Road under tramway	152° 46'	2.51	-12° 16'	240	-52.4	3784.3
C.P.	121° 46'	2.18	-0° 47'	219	-3.0	3833.7
End track dump 3	216° 00'	2.05	-12° 45'	196	-44.4	3792.3
E end glory hole	285° 39'	0.97	-8° 53'	95	-15.0	3821.7
W " "	281° 7'	1.62	-9° 46'	158	-27.3	3809.4
Paton tunnel	255° 39'	2.12	-22° 41'	181	-75.9	3760.8
On road	271° 9'	2.82	-13° 33'	267	-64.5	3772.2
" "	163° 34'	1.54	-21° 36'	134	-53.2	3783.5
C.P.	323° 11'	0.96	+2° 51'	97	+4.8	3841.5

the air was tremulous, and therefore it was found very difficult to always get a proper rod-reading.

A plot of all traverses, with side shots, was kept in the note book on the opposite page to the notes; sketch contours were drawn on the plot to give the shape of the ground. The accompanying extract from one of the field note books, shows the method of keeping the notes. The last three columns in the notes are filled in the office. A few only of the side-shots are shown in the sketch so as to avoid confusion.

The notes were reduced in the office by means of tables and Cox's stadia slide rule. This slide rule is a very useful and convenient instrument and with a slight amount of practice, can be used very quickly and gives good results.

The latitudes and departures for all the courses of the main traverse were worked out with Gurden's traverse tables; the total distances checked and any appreciable error was distributed in the usual way.

The elevations between the traverse stations were carried out to one one-hundredth of a foot in order to prevent an accumulation of errors on the line; the elevations of objects were taken out to the nearest tenth of a foot, and for contour points to the nearest foot.

The reduction and plotting of the traverses in the office was, as far as possible, kept up with the work in the field, so that in case of any errors, they could be rectified before leaving that particular part of the ground.

The stations on the main traverses were plotted by means of their total latitudes and departures from the starting point. On shorter traverses the courses were plotted by protractor. For plotting side shots the quickest and most convenient method was found to be as follows:—A very thin 14 inch cardboard protractor reading to 15 minutes was used. The centre was cut out to within 2 inches of the edge. The protractor was then fastened down on the map over the area to be filled in with the 0° and 180° marks coinciding with the true north line through one of the stations, and the directions of the side shots transferred, with a parallel ruler, to their corresponding stations on the plan. As soon as enough side shots and contour points were located on the map around a certain area, the contours were drawn in, using the note book sketch as a guide.

The plane table and stadia was used over a great portion of the sheet and was found to give very good results. For this work two rodmen were used, as well as a recorder who kept the notes and reduced all the readings in the field, with the aid of the stadia slide rule. No record was kept of the contour points; only the readings to buildings, shafts, tunnels and prospects and other important features were recorded for the sake of referring to their elevations during the course of the work. The form of record in the note book was the same as kept for the transit work, with the exception of the azimuth column, it being omitted.

The methods of traversing were similar to those used in the transit work. Long traverses, however, were, as a rule, not run with the table as sometimes they occasioned a little difficulty in tying in properly. In shorter traverses, if there was any closing error, it was generally found to be so small that it might be neglected.

The table used was furnished by Keuffel & Esser, and was one of the U. S. Coast and Geodetic Survey Pattern. The board was 16″ x 20″. A three screw levelling arrangement with tangent screw was attached to the tripod head. It was provided with a telescopic alidade with vertical arc, reading to 30° each way, with vernier reading to 1 minute; the blade of the alidade was 12″ x 2½″ with spirit levels attached; the telescope was furnished with fixed stadia hairs including 1 foot on a rod at a distance of 100 feet plus the instrument constant.

The paper used was two sheets of paragon paper mounted with the grain at right angles and with cloth between. This is the same kind of paper as used by the U. S. Geological Survey, and reduces distortion, owing to atmospheric changes, to a minimum. Each sheet was prepared for the field by laying down on them all triangulation points that would fall on the sheet and all traverse stations around the part to be filled in. The scale used on the sheets was the same as for the finished map, namely, 400 feet to 1 inch. As one hundredth of an inch is as close, perhaps closer, than can be conveniently plotted in the field, and as on the scale used this would correspond to 4 feet, all rod readings to locate objects were taken just to within this amount and no closer, since it would be a waste of time to locate objects more accurately than they could be plotted.

With the prepared sheets, the table was taken into the field to one of the stations plotted, set up, oriented and the immediate neighbourhood filled in; new hubs set and these in turn occupied with the table and the detail filled in, and so on, till a tie point was reached, where the traverse and elevation were checked up.

A good feature of the plane table is that it enables the topographer to determine his position at an unknown point easily and fairly rapidly, by the graphic solution of the three-point problem. This can only be done when the country is open and three or more triangulation stations visible, the plotted positions of which are shewn on the sheet. This method was used very frequently and was found very convenient, as well as saving a lot of time in places where it would be difficult to run a traverse into. Sometimes in difficult country where the position of the table was determined by the three point problem, a short traverse was run from this point to get the detail, the end of such a traverse being also tied in by the three-point problem.

The elevations of the points fixed by the three-point problem were either determined from the triangulation stations themselves, by reading the vertical angles to them and scaling the distance on the sheet, or, as was done in most cases, by taking a rod reading to some neighbouring traverse hub, as one could always be found near at hand. Often from points fixed by the three-point problem, after the elevation had been determined, hubs were set in several different directions by the stadia. These were used for elevation only, the table being taken to a good situation beyond these hubs, its position determined by the three-point and the elevation determined by taking a rod-reading back on to one of these hubs. This was found to be a convenient and quick way of getting the elevations for points near at hand fixed by the three-point problem. Flags were left on all points fixed by the three-point problem, in order that these points could be used for fixing one's position from some other point, where it was impossible to see enough triangulation signals.

A very satisfactory way of using the table for filling in was found to be as follows:—Traverses were run with the transit and stadia, hubs set at suitable points, side shots were neglected. These traverses were then plotted in the office and transferred to the plane table sheet; the table was then taken into the field, set up over each of the hubs, oriented and the detail filled in.

In some cases, however, as around the larger mines, where there was a large amount of detail to be shown, such as, buildings, tramways, etc., many of these features were taken while running the transit stadia line. These features together with the traverse stations were then plotted on the plane table sheet; the table afterwards taken into the field, set up over the various already determined hubs and the remaining features and contours filled in. This combined method was used in the complicated areas, since the crowded main features could be plotted and drawn to scale better in the office than on the table in the field.

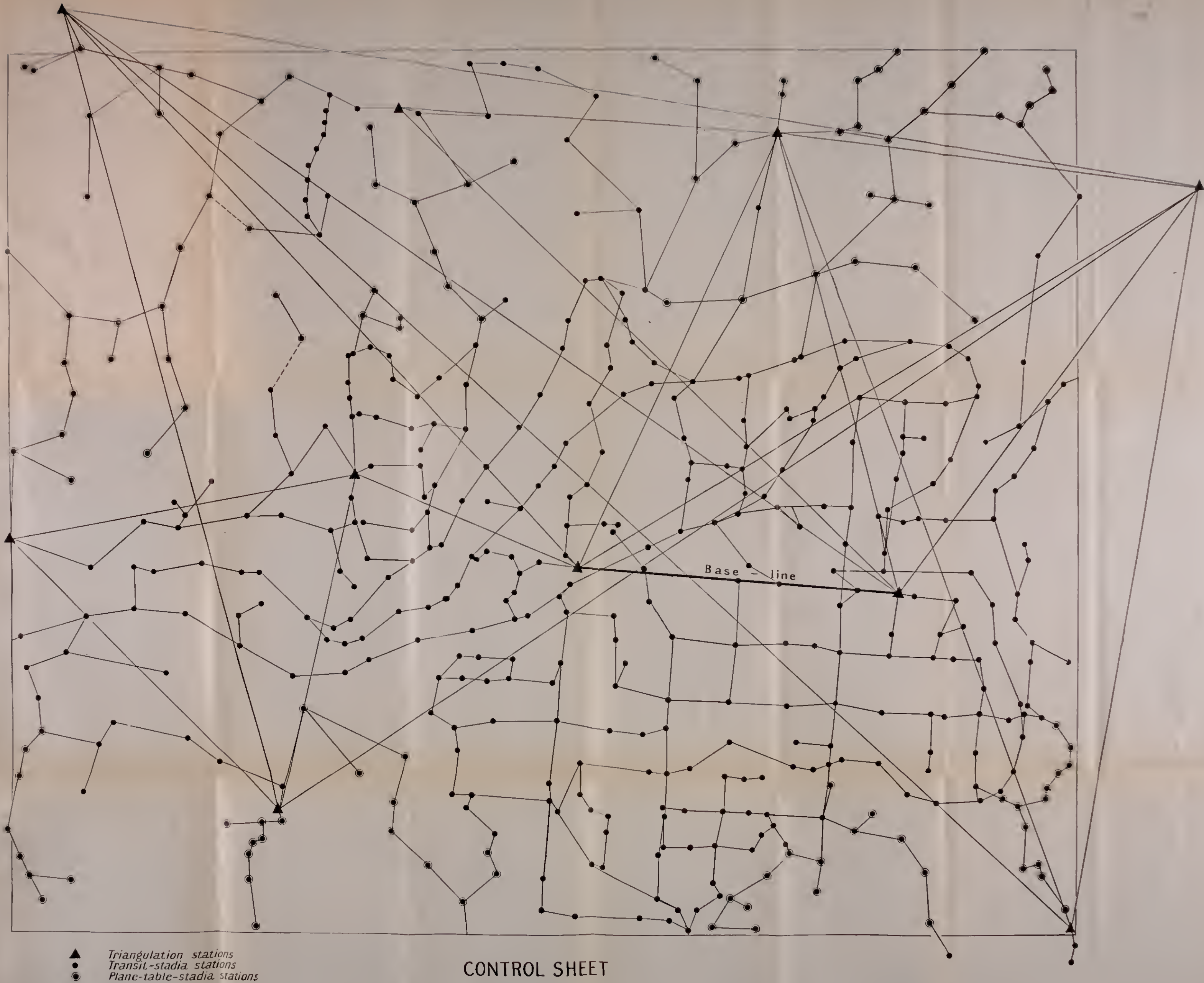
In all of the work done with the table it was found, as compared with the transit stadia method, that the number of side shots for contours was reduced to a very great extent, and also that the contours themselves could be sketched in far more accurately. For, with the table, the recorder gave the true elevations of each point as it was taken and thus, at a glance, it could be seen where the contours would come on the ground and they could be immediately sketched on the sheet with fewer side shots and much greater ease and accuracy, than could be accomplished in the office from the field sketch accompanying the transit notes. The advantages of the plane table, for this class of work, over the transit are important. With the transit, where only a sketch is kept, and no elevations worked out in the field, it becomes necessary to take an excessive number of points, at practically any slight change in the nature of the ground, in order to be able to properly interpolate the contours in the office. The office work in connection with the reducing and plotting of the transit notes is very long and tedious, in using the plane table, however, all the office work is practically done away with and was found to be a quicker and more satisfactory way of filling in the detail.

Great difficulty was encountered at times in getting the detail of the ground on account of the heavy growth of brush on some of the slopes. The rodmen always carried axes and would slash out the brush in case a shaft or prospect was to be located. Owing to this heavy brush, the rodman could not see all the prospects, so some may not be shown on the map. In taking contour points in brushy ground, the rod was often held on the shoulder or knee of the rodman, or else the rodmen stood upon some object; the distance to the ground in each case being called out.

In order to get shots into stream bottoms where trees in the bottom prevented the rod from being seen, the rodman would climb up one of the trees and hold the rod on one of the limbs where it could be seen by the transit man; after the reading was taken, he would measure the distance to the ground and note how far the stream was from the bottom of the tree and then call out the measurements to the transit man. In this way much time was saved in getting points at the bottoms of timbered draws.

A good rodman soon learns to recognize which points are the best to give in order to get the shape of the ground. By a judicious selection of contour points, much time is saved and better results are obtained.

The City of Rossland was resurveyed with transit and stadia and was blocked out from these surveys with the aid of the measurements of the blocks as given on a plan of the city. About one half of the houses were fixed from these surveys; the remainder were taken from the insurance plan of the city, after all the positions and shapes included thereon were checked in the field, and others inserted that were not shown.



CONTROL SHEET

CANADA

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BRANCH

HON W TEMPLEMAN, MINISTER. A.P.LOW, DEPUTY MINISTER.
R W BROCK, ACTING DIRECTOR

1908

CANADA

DEPARTMENT OF MINES

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HON. W. TEMPLEMAN, MINISTER. A. P. LOW, DEPUTY MINISTER.
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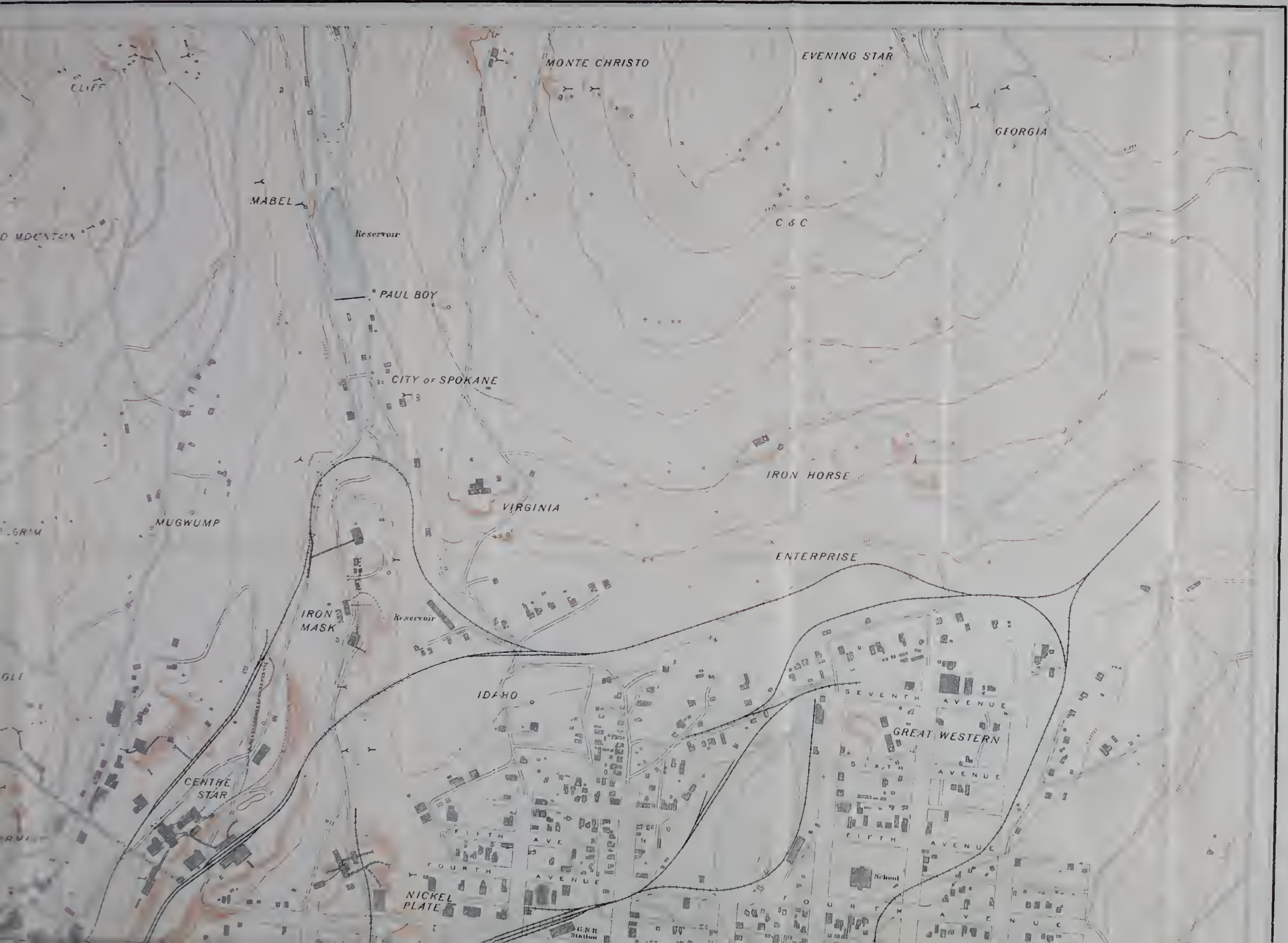
1908



Legend

Roads & Buildings

Trails

Railroads

Shafts

Tunnels

C O Senécal, B A Sc, *Geographer & Chief Draughtsman*
A. Dickison, *Draughtsman*

Topographical Sheet

SPECIAL MAP OF ROSSLAND

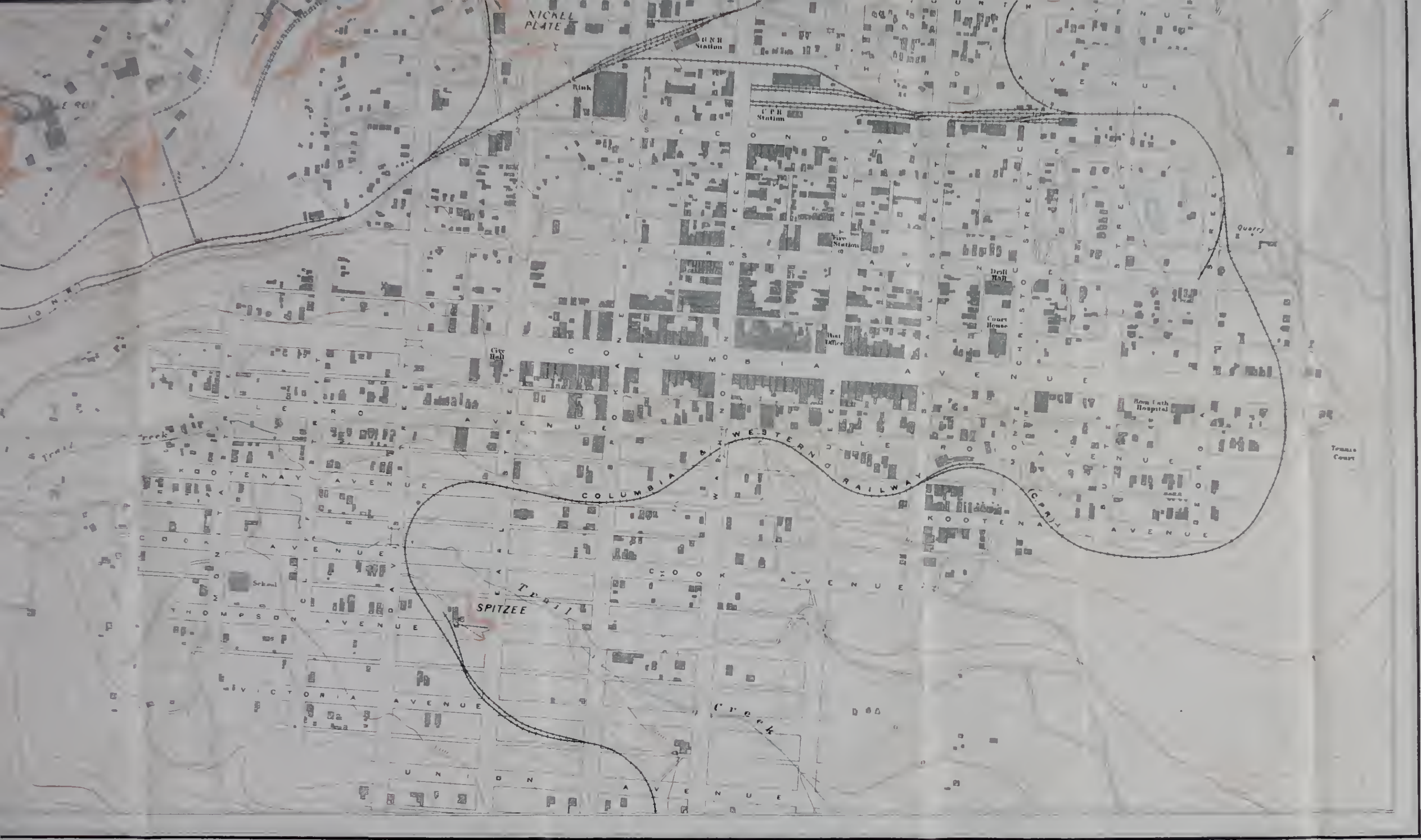
BRITISH COLUMBIA

by

W. H Boyd

Scale: 400 Feet to 1 Inch $\frac{1}{4800}$

Feet 400 300 200 100 0 400 800 1200 Feet



Surveyed in 1905 1906

Nº 1001

Topographical Sheet

SPECIAL MAP OF ROSSLAND

BRITISH COLUMBIA

by

W H Boyd

Scale: 400 Feet to 1 Inch $\frac{1}{4800}$

Feet 400 300 200 100 0 400 800 1200 Feet

NOTES ON COSTS OF DIAMOND DRILLING IN THE BOUNDARY DISTRICT.

By FREDERIC KEFFER, Greenwood, B.C.

(Nelson Meeting, January, 1908).

Two years ago I contributed to the Institute a paper on the results of diamond drilling as carried on at the mines of the British Columbia Copper Co., Ltd., during 1905. That paper gave some details as to costs, etc., and the period covered was but 8½ months. Since that year drilling has been carried on more or less continuously in the mines of the Company, and the results of this work, so far as progress and costs are concerned, are given in detail in the following tables.

The Progress Table gives the monthly results of work as well as the yearly totals. It is of course important to know the general character of the rock drilled in order to institute comparisons with other localities. In the narrow limits of this table it is not possible to give details as to rocks, but so near as possible the rocks drilled are classed as hard, medium hard, and soft. The hard rocks comprise diorites, compact garnetites and certain very hard and silicious eruptives occurring in Summit camp. The medium hard rocks include all ores, and, in Deadwood camp, much of the greenstone country. The soft rocks are the limestones, porphyries and serpentines. Of all rocks drilled the garnetites proved much the most severe in diamond consumption, as is illustrated by the work from May to August, 1907, which was mainly conducted in garnetite with some silicious limestones.

Eight hours constitute a shift underground, and nine hours on the surface. On Sundays no work is done apart from repairs to machinery. In May, 1906, the labour was contracted as an experiment, but was abandoned as being unsatisfactory.

The Cost Table gives details of costs under the four groups of Labour, Power, Repairs, Oils, etc., and Diamonds. The employees were, normally, a runner and a setter. Extra help was required at times for blasting places for good set ups, for laying pipe lines, moving plant, etc. In August, 1907, two shifts were employed. In June and July of that year the increase in labour costs is mainly on account of the long pipe lines required. The power consumed is taken as being equivalent to that required for a $3\frac{1}{4}$ inch machine drill, that is to say about 20-h.p. When drilling at a mine, where for example 15 machines are used on each shift, the diamond drill is charged with $\frac{1}{31}$ of the total power costs—it being in this instance run on one shaft only.

Where steam power is used either directly or through a steam driven air compressor, the costs are much increased. Where, as in some cases, an isolated 24-h.p. boiler was used, the power costs are still higher, as an engineer has to be provided as well as a team to haul wood.

Oils, repairs, etc., include these items as well as all small miscellaneous expenses. The increasing cost of diamonds added materially to cost per foot in 1907.

The third table is a summary of the first two, and shows an average cost per foot for the two years of $1.705. The carats used per foot are $\frac{0.572}{64}$, or in more intelligible decimals, .00893 carats, so that one carat on the average drilled 111.9 feet. All holes over 30 degrees dip are classed as vertical, and feet per hour in horizontal holes is about 15 per cent. greater than in vertical ones. The average depth of holes is 81.3 feet, and diameter of cores is $\frac{7}{8}$ inch.

In comparing these costs with contractors' prices, it must be borne in mind that contractors usually require air (or steam) and water to be piped to the work, and the mine must in addition furnish the air and water free of charge. In the present cost sheets all these items are charged against costs of drilling.

PROGRESS TABLE.

Date	Depth of Holes. Vertical feet.	Depth of Holes. Horizontal feet.	Depth of Holes. Total feet.	Hours actual drilling.	Hours moving to new holes, setting bits, etc., etc.	Total hours	Number of holes.	shifts	Feet per shift.	Feet per drilling hour.	Character of Rock.	Remarks.
1906												
Jan. . . .	170	0	170	106	46	152	6	19	8.94	1.60	Mainly hard diabase 1	No. 1=Hard rocks 2=Medium hard rocks 3=Soft rocks
Feb.. . . .	0	191	191	104	24	128	3	16	11.93	1.83	Softer lime rock 3	
March . .	332	66	398	205	77	282	5	33	12.06	1.94	Equal parts of above rocks 2	
April . . .	214	0	214	76	55	131	7	16	13.37	2.81	Lime rocks and ore 2	
*May. . .	390	73	463				4				Nearly all in ore 2	
June . . .	. . . .	. . . .	 0	. . . . . .	. . . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	No work in June and July.
July. . . .	. . . .	. . . .	 0	. . . . . .	. . . . . .	. . . . .	. . . . .	. . . .	. . . .	. . . .	. . . .	
Aug. . . .	0	508	508	160	48	208	7	26	19.59	3.17	Fairly hard rock 2	
Sept. . . .	0	96	96	29	3	32	0	4	21.00	.31	Mainly ore 2	Drill men off on vacation.
Oct.. . . .	195	40	235	95	53	148	4	17	13.82	2.45	do. 2	
Nov. . . .	33	378	411	157	63	220	6	27	15.22	2.62	Hard silicious rock 1	
Dec.. . . .	189	127	316	144	48	192	3	24	13.17	2.19	do. do. 1	
	1523	1479	3002	1076	417	1493	45	182	Av. 13.59	Av. C. [illegible].39		C.—Averages calculated on 3002 ft. *less* 463 drilled on contract.
1907												
Jan.. . . .	246	165	411	159	57	216	6	27	15.22	2.58	Lime and porphyry 3	
Feb. . . .	0	378	378	137	79 D	216	2	27	14.00	2.76	Ore and lime rock 2	D.—Several days lost moving 15 miles to another mine
March . .	200	340	540	180	28	208	5	26	20.77	3.00	do. do. 2	
April . . .	278	186	464	181	27	208	1	26	17.86	2.56	do. do. 2	
May. . . .	67	433	500	163	53	216	3	27	18.52	3.07	Hard garnetite 1	
June . . .	189	288	477	187	39	226	6	2[illegible]	18.34	2.55	Very hard garnetite 1	
July. . . .	96	304	400	203	23	226	6	27	14.81	1.97	do. do. and diorites 1	
Aug. . . .	497	0	497	213	129B.	342	8	38	13.18	2.33	do. do. 1	B.—Much trouble with caving ground in August. Worked two shifts nearly all the month.
	1573	2094	3667	1423	435	1858	37	224	Av. 16.34	Av. 2.577		

(*) This month's work was contracted as to the labor. Feet drilled are therefore not included in averages, as contractor worked overtime.

COST TABLE.

Date	Labor cost	Cost per foot	Power			Repairs, Oils, etc.	Cost per foot	Diamonds				Total Costs	Total per foot	Feet drilled	Remarks
			Kind	Cost	Cost per ft.			Carats used	Market price	Cost	Cost per ft.				
1906															
Jan. .	172.00	1.012	Elec. ☞ A.	36.30	.213	22.72	.133	61/64	56.53	53.99	.318	285.01	1.676	170	A.—"Electric power" is compressed air from electric driven compressors.
Feb. .	152.50	.798	do.	32.10	.165	7.01	.036	3.47/64	"	206.70	1.082	398.31	2.081	191	Costs reckoned on assumption that diamond drill consumes as much power
March	292.00	.734	½ do. ½ steam	112.20	.282	68.60	.172	3.35/64	60.07	213.07	.535	685.87	1.723	398	as a machine rock drill; that is approximately 20 H.P.
April .	188.87	.882	Elec.	31.58	.147	26.93	.126	1.59/64	"	11 .45	.539	362.83	1.694	214	
May. .	480.48	1.037	do.	38.83	.083	19.41	.042	5.36/64	"	334.15	.722	872.87	1.885	463	Labor contracted this month
June .															No drilling done
July. .															Do. do.
Aug. .	269.25	.530	do.	52.95	.104	30.67	.060	3.25/64	60.07	203.68	.401	556.55	1.095	508	
Sept. .	52.85	.551	do.	5.07	.053	.00	.00	.46/64	"	43.17	.449	101.09	1.053	96	Drill men on vacation
Oct. .	183.60	.781	do.	51.12	.217	2.29	.009	2.19/64	61.90	141.70	.600	378.71	1.610	235	
Nov...	280.10	.681	Steam	127.42	.310	118.18	.288	2.40/46	"	160.50	.390	686.20	1.669	411	Drill operated most of Nov.
Dec. ..	288.00	.911	Steam	128.32	.406	34.21	.108	4. 8/64	"	255.24	.808	705.77	2.233	316	and Dec. by steam direct from boiler.
	2359.65	AVE. .786		615.89	AVE. .205	330.02	AVE. .109	£8.56/64		1727.65	AVE. .576	5033.27	AVE. 1.676	3002	

COST TABLE.—Continued.

1907 Jan. .	264.25	.643	Steam	236.24	.575	13.37	.032	1. 3/64	61.90	62.89	.153	576.75	1.403	411	
Feb.. .	245.10	.648	Elec.	68.60	.182	5.45	.014	1.50/64	80.00	141.70	.375	460.87	1.219	378	Great advance in price of diamonds.
March	265.75	.492	do.	53.31	.099	26.23	.049	2.37/64	"	219.14	.405	564.46	1.045	540	Best month on record for low total costs.
April .	277.90	.599	do.	51.13	.110	.31	.015	3.18/64	"	262.50	.566	598.84	1.290	464	
May .	332.00	.664	do.	58.85	.117	6.38	.013	5. 4/64	"	405.48	.816	802.71	1.604	500	
June .	397.55	.833	do. B.	175.00	367	47.92	.100	5.16/64	71.75	376.36	.790	996.8	2.090	477	B.-Increase in power cost due to partial closing of mine throwing more costs on the power for diamond drilling.
July .	402.56	1.006	do. B.	182.25	.455	164.83	.412	7. 3/64	"	511.88	1.279	1261. 2	3.153	400	
Aug. .	439.22	.883	do. B.	200.01	.403	93.78	.189	4.41/64	"	342.77	.689	1075.77	2.164	497	June, July & August were drilling in very hard garnetite increasing diamond consumption.
	2624.33	.715		1025.41	AVE. .280	365.27	AVE. .109	30.47/64		2322.72	AVE. .633	6337.73	AVE. 1.728	3667	

SUMMARY.

PROGRESS.

Year	Feet Drilled.			Hours.			Number of Holes	Number of Shifts	Feet per Shift	Feet per Drilling Hour
	Vertical	Horizontal	Total	Drilling	Moving, &c.	Total				
1906	1523	1479	3002	1076	417	1493	45	182	13.59	2.359
1907	1573	2094	3667	1423	435	1858	37	224	16.34	2.577
	3096	3573	6669	2499	852	3351	82	406	15.285 A.	2.482 B.
	Contract feet		463							
Feet used in calculating averages A. and B.			6206							

COSTS.

Year	Labour		Power		Repairs, Oil, &c.		Diamonds			Totals		Feet
	Cost	Per ft.	Cost	Per ft.	Cost	Per ft.	Carats	Cost	Per ft.	Cost	Per ft.	Drilled
1906	2359.65	.786	615.89	.205	330.02	.109	28.56/64	1727.65	.576	5033.21	1.676	3002
1907	2624.33	.715	1025.41	.280	365.27	.100	30.47/64	2322.72	.633	6337.73	1.728	3667
	4983.98	AVE. .747	1641.30	AVE. .246	695.29	AVE. .105	59.39/64	4050.37	AVE. .607	11370.94	AVE. 1.705	6669
						Carats used per foot		0.572/64				

DISCUSSION.

MR. WILMOTT:—I would like to point out one item in this paper. The system of weighing diamonds by the carat is an interminable nuisance, particularly the dividing of the carats into sixteenths, thirty-seconds and sixty-fourths. In order to avoid this enormous amount of calculation I have had a set of weights constructed (costing only a few dollars) in which the fractions of a carat are tenths, etc.

THE PRESIDENT:—We have kept to the old system because we buy the diamonds in that way, but there is no doubt the decimal system is better. In selecting diamonds we usually have a lot sent to us by dealers from which to select. On one or two occasions we found that the stones had been previously soaked in some wax or paraffin to conceal the cracks. Since then we have always boiled the diamonds before making our selections.

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GRANBY MINING METHODS.

By C. M. Campbell, Phœnix, B.C.

(Rossland Meeting, May 1908).

The Granby Company is at present operating in Phœnix what appears to be two distinct groups of ore bodies. The oldest workings are in the deposits which outcrop on the Knob Hill and Old Ironsides claims (Fig. I), while the later workings are about half a mile to the east and are almost entirely on the Gold Drop claim (Fig. II). The Knob Hill-Ironsides deposit has been opened up, at one hundred foot intervals, by several levels. The upper one of these, No. 1 Tunnel (Fig. III), was originally a shipping level and from the stopes above this level and from the open cuts in which a steam shovel worked, nearly a million tons have been shipped. When the crusher at the mouth of this tunnel was destroyed by fire, it was rebuilt at the mouth of the next lower level known as No. 2 Tunnel (Fig. IV). No. 1 Tunnel then became nothing more than an intermediate level, all the ore above No. 2 Tunnel being handled through that outlet. After being crushed this ore falls directly into C.P.R. cars, or if none are at hand it is diverted into a pocket which is reached by a cross-cut from the next lower level known as No. 3 Tunnel. The No. 3 Tunnel equipment handles all the ore between this level and No. 2 Tunnel and its terminals are on the G. N. Ry. (Fig. V). In descending order the remaining main levels are known as 200 ft., 300 ft. and 400 ft., and the tonnage from all these levels is hoisted through the Victoria Shaft. The bins connected with this shaft are served by both the Canadian Pacific and Great Northern railways (Fig. VI). The Knob Hill-Ironsides mine is thus divided into three distinct units known as No. 2 Tunnel, No. 3 Tunnel, and Victoria Shaft. These have a distinct and complete equipment of rolling stock, crushers and bins and are manned by separate crews under separate shift bosses. The Gold Drop is equipped like the others

Fig. 1—General View of City of Phœnix and Knob Hill-Ironsides Workings.

Fig. II—General View of Workings on East side of Monarch Hill. Rawhide (Dominion Copper Co.) bins to extreme left, Curlew (Granby Co.) and Snowshoe (Canadian Consolidated Co.) bins at left lower corner. The Snowshoe property is in the foreground while the three upper pits are on the Gold Drop (Granby Co.) property.

and forms a fourth unit. The output from this mine is handled by the Canadian Pacific, and a view of the terminals is shewn in Fig. VII. It will thus be seen that in case one railway is unable to operate, the shipments from at least three outlets can be handled by the other road. Also, if one or more of the units happen to be out of commission, each of the others can be pushed towards its maximum capacity of 150 tons per hour and the day's shipment made up.

The methods of underground mining are largely the result of evolution. The first few years of work showed decidedly that the ore was of low grade character. On the other hand it also showed the ore bodies to be of vast size with values uniformly distributed. The nature of the ground was also found to be such that timbering could be almost dispensed with. As a result of this, sorting was abandoned; the square set method gave place to open stopes with the roof supported by rock pillars; cheap electric power was introduced to operate air compressors, for pumping and for haulage; cars up to ten ton capacity and running on a three foot gauge took the place of the small mine cars previously in use, and, as stated above, the different outlets were equipped with up-to-date shipping facilities. All these improvements have had the end in view of giving the mine a large, uninterrupted, daily tonnage.

Nature of the Deposit.—Figure VIII shows a transverse vertical section taken about the middle of the ore body. At this point it shows up to, perhaps, the best advantage. The section shows two ore bodies. As a rule the area between these ore bodies is absolutely barren. Some drill holes, however, have shown it to contain a few tenths in copper and in this section part of the area is mineralized sufficiently to place it in the shipping class. At the place where this section is taken a cross-cut could be started in ore at the footwall and driven over 600 feet before again encountering waste rock.

The ore body is cut by several faults. The only one which seems to throw the ore body to any extent is shown in the section. This has been traced from one end of the deposit to the other and shows a throw of from nothing to one hundred feet. This fault plane dips to the west at an angle of about 55 degrees. Several other fault planes occur dipping at various angles to the east, but none of these affect the continuity of the ore. In some cases they apparently do so. This is due to the fact that the strike and dip of these slips is much the same as the ore body and when one occurs close to the hanging wall of the deposit it may act as such for a hundred or two hundred feet. Beyond this the mineralization will either break through and ore be found on each side of the slip or it will fall away from the slip and waste will replace the ore. When a clean slip occurs as a hanging wall, few pillars are needed and a large stope can be made with a safe roof. In most parts of the mine the division between ore and waste is more gradual. Sometimes it may be a few inches; it is seldom more than a few feet and can usually be told without any sampling.

Scheme of Operations.—In opening up a level, parallel drifts, usually about 75 feet apart, are started in the direction of the strike of the deposit. At intervals of about 45 feet along the drifts raises are begun. An eighteen hole round is drilled and blasted. Before the muck is cleared away the bar is again set up and another round drilled and blasted. The third round is then drilled but the cut holes only are blasted. All the rock is then shovelled up and the chute is built. The remaining holes of the last round are then blasted and as these throw the rock to the sides of the raise the timbers of the chute are uninjured. The raise is then carried ahead at an angle of about 45 degrees. This allows the muck to run and also enables the men to get about without the aid of timbering. For ventilation purposes the first raise of a series is usually carried through to the level above or some other convenient opening. In the case of the highest level the most convenient opening is the surface. When the face of No. 2 raise is about 30 feet above the sill floor, stoping is commenced and it is widened out till it connects with No. 1 Raise. The same thing is done at an elevation of about 60 feet. In this way the raises are carried ahead, connecting with each other at heights of 30 feet and 60 feet and breaking through into the next level at 100 feet. The only small work is in the first 30 feet. This is charged to development, the remaining excavations being placed in the stoping account. In this way a network of pillars is left throughout the stope So far a column only has been used. As soon as the sill floor above has been reached, tripods and long steel can be used to advantage. In this way a glory hole is started and the opening

Fig III. —Open Cuts on Surface. The large pit shown on the right is 900 feet long and rises to a height of 200 feet. This ground was originally opened up by No. 1 Tunnel Level.

Fig. IV—No. 2 Shaft and No. 2 Tunnel Bins and Crusher.

Fig. V—No. 3 Tunnel Bins and Crusher.

can be widened out until the sides of the glory hole get too flat for the ore to run. Machines are also put to work where the connections between the raises have been made and at other advantageous places. The stope may thus be turned back to meet the hanging wall and the pillars reduced in size, or where the nature of the ground permits, a pillar may be eliminated altogether. Reference to Figure IX shows a part of the stopes above No. 3 Tunnel and shows the progress between March, 1905 and March, 1908. Figure X is a photograph of a series of pillars above No. 1 Tunnel level.

One series of raises is seldom sufficient to tap all the ore. If the foot-wall is flat a parallel drift in waste with accompanying raises will have to be driven. There will also be several drifts between the foot and the hanging walls. At one place on No. 3 Tunnel level there are five parallel drifts now operating and at least another will be required. In this case the pillars in the stopes are left nearly vertical instead of at an angle as when the deposit is steeper. It is often advisable when breaking a raise through from a lower level to make the connection at the back of the chute timbers. The timbers can be taken out and a glory hole started. At the same time the raise can be carried ahead as a stope ten to fifteen feet beneath the foot of the old stope. While stoping ahead upper holes are drilled into the undercut rock. In this way the back is always within reach. In fact it is rarely necessary to work in a stope at any great distance from the roof.

When raising in waste no connections are made until the ore is reached. If the ore is at any considerable distance the raises are put in less frequently and are branched so as to tap the ore at two or three places. After the ore is blasted the large blocks that can be reached are bulldozed. No blockholding is attempted. It has been found cheaper to buy more powder than bother with hand or air-hammer drilling. When the raises are in ore there are always convenient temporarily abandoned chutes which have been cleaned out, through which access is had to the broken ore in the raises. In the case of raises through waste where no connections have previously been made it is necessary to drive manways. To do this a staging is constructed midway between two chutes and about eight feet above the track, high enough to allow the trolley wire to pass under. The planks at the centre of the staging, over the cars, are moveable. A miner with an air hammer drill or a small ordinary drill starts a raise at about 60 degrees and continues for about 25 feet when he branches and drifts till he connects with the raises on each side. The waste with a little help is run into the cars without interfering with traffic.

The abandonment of timbering in the stopes has already been referred to. The only other timbering required is for chutes, tunnel sets and occasional posts and caps on the sill floor where needed. The details of a chute are shown in Figures XI and XII. In building this a temporary staging is constructed, hitches are cut for the posts, a sprag is wedged between the hanging and foot walls of the raise, a block and tackle attached thereto and the stulls raised and wedged in position. The stulls are then lagged up inside. A space is left unlagged for the chute proper and at the sides of this space and inside are placed posts surmounted by a heavy cap. The chute is built in, the gate placed in position, a permanent platform built for the chutemen and the work is completed. The chute opening is about three feet square and anything that can go through the chute can go through the cars and be handled by the crusher. When the muck is drawn through the chute from the raise the lagging and inside posts are pretty well protected by broken rock. The cap, however, suffers more or less from blasting and in course of time is replaced if necessary. If convenient, heavy railroad iron covered with lagging may be used instead of a wooden cap. Chutes have been built-lined with tank plates, and the inside timbers armour-plated. This, however, is seldom done as the life of an ordinary chute is usually long enough to handle all the ore from that part of the stope of which it is the outlet. The chute gate is a solid piece of sheet iron, and is operated by a lever. It is shown in section in the drawing of a chute. In case a car is loaded and the gate is prevented from closing by a large rock, a plank or two is moved along the staging against the mouth of the chute thus preventing any loose rock from running over. Tunnel sets are rarely needed. The main haulage way on the 400 ft. level, a straight run of about 1,000 feet, has no timbers other than those necessary to carry the electric light and trolley wires. This is the usual experience. In No. 3 Tunnel there is a

Fig. VI.—Victoria Headworks.

Fig. VII—Curlew Terminals. These handle the output from the Curlew, Gold Drop, and Monarch claims. At present the ore is delivered into cars from a travelling belt. Bins, however, will shortly be constructed.

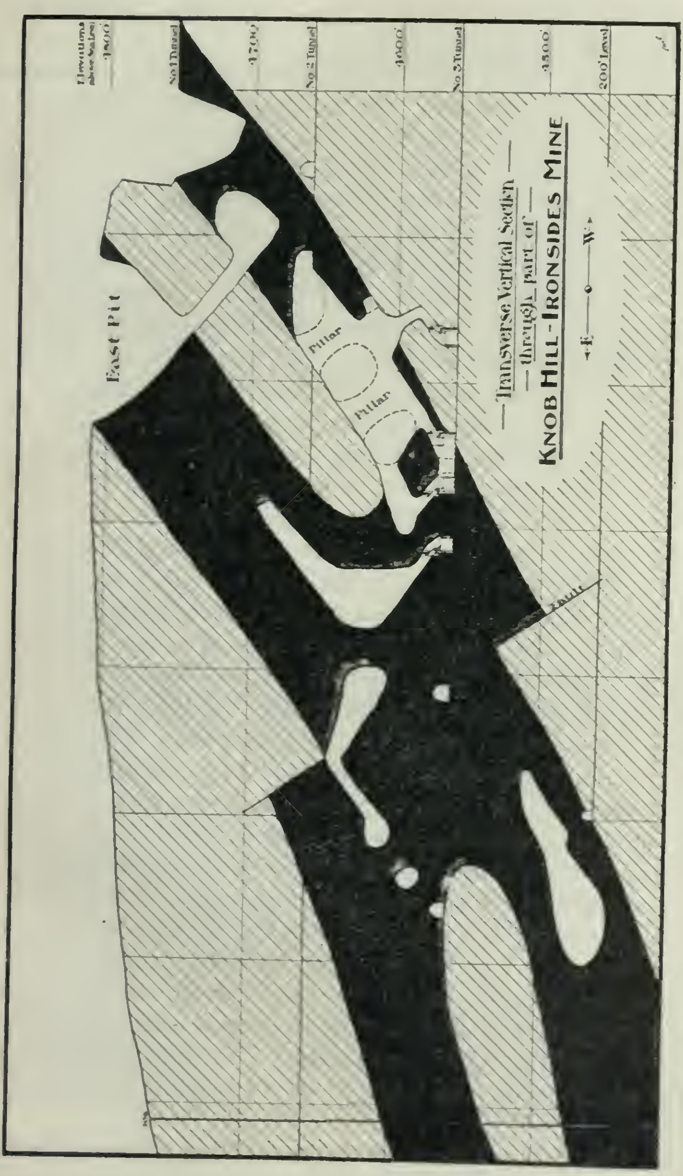


Fig. VIII—Transverse Vertical Section through Ore Body. The area shewn is blocked out in squares with 100 foot sides.

double tracked stretch of 900 feet of which three hundred is timbered with sets and top lagging.

Sill Floor Work.—On the sill floors the haulage tunnels are always being driven ahead. On the levels where the big cars run these are about 9 ft. x 11 ft. in size. For a drift of this size a twenty hole round is used. This is made up of four lifters, four cuts, eight breast holes in two rows and four back holes. All the rock broken on the sill floor is hand shovelled. For handling the ore different types of cars are in use. On the No. 3 Tunnel level ten ton, steel, hopper bottom and seven ton, wooden, gable bottom cars are operated. These run on a three foot gauge and are operated by an electric locomotive. Owing to the six foot height of the steel cars they could not be used for shovelling into from the sill floor and for this reason the lower wooden cars were built. They are not adapted for loading from chutes as on account of their low height the muck is liable to shoot over. In order to deliver the large tonnage required of this level these cars were an absolute necessity. There are fifteen of the steel ones and five wooden ones on this level and since their introduction three years ago they have handled close to a million tons of coarse ore besides a large amount of waste. They are all still in use and in good working condition. They have, however, their defects. The steel cars are a little too long to receive a full load without being moved. The bottom gates do not always close tight and men have to be kept shovelling off the track. In unloading, the large rocks often arch over in the car and when they cannot be dislodged with a pinch bar, dynamite has to be used. As this is hard on the rolling stock there is usually a car or two in the repair shop.

Underground the ore loading is in the hands of a mucker boss who is responsible to a shift boss and who oversees the shovellers and chutemen. A chuteman, working with a helper, loads the ore from the chutes. In case a chute gets blocked he does the blasting necessary to clear it. The train crew consists of a motorman and a head and back brakeman. The head brakeman is in charge of the train and does whatever blasting is necessary in the cars.

On the No. 2 Tunnel level the working and equipment is practically the same except that a steam locomotive takes the place of the electric one.

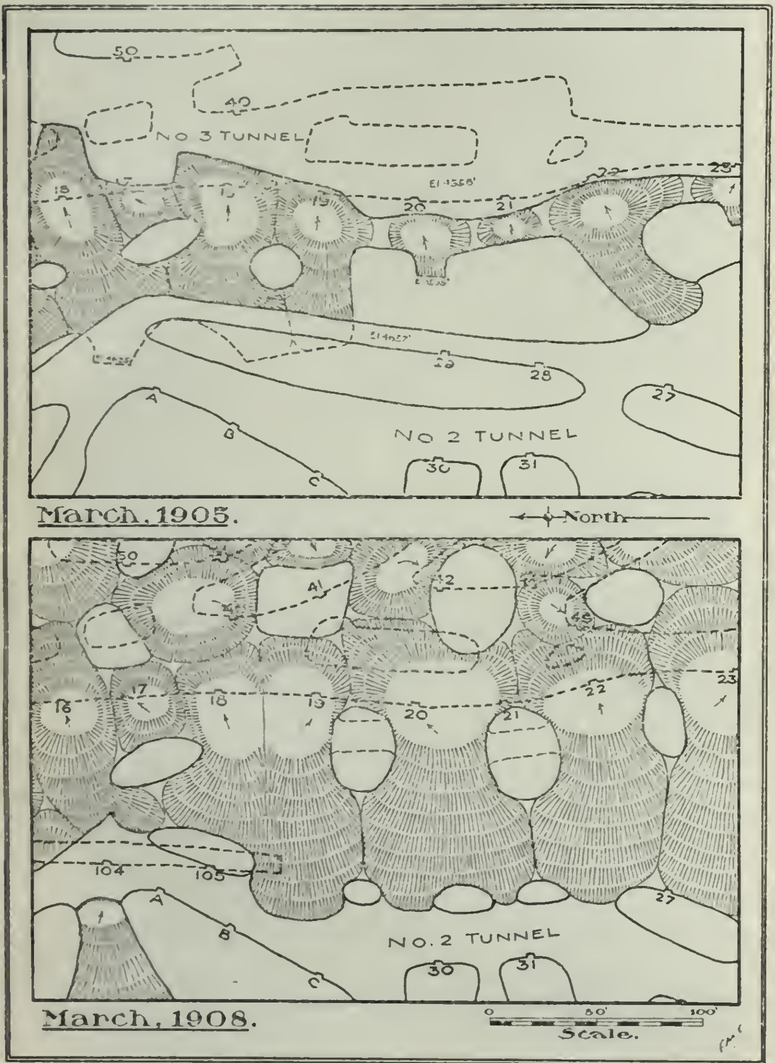


Fig. IX—Map of Stopes between No. 3 and No. 2 Tunnel Levels. No. 3 Tunnel Level is shown in dotted lines.

In order to overcome the defects of the cars in use and those available, a special steel car was designed at the works. This is used on the 400 ft. level. This car, shewn in section in Fig. XIII, is five feet high and can be used for sill floor shovelling as well as loading from the chutes. The box has a five ton capacity, and has an automatic side dumping arrangement. When a train comes to the unloading pocket, the motor goes ahead with slackened speed and a side wheel attached to the box runs up an inclined plane, the box tips, dumps its load and closes again. Since its installation in January, 1908, this arrangement has given excellent satisfaction. Figures XIV and XV show photographs of the dumping arrangements.

At the Gold Drop mine the entire output is dropped down a raise 300 feet long to the Curlew tunnel. From the chutes at the bottom of the raise to the crusher bins, a distance of 800 feet the ore is hauled in three ton capacity, side dump wooden cars by an electric locomotive. An air lift is used to dump the cars.

The Victoria Shaft.—The lower levels were originally worked by Shafts Nos. 1 and 2. These were vertical, of small size and capacity and were being worked to their limit. Besides, they were not centrally located for future workings. In order to materially increase the output from below, the Victoria Shaft was constructed in 1905. This shaft cuts the upper ore body where that deposit crosses the 400 ft. level. The shaft is on a 60 degree incline and connects with large storage pockets below the 400 ft. level. These pockets, ore and waste, are connected with the 300 ft. level by raises, thus materially increasing their capacity. The 200 ft. level will eventually be connected in the same way or separate pockets may be cut out below that level.

The skip loading device is shown in Figure XVI. The finger gates shown in the drawing is supplemented by an extra gate made out of a piece of sheet iron. By this means the fines which would naturally slip through the fingers of the main gate are caught and prevented from going down the shaft.

This type of finger gate, the sheet iron attachment being omitted, is in general use at all crushers except that at No. 3 Tunnel bins. The arrangement at the Victoria crusher is shown in Figure XVII. In the case of the No. 3 Tunnel crusher 4 in. x 4 in. square steel bars running in guides and worked by an air lift

Fig. X —View of Pillars above No. 1 Tunnel.

are used as shown in Fig. XVIII. These do as good work as the finger gates, but no better, while they need more head room to install and have a greater initial cost.

A classification of the underground force employed at two different periods will show the expansion and development along new lines of the company's operations. The figures refer to the Knob Hill-Ironsides mine only, the Gold Drop being left out of consideration. In March, 1902, the average 24 hour crew consisted of 1 foreman, 5 shift bosses, 1 timber boss, 92 miners, 26 timbermen, 139 muckers, 1 pumpman, 4 nippers, 2 trackmen, 2 samplers, 4 blasters and 2 cage tenders. This makes a total of 280 and during this time the shipments averaged about 1,000 tons per day. In March, 1908, this crew was made up as follows: 1 day foreman, 1 night foreman, 7 shift bosses, 1 timber boss, 6 mucker bosses, 160 miners, 9 timbermen, 6 timbermen's helpers, 46 chutemen, 84 muckers and chutemen's helpers, 12 nippers, 6 blasters, 10 barmen, 3 trackmen, 3 trackmen's helpers, 3 pumpmen and pipemen, 1 ditcher, 6 motormen, 2 locomotive engineers, 8 head brakemen, 6 back brakemen, 2 car repairers, 2 oilers and 2 skip tenders, a total of 387. During this month the shipments went slightly over 3,000 tons per day.

Diamond Drilling.—Since starting operations over 30,000 feet of holes have been drilled. Almost all of this has been of small size and no holes have been deeper than 600 feet. All work is done by contract, the company furnishing power and water. The mineralized portion of the core is sampled and the results are found to agree remarkably well with those of the ore body when opened up. From several holes the cuttings were collected every few feet and analyzed. As the values were away high this method was abandoned. The location of all drill holes is surveyed and the co-ordinates and elevation above sea-level of the collar of every hole noted. If the hole varies from the vertical the course and dip are also kept. Drill holes can then be plotted independently of all other information. These figures are kept in a separate set of books together with all other facts regarding this work. Several holes which have been cut underground at distances of about 300 feet below the collar have been found to be from two to four feet from the vertical at that depth.

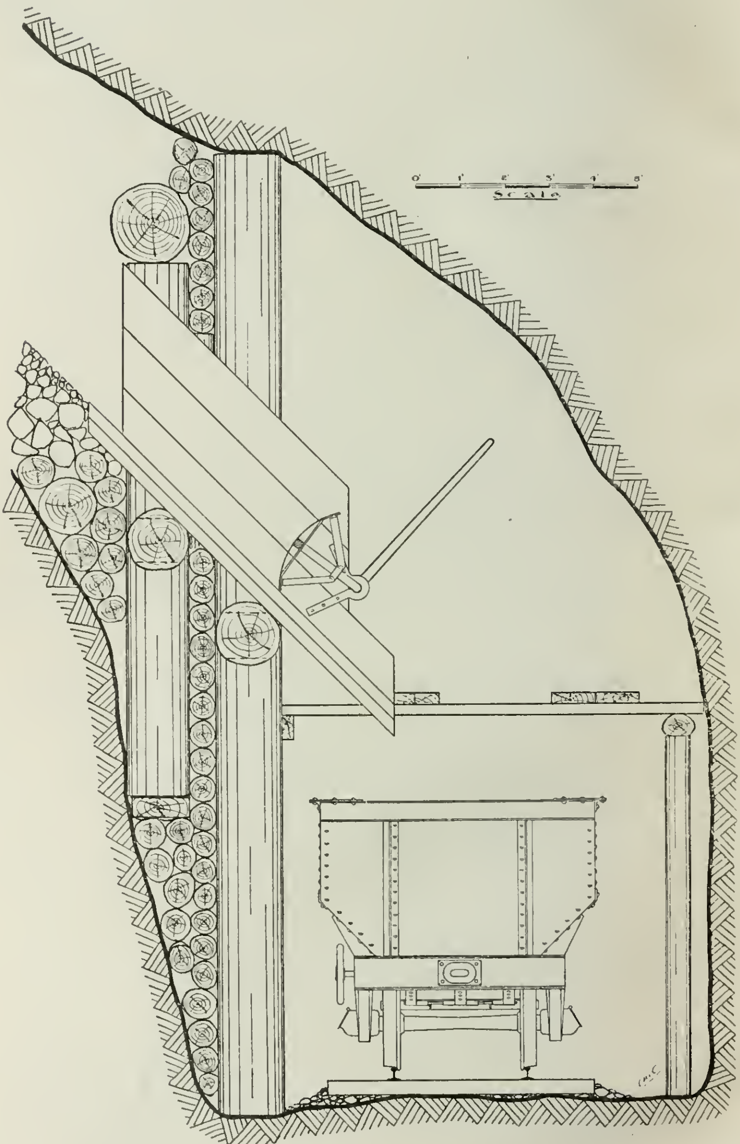


Fig. XI—Section showing Construction of Chute. Dimensions of car: Height, 6 feet; Width, 6 feet; Length, 12 feet; Capacity, 10 tons.

Surveying and Mapping.—Where the conditions are the same the surveying operations are, I think, much like those in other B. C. mines. The co-ordinates of all important stations are kept on different sheets in loose leaf ledgers. Depending on the importance of a piece of work the notes may be plotted by co-ordinates, by tangents or with a small protractor. It has been found necessary to keep a considerable number of maps on file. A general map showing the bulk of the company's land, buildings and underground workings is made to a scale of 100 feet to the inch. Combined sill floor plans on a scale of 40 feet to the inch are made of the Knob Hill-Ironsides and Gold Drop mines. Brown print copies of these are placed in the shift bosses' offices. It has also been found necessary to keep the stopes above each level on a separate map and separate maps are made of each level showing the geological features, especially the ore boundaries. Transverse vertical sections are made every 200 feet. These last two series of maps are used in calculating the ore in sight. The permanent features such as shafts, side lines, drill holes, etc., are put on in ink, but as the geography of a level changes so rapidly the rest of the workings are indicated in lead pencil. From all these maps a set of brown prints is made at intervals. From the sill floor plans a glass model of the Knob Hill-Ironsides is kept up-to-date. This consists of sheets of glass running in slides in a plate glass frame. On the glass sheets are outlined the different levels, areas of the ore bodies, faults, etc., and as the space between the glasses corresponds to the space between the levels a better idea of the ground can be obtained than when all the plans are in the one plane. This arrangement does not need to be referred to often but when it is needed it is found to be of very considerable help. It is the intention to supplement this with another similar arrangement having vertical glasses instead of horizontal ones. These will have the transverse vertical sections marked on them.

Stope Maps.—The method of mining employed, whatever other advantages it may have, certainly does not tend towards simplicity in the stope maps. These are necessary to show the relation of the pillars to the level below and the level above. The vertical sections are also constructed from these maps. As the stopes consist of a series of raises and glory holes with all the intermediate stages and with the pillars standing at different angles due to different dips of the ore body, it is not a simple matter to make a map which will show all these features to advantage. After considerable experiment it was decided to adopt, and adapt somewhat, what is known as the hachure method of map construction as used in topography. As the appearance of a stope soon changes no attempt is made to go into unnecessary detail. In surveying, a set-up is made in as commanding a position as possible, sights are taken to the governing points on the pillars and the ridges between the glory holes. These points are plotted and when the tracing is made, contour lines, afterwards erased, are drawn in pencil on the tracing, approximately at ten foot intervals. The hachure lines are then inked in, their extremities being at right angles to the adjacent contour lines. Thus when the contour lines are not parallel the hachuring has a radiating appearance. This is shown in Figure IX. When it is advisable to know the exact height of any part of a stope the elevation above sea-level is marked on the map at that place.

Ore in Sight.—Ore in Sight, Ore Developed, Ore Blocked Out or whatever term may be preferred is calculated independently from the sill floor plans and from the transverse vertical sections. The mean of these estimates, which do not vary to any considerable extent, is then taken. The horizontal area of each ore body as it crosses a level has been pretty well defined by drifts, crosscuts and drill holes. The average of this area and the area on the level above is multiplied by the vertical distance and from this product the tonnage is calculated. Each block of ground is figured out separately and from the total the ore shipped is deducted, the balance being Ore in Sight. The ore extracted between shipping levels is also kept track of and the Ore in Sight in different blocks of ground can thus be estimated.

Brown Prints.—As a considerable number of technical men who have visited us during the last few years have found this process to be a novelty, a few remarks regarding it may be excusable. The process is used chiefly for the reproduction of mine maps, blue prints being used for mechanical drawings. A tracing is first made from which a negative on thin brown print paper is obtained. Using paper of a heavier grade a positive consisting of very dark brown, practically black, lines on white background is produced. The different levels, which are superimposed in part, can

Fig. XII—Photograph of Mine Chute. A wooden, gable-bottom car is shewn in the figure. This is used specially for sill floor shovelling.

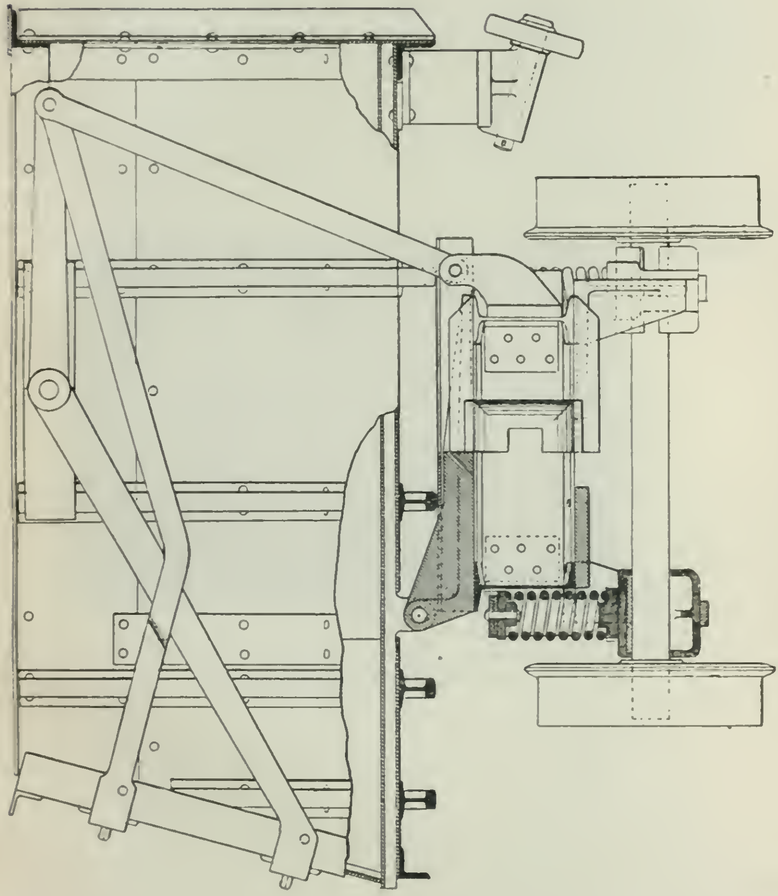


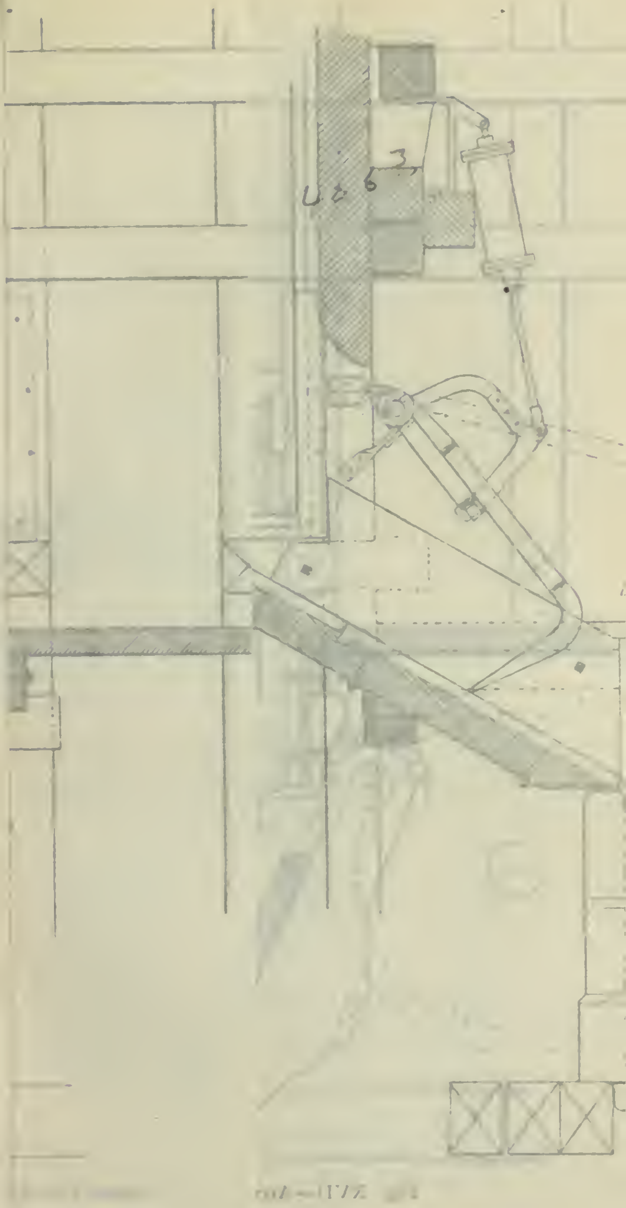
Fig. XIII—Section through Mine Car, 400 Foot Level.

then be coloured and the map rendered intelligible to others besides the draftsman. There are also other advantages. When a tracing has to be brought up to date it may happen that some pillars have been removed, drifts widened, etc. No erasures are made on the linen but the extra lines needed are inked in and the lines not needed are simply inked out on the negative. Another advantage is that the title, and other important lettering, has only to be made once and traced once. On subsequent tracings it is omitted. The original negative is, however, kept and in future negatives it is only necessary to cut a hole where required and attach the negative of the title or whatever it has not been advisable to alter. There are other minor advantages which will show themselves after the process has been used for a little while.

406'

Fig. XIV—Ore Train approaching Pocket. The incline for dumping the cars is shewn on the left.

Fig. XV—Ore Train at Pocket.



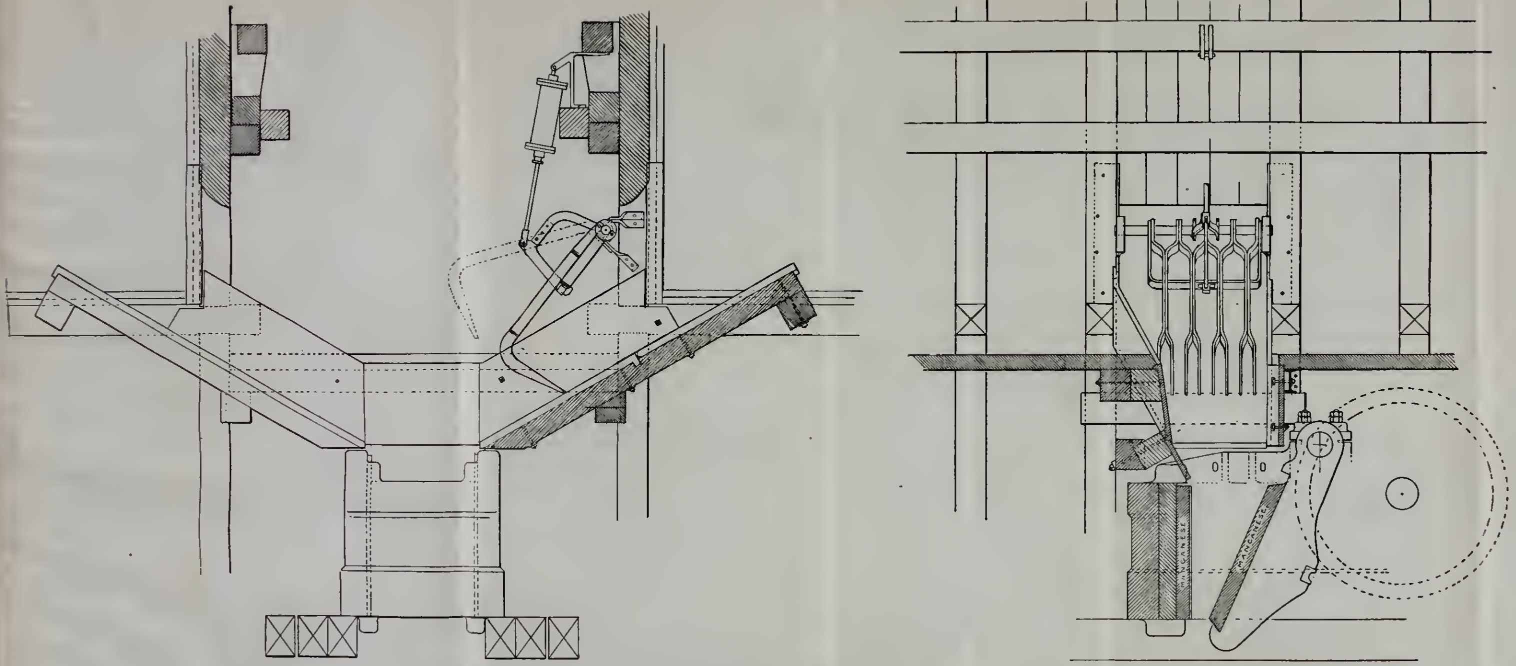


Fig. XVII—Arrangement of Gates at Victoria Crusher.

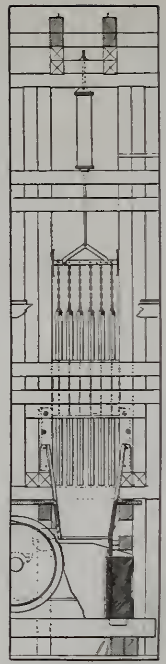
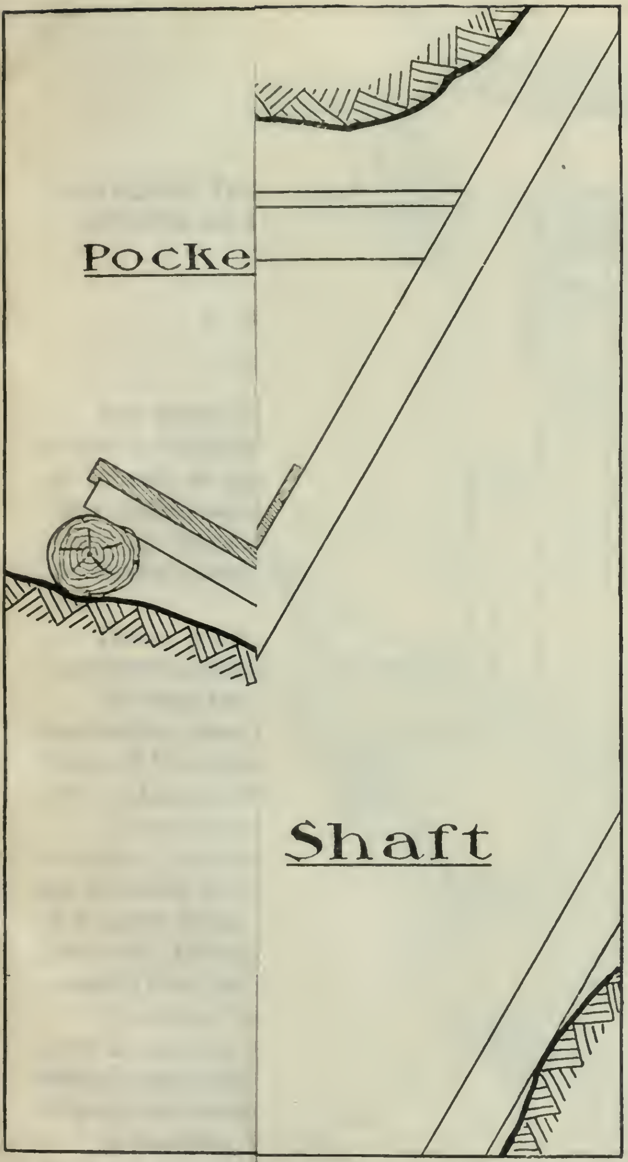


Fig. XVIII—Type of Gate used at No. 3 Tunnel Crusher.


Pocke
Shaft

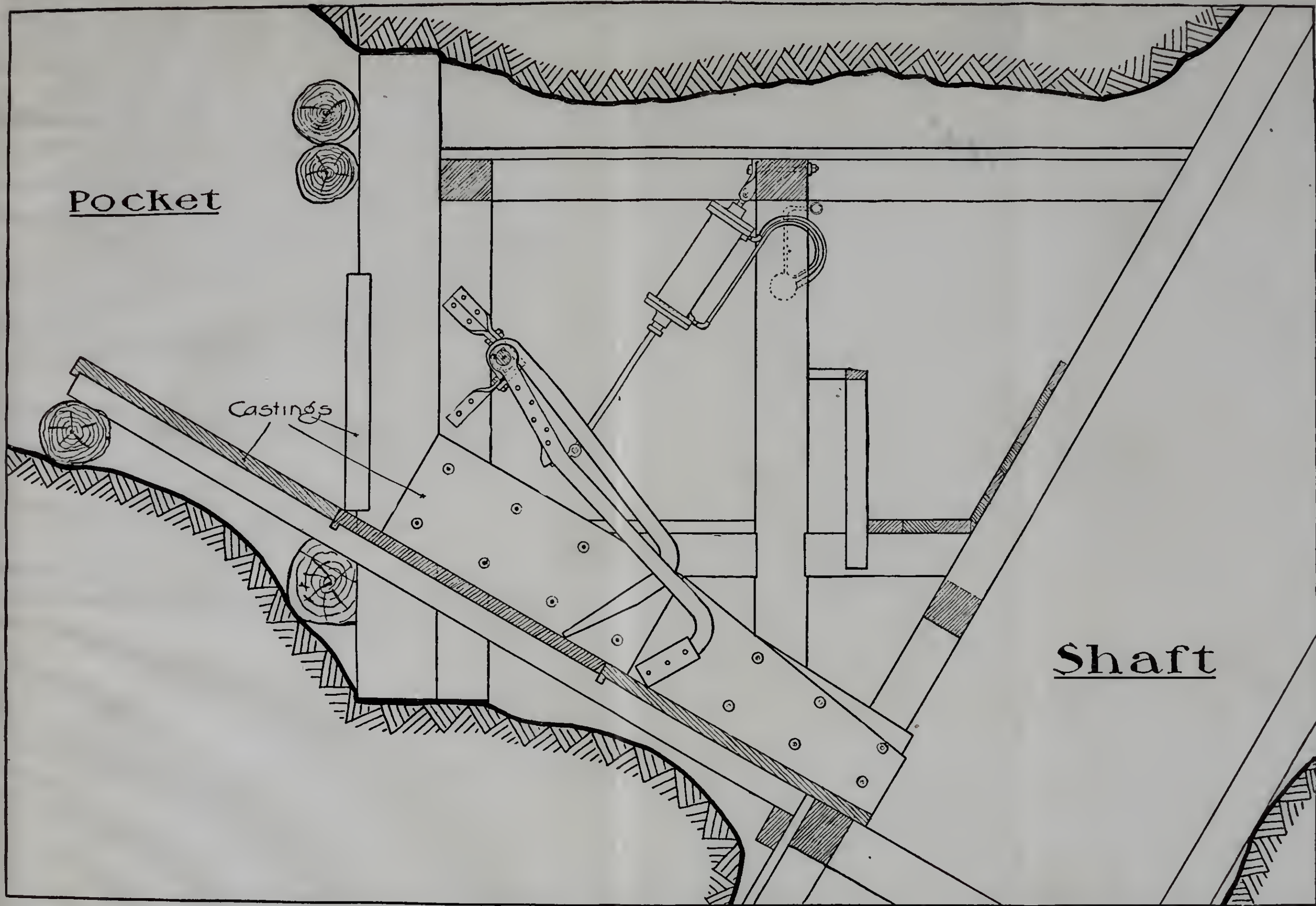


Fig. XVI.—Skip Loading Device at Victoria Shaft Pockets.

HANDLING THREE THOUSAND TONS OF ORE PER DAY AT THE GRANBY MINES AND SMELTER, PHŒNIX AND GRAND FORKS, B.C.

A. B. W. Hodges, Grand Forks, B.C.

(Nelson Meeting, January, 1908).

Few people realize the amount of work and the problems to be solved in handling daily 3,000 tons of ore from the Granby mines at Phœnix to the smelter, delivering this ore to the smelter (24 miles distant and nearly 3,000 ft. lower in elevation) all crushed ready for the furnaces, then discharging it into the furnaces, and finally taking away the resulting slag and putting it over the dump.

Before going into methods in detail, a description of the machinery necessary for this work may be afforded.

To bring the ore out of the mines requires one 14-ton steam locomotive, three 75-h.p. electric locomotives, one 250-h.p. electric hoist, 30 10-ton steel ore cars, 40 5-ton ore cars, 20 1-ton steel mine cars, and about 10 horses.

The ore is crushed at the mine by three 36 x 42 in. Blake type crushers, operated by 150-h.p. induction motors. This crushed ore is loaded in 30 to 50-ton steel bottom dump railway ore cars. It requires about eighty 50-ton and eighty 40-ton ore cars, and five or six 150-ton steam locomotives to convey this amount of material from the mines to the smelter daily.

The ore at the smelter is dumped into elevated bins directly from the railway ore dump cars. From these bins it is drawn into steel charging cars, when, with the proper amount of coke, it is run directly into the ends of the blast furnaces and dumped.

In charging 3,000 tons daily four charge trains of three cars each are required, each train holding four tons of ore and the requisite amount of coke for smelting it. Four electric locomotives of 30-h.p. capacity are required for each train. There are also two spare trains.

The slag is carried away from the furnaces in slag pots holding five tons each, and three pots are required for each of the eight furnaces, making twenty-four in all. It requires four 14-ton steam locomotives to carry the slag away from the furnaces. There are ten extra slag pots and one extra engine ready for use in an emergency.

From the foregoing it will be seen that as the movement of ore must go on in the different departments each 24 hours, the machinery and equipment must be large and in first-class condition to handle it.

The ore from the different levels of the Granby mines is taken from No. 2 tunnel, which is about 250 ft. below the top of the hill; No. 3 tunnel, 100 ft. below No. 2; and the 400-ft. level, which is about 650 ft. below the top of the hill.

No. 2 tunnel has about 3,800 ft. of 3-ft. gauge 30-lb.rails, and the ore is drawn from 56 chutes into 10 steel ore cars, bottom-dump; also into low wooden cars holding five tons each, and is hauled out by a 14-ton steam locomotive using coke for fuel to avoid smoke. Eight to ten cars are hauled in a trip, and in two shifts of 16 hours 1,000 tons can be brought out. These trains come out from underground and run over the bins into which they dump the ore, and it is then fed into a very large Blake-type crusher, having a jaw opening of 42 x 36 in., and crushed to about 7 or 8 in. in thickness. This crusher can handle 150 tons of ore per hour.

FIG. 1 shows No. 2 tunnel train passing over the ore bins. The smoke stack and cab of engine are cut down to enable it to go into small places.

The ore bins and crusher are situated about 700 ft. from the mouth of the tunnel, and the ore from the crusher is delivered to railway ore cars built specially for ore hauling and having movable doors at the bottom for dumping the ore after it arrives at the smelter bins.

No. 3 tunnel has 3,800 ft. of 3-ft. gauge 30-lb. rail track, and 92 ore chutes, and the ore is taken out of the mines with the same style car as used in No. 2 tunnel, only electric mine locomotives are used to haul the trains.

FIG. 2 shows two of these trains, looking at them from the motor end. These locomotives are manufactured by the Westinghouse Baldwin Company, and have two 35-h.p. motors, one on each axle.

FIG. 1.

FIG. 2.

They are run at 500 volts pressure, direct current, the current being taken from a motor generator set near the tunnel mouth.

The crusher bins for this tunnel are 1,200 ft. from the mouth of the tunnel, and the trains run over the top of two bins, each holding 500 tons of coarse ore. These bins are about 16 ft. apart, and the crusher is placed between with a run-way and gates from each bin into the crusher. This crusher is also of the Blake-type, having an opening 42 x 36 in., and a capacity of 150 tons per hour.

The crushed ore is dropped into a large steel continuous-bucket elevator and is elevated at an angle of 45 deg. to a small chute, where it is fed directly into 53-ton railway steel ore cars, with bottom dump. Two thousand tons of ore have been hauled out, crushed, and loaded in railway cars in 24 hours.

All the ore from under No. 3 tunnel is dropped to the 400-ft. level, which is 300 ft. below, and then taken from about 42 chutes at the present time to the Victoria shaft, whence it is hoisted to the surface.

There are about 4,000 ft. of 3-ft. gauge track on this level. The ore is hauled in 5-ton steel cars. These cars are specially designed for this level. They are not over 5 ft. high, but are wide and flat at bottom, the body is hinged on one side of the running gear or trucks, and the long side gate is opened and the car tipped, both automatically, when directly over the ore pocket.

The ore in the Granby mines is rather soft and breaks in large pieces, hence bottom-dump cars with small openings must be avoided. We have found a side-dump car the best, although our 10-ton steel ore car has a 3 x 3 ft. opening in the clear in the bottom, but the hole is hardly large enough.

The cars on this level are hauled by an electric locomotive, of similar power and voltage to that in No. 3 tunnel.

The ore pockets on this level hold about 400 tons of ore, and extend to 40 ft. below where the skip is filled. There is also a pocket for waste rock.

The shaft is three-compartment, having a man-way 4 x 6 ft. in the clear, and two skip-ways each 5 x 6 ft. in the clear. The skips are balanced, hold about 5 tons of ore, and run at a speed of about 900 ft. per minute. This will hoist 2,000 tons in two 8-hour shifts.

The sheave wheels of the gallows frame are about 90 ft. above the ground and are so elevated that the skip can dump about 60 ft.

up, and the ore run into either one or other of two coarse ore bins, each holding 500 tons of ore. These show at the right of Figure 3. Between the two bins is a large crusher of similar size and pattern to the others mentioned; it is driven by a 150-h.p. 2,000-volt induction motor. This motor shaft is extended on one side about 16 ft. by a flexible coupling and on this shaft are two pulleys of suitable size, which drive the two pulleys on the crusher.

It would seem that a 150-h.p. motor is too large a motor for operating the crusher which only takes from 75 to 80-h.p. to crush the ore, but the crusher is so big and the moving parts so heavy that it takes 280-h.p. to start it.

The skips are hoisted by a double conical drum hoist driven by a 250-h.p. variable speed induction motor at 2,000 volts pressure. They generally run in balance, but can be operated separately in either direction. The drums are large enough for 1,000 ft. of cable.

FIG. 4 A. is a photograph showing one of the spouts and finger gates where the coarse ore from the storage bins runs into the jaws of the crusher. These finger gates are used in all ore crushers, also down in the skip ore pockets, and are best suited for handling large material. The four fingers are each made of two bars of 1 x 4-in. iron and all are raised at once by compressed air in the cylinder as shown in the picture, and are also let down by air pressure, but each of the four fingers is independent, and one or two might stay half way up on account of a large piece of rock getting in the way, but the other two would be down and stop small rocks from getting through.

The ore from this crusher falls directly upon a belt conveyer, travelling at a speed of 250 ft. per minute, and having a capacity of 200 tons per hour. The belt is 42 in. wide and 241 ft. centres; it goes up at angle of 14 or 15 deg. and is operated by a 50-h.p. induction motor suitably geared to the driving pulley which is at the upper end. This belt conveys ore to four bins, two of which discharge into Canadian Pacific railway ore cars on one side, and the other two into Great Northern railway ore cars on the other side. These four bins have a capacity of 700 tons of crushed ore.

The relative positions of the gallows frame, conveyer and shipping bins are illustrated in Figure 3.

Fig. 3.

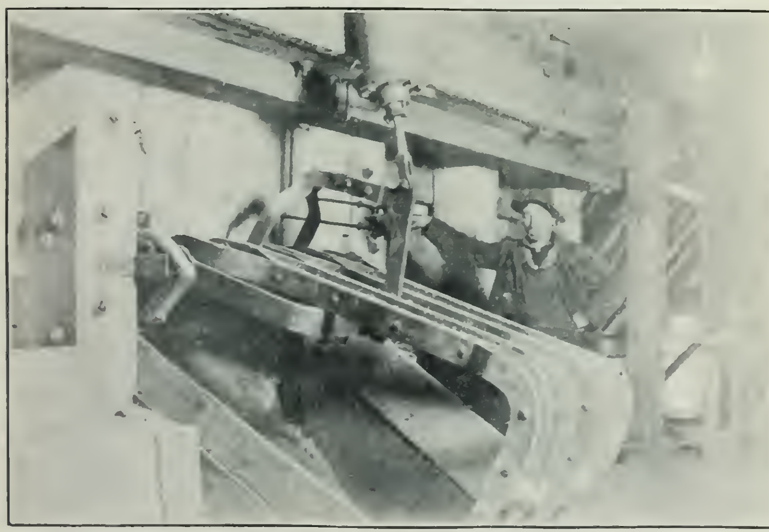


Fig. 4 A.

Fig. 4.

Fig. 5.

FIG. 4 shows a nearer view of the gallows frame coarse ore bins on either side and hoist room in front. The gallows frame is now entirely covered in.

FIG. 5 shows the shipping and loading bins at the terminus of No. 3 tunnel, where the crushed ore is loaded into Great Northern railway bottom-dump 53-ton steel ore cars. These bins are capable of loading 900 tons into cars in half an hour.

The 3,000 tons of crushed ore are hauled to the smelter, 24 miles distant, on branch lines of the Canadian Pacific railway and Great Northern railway, in special steel bottom-dump ore cars, and the 65 or 70 cars of ore required daily are brought down in four trains. The grade from the mines to the smelter is about 3 per cent. and the great difficulty experienced is in getting the empty cars back up to the mines again.

These ore trains are weighed at the smelter on track scales and are run out over the ore bunkers and the ore dropped into the different bins. Here there are three sets of ore bunkers parallel with one another and 760 ft. long, and each holds about 5,000 tons of ore.

About one car in ten is set over the sampling bin and the ore from this is re-crushed and a sample automatically taken which fairly represents the day's shipments. The metal contents of the ore being so uniform very careful sampling is not required to determine its contents, in fact, one lot of 30,000 tons will not vary more than 20 cents per ton over or under another of similar quantity.

The ore chutes at the bottom of these bins are about 6 ft. above the furnace charging floor, so that the furnace charge cars are run under these spouts and receive the crushed ore by gravity, and these cars, which have already received the requisite quantity of coke in the bottom, are weighed again to get the proper amount of ore, and then the train of three cars is pushed on a 20-in. gauge track into the end of the blast furnace, when the charge is dumped into the proper place, these cars being just the length of the inside of the furnace. Each train of cars feeds two 44 x 210-in. blast furnaces and handles from 750 to 900 tons of ore per 24 hours.

FIG. 6 shows the furnace charging train being loaded at the ore bunkers, and FIG. 7 shows the same train just about to enter the blast furnace.

The track rails do not enter the furnace but the cars are carried in on auxiliary wheels on the upper corners of the cars and run on tracks built in the sides of the furnace, as shown in Figure 6. These cars are divided longitudinally in the centre, and the doors open on each side, the hinge being at the top. This spreads the charge along each side of the furnace in the proper place. These charging cars are used only at the Granby smelter and are an invention of the writer's. They are pushed around by a 30-h.p. electric locomotive, 250 volts direct current. Each train holds a little more than four tons of ore, together with the proper amount of fuel at the bottom of each car.

The final work in the handling of the 3,000 tons of ore is taking the moulten slag and matte from the blast furnaces. The matte, which is only about three or four per cent. of the charge, is tapped out of the settlers in front of the furnaces into a cast steel pot holding about four tons, and while still in a molten state is taken by an overhead electric crane to the converter building and dumped into the converter. The slag runs from the first settler into a second one in front and thence into a slag pot of 44 cubic feet capacity. The second settler has two spouts, one on either side, and there are two slag pots on one side and one on the other, so that there is always one in place for the slag to run into.

FIG. 8 shows front of blast furnace on furnace floor, also both settlers, electric crane, slag pots, etc.

FIG. 9 shows trains of slag pots going to the slag dump. These slag pots dump automatically, that is, when full of slag the centre of gravity is above the trunnion, therefore by removing a latch the pot dumps itself, and after the slag is out, comes back to normal position itself, when it is again latched in place. The bowls of these slag pots are cast in halves and bolted together, thus preventing cracking from the continual expansion and contraction. These pots have been very serviceable, but they are too small in capacity after the furnace gets beyond 400 tons per day.

The slag from two furnaces is drawn away by one 14-ton 3-ft. gauge steam locomotive. An electric locomotive would do just as well. One of these locomotives and six slag pots will handle from 800 to 850 tons of slag per 24 hours, provided the dump is not more than 1,500 ft. long.

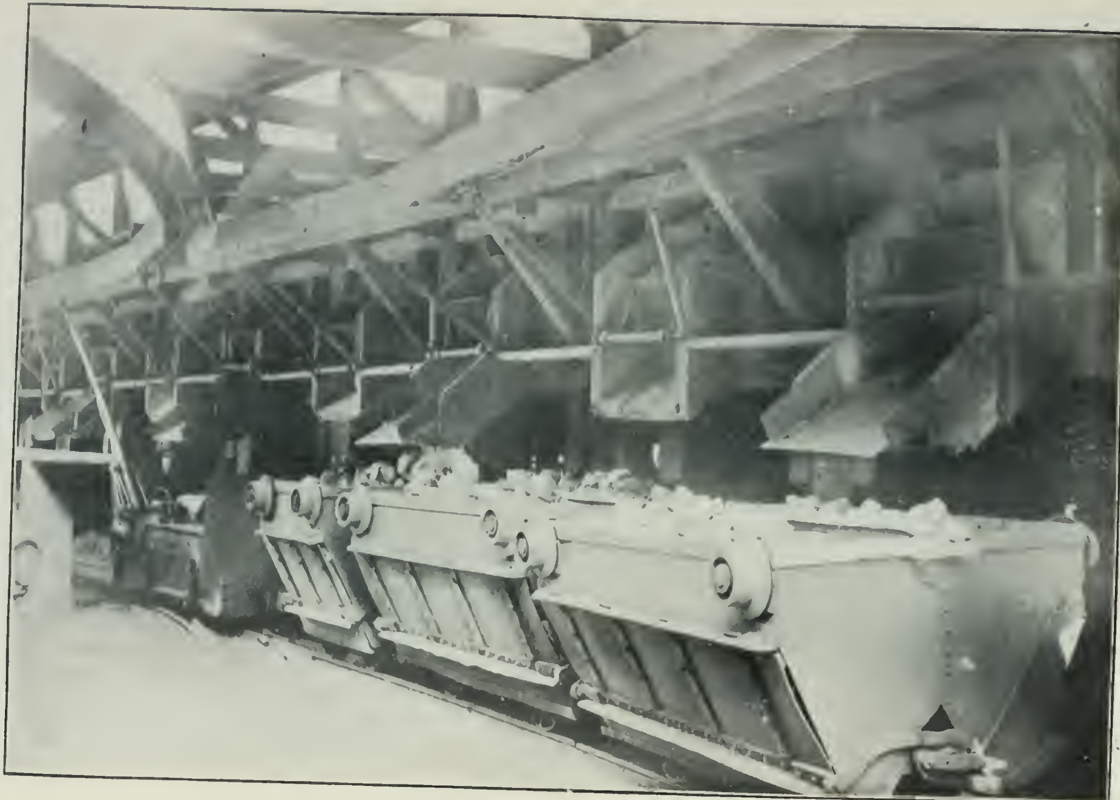


FIG. 6

FIG. 7.

It will be seen from the foregoing that it is practically necessary to handle nearly all of the 3,000 tons of ore four different times in one day before the process is completed.

FIG. 10 shows a general view of the Granby Smelting Works at Grand Forks, the slag dump, and general arrangement of buildings.

DISCUSSION.

MR. D. H. BROWNE:—I would ask Mr. Hedley if this reduction has not been greatly increased? I understand that three thousand tons a day does not represent the maximum output.

MR. HEDLEY:—I understand that since this paper was prepared they have since reached a maximum output in a day of twenty-four hours, of 3,450 tons. Before this paper was presented the company had made an average for a week of 3,200 tons a day. They expect to increase the capacity by lengthening the furnaces.

MR. BROWNE:—At Copper Cliff we are running two furnaces each of 204 by 50 inches, which figure out slightly larger than those referred to in this paper. At the present time we are putting through every day over 900 tons of ore with an additional 225 tons of converted slag. That is why I wanted to ask if 3,000 tons was the record achievement of the Granby Company, because if it is our record in Ontario may challenge comparison.

THE PRESIDENT:—The B.C. Copper Co's furnaces at Greenwood will average eight tons per square foot of hearth area, day in and day out. The average output is nearly two thousand tons a day, or 650 tons per 24 hours for each furnace. The furnaces are 240 by 48 inches, or twenty feet long and four feet in diameter. The furnaces were originally 48 by 240 inches, but we have changed them by altering the jackets to reduce the consumption of sulphur. We have, however, found another method of doing that and so intend to widen the furnaces to the original area. They are now temporarily 44 inches wide.

THE PRESIDENT:—Mr. Hodges states in his paper that it is found necessary to use a 150 horse power motor to start the crusher. In our works we have the same size crusher driven by a

100 horse power motor. We get over the trouble of starting by drilling a hole through the pitman of the crusher and turning on a steam jet, which warms the pitman so that it will not stick. Then we put in a counter shaft between the crusher and the motor, and on the counter shaft we put a heavy fly-wheel connected directly with the motor. We start the motor until we get the fly-wheel going at full speed and then gradually throw on the crusher with the friction clutch, and in this way we have had no difficulty starting it with a 100 horse power motor. But if you start the crusher directly you will need a 150 horse power motor.

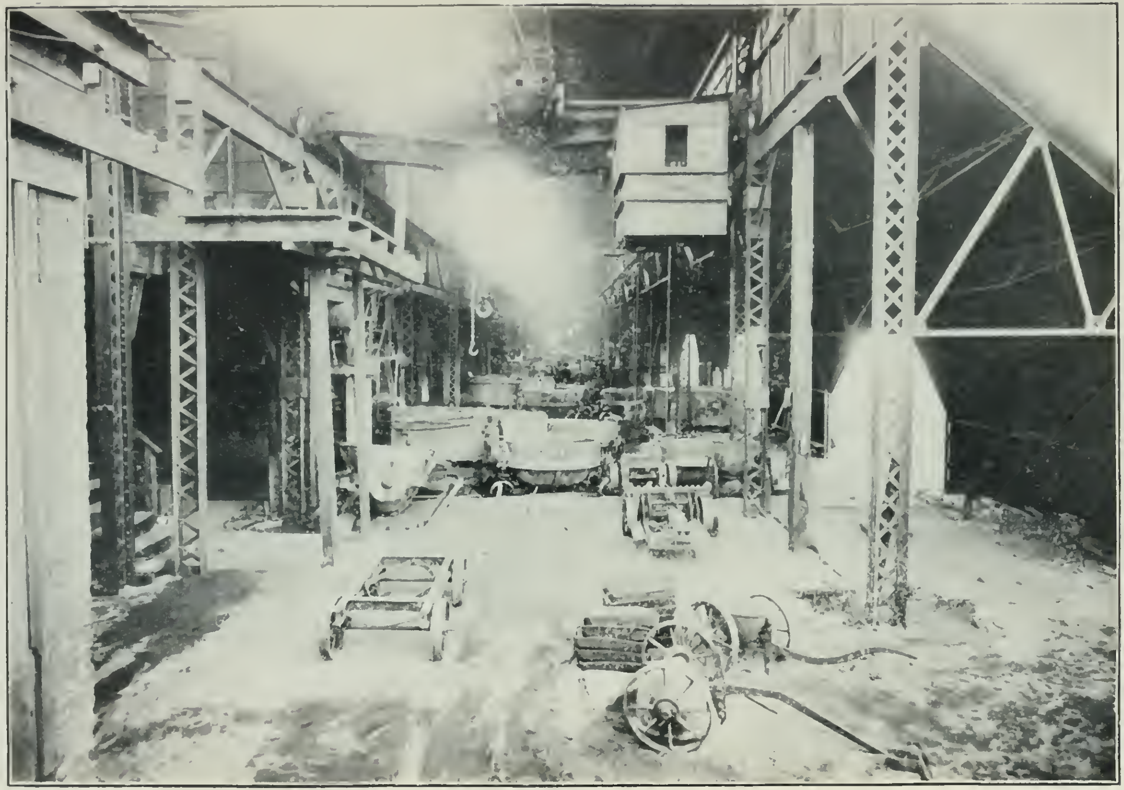


FIG. 8.

FIG. 9.

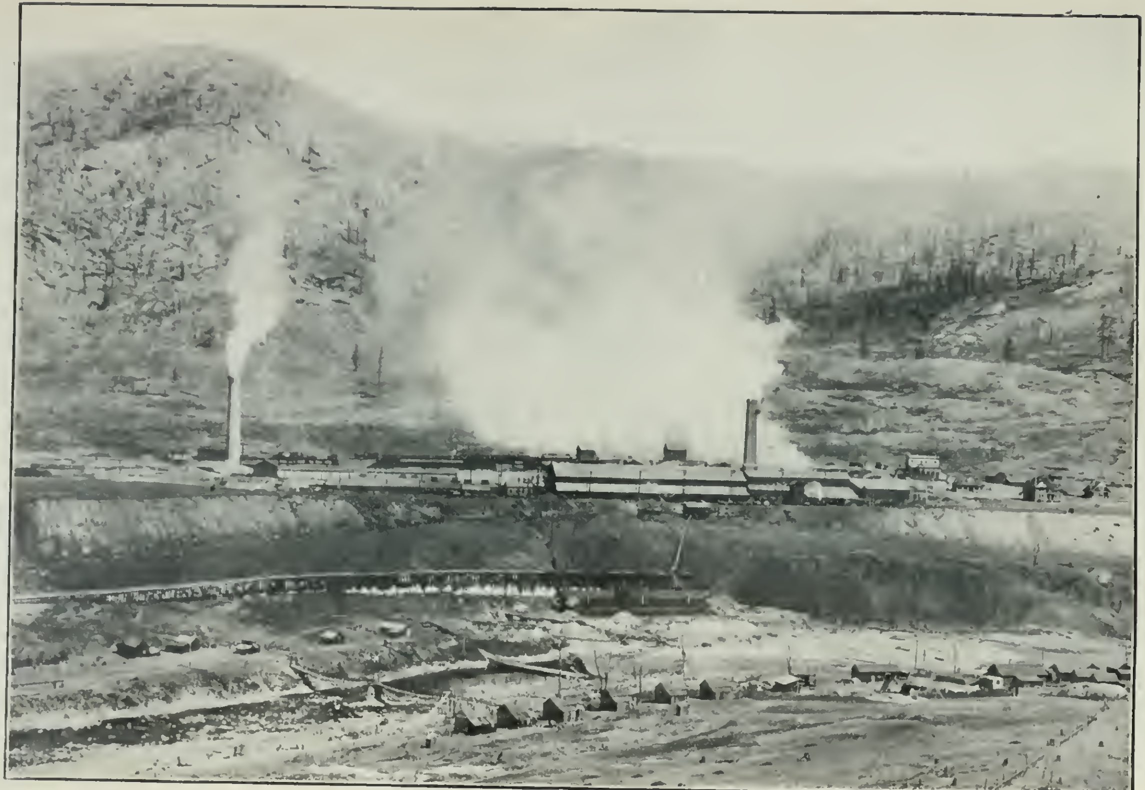


Fig. 10.

SOME NOTES ON THE COPPER RIVER DISTRICT, ALASKA.

By Wm. M. Brewer.

(Ottawa Meeting, 1908).

Until after the discovery of the occurrences of native copper and copper-bearing ores in the British Yukon and Alaska, there had always been considerable speculation as to the source from which the British Columbian and Alaskan Indians had procured the native copper which they were found to be using. Usually, this native copper was applied to the manufacturing of large plates engraved with Indian symbols, and these were handed down from generation to generation as heirlooms. The dimensions of many of these copper plates are from one and a half to three feet square, and about one-fourth of an inch in thickness.

Early explorers of Northern British Columbia, especially of the Queen Charlotte Islands and portions of Alaska, have called attention in their writings to the possession of these copper plates by Indian families, and many of the best specimens of this character of Indian craft are preserved in the Provincial Museum at Victoria.

Since systematic prospecting for copper ore has been carried on, it has been discovered that in the Rainy Hollow district, about forty miles in the interior from Haines' Mission on the Lynn Canal, also in the Copper River district, Alaska, native copper occurs, and is very often found in nuggets and masses of quite considerable weight. The first named of these districts is in British territory, and the latter in United States.

So far as our present knowledge goes, the first prospecting for copper-bearing ores in this portion of the American Continent was contemporaneous with the discovery of placer gold in the Klondike. Nuggets of native copper were found by pioneers in the streams flowing from the glaciers which are of great extent, and very numerous in the district referred to. Naturally, the finding of these nuggets led prospectors to endeavour to locate their source or origin. The result of this was the discovery of deposits of copper-bearing ores over a very large area of the British-Yukon and Alaska. In this territory are the districts of Rainy Hollow, Whitehorse, and Kluahne, all in the Yukon, the last named being situated about two hundred miles to the westward from Whitehorse. In Alaska, the districts in which copper-bearing ores were discovered, included many of the islands in the Pacific, notably: Prince of Wales, Latouche, and Knight's Island; again in portions of the Coast Range of mountains, and in what is known as the Copper River district, with which it is proposed this paper shall deal in particular.

A reference to the accompanying map will give some idea of the superficial area, and also the possible extent of the district under discussion.

The Copper River proper is a stream of some magnitude, being navigable for stern-wheel steamers of light draft, for a distance of some two-hundred miles above its mouth, except through the rapids known as the Abercrombie Rapids. The principal tributary of this river is the Chitina, which is also navigable for several miles above the confluence of the two rivers. The Copper River flows from the north in a nearly due southerly direction, emptying into the Pacific Ocean near Catalla, about seventy-five miles easterly from Cape Hinchinbrook, and about thirty-five miles from Cape St. Elias. Its main tributary, the Chitina, flows in the south-westerly direction, and heads among the glaciers in an unexplored territory, and not a very great distance from the source of the White River, which flows toward the east and north, and empties into the Yukon River near the mouth of the Stewart River.

As a matter of fact, the occurrences of copper-bearing ore and native copper so far discovered, are more closely situated into the Chitina River than to the Copper River itself, and it is believed that the Indians always recognized the Chitina as the source from which they procured the native copper they hammered into plates; as in the Indian language, the meaning of the word Chitina is copper water—*Chit*—copper; *Ina*—water.

To the present time, the only discoveries of copper-bearing ore in the immediate neighbourhood of the Copper River itself, are near Taral, not a great distance from the Abercrombie Rapids.

416a

COAL
COPPER CENTER
KLUTINA RIVER
KLUTINA
SILVER TIN & COPPER
MT BLACKBURN 16140
MT REGAL 13400
COPPER
COPPER
COPPER
COPPER
COPPER
PLACER GOLD
COPPER
COPPER DISTRICT
CHITINA RIVER
LAKINA RIVER
PLACER
WHITE RIVER
COAST RANGE
MOUNTAINS
VALDEZ
PORT VALDEZ
COPPER
RIVER
COPPER
PLACER GOLD
UNEXPLORED TERRITORY
ALASKA
BOUNDARY LINE
YOUKON
PRINCE WILLIAM SOUND
HAWKINS ISLAND
HINCHINBROOK ISLAND
ST. ELIAS RANGE
COAL & OIL
COAL & OIL
Behring Glacier
CHILKAT VILLAGE
Mount St Elias
PLACER GOLD
NORTH PACIFIC OCEAN
Scale Miles 20 30 40 50 60
62°
61°
60°
146°
145°
144°
143°
142°
141°

These discoveries have not provoked as much discussion, or been as thoroughly advertised as those made near the Chitina River and its tributaries. In fact, till last year, only one or two prospectors were engaged in exploring the section around Taral, while in the Chitina country there were probably all told, two hundred men, many of whom were engaged in prospecting, and the balance employed by the companies owning prospects and engaged in performing representation work on their mineral claims.

The Copper River district extends from a point about 60 miles from Elliott Creek, a branch of the Kotsina River—where the Hubbard and Elliott group of claims is located—to the Kennicott River near the head of which is located the Bonanza group of mineral claims. From this latter point, it is about 80 miles in an air line to the boundary line between Alaska and the British Yukon territory. In this section scattering occurrences of copper-bearing ore have been discovered towards the east and north-east from the Bonanza mine, especially in the vicinity of the head-waters of the White River. Some of the latest discoveries of copper-bearing ore have been made in the British-Yukon, near the White River, also in the Kluahne Lake district. From this it would appear as though a mineralized zone extended from what is known as the Copper River district in Alaska, across the boundary easterly to the Whitehorse district, and that the territory, especially near the head-waters of the various rivers throughout this entire section of country, would well repay careful prospecting.

Until now, travel into the Chitina country has been by way of Valdez, at the head of Prince of Wales Sound, thence by trail, following the Valdez-Fairbanks trail for a distance of about 80 miles to the telegraph station on the Tonsina River, a tributary of the Copper River. At that point a trail branches off towards the east from the main Valdez-Fairbanks trail. This trail follows down the Tonsina River, and crosses Copper River at about two miles above the mouth of the Tonsina, where a crossing is made by ford or boat-ferry. From this point the trail takes a general easterly course, and crosses the Kotsina, Strelna, Kuskulana, Chokosna, Lakina and Kennicott Rivers, all of which are tributaries of the Chitina River, and head in the mountain range where glaciers are so extensive and numerous that although each one of these rivers is comparatively short, and under ordinary circumstances and elsewhere would be regarded as insignificant streams, yet under the peculiar local conditions any of these streams are likely at any time to present a formidable obstacle to travel, since heading as they do, in glaciers, the volume of water between their banks is so variable, and is subject to such extremes of rise and fall that crossings are dangerous to the unwary or inexperienced. A few hours, for example, of hot sunshine will change any of these streams from a harmless creek into a mighty torrent.

The distance from the crossing of the Copper River to the Kennicott River by the route of the present trail, is about fifty-five miles.

I understand that during the coming summer, it is proposed by the J. Pierpont Morgan interests, who are building a line of railroad into this region, to place stern-wheel steamers on the Copper River; one to ply from the mouth to the Abercrombie Rapids, and the other from above the Abercrombie Rapids to the head of navigation on the Chitina River. In fact, during the summer of 1907, a steamer was taken into this district, packed in sections, from Valdez to the Copper River, over the winter trail, put together, and made one trip on the Copper River from Abercrombie Rapids up to Copper Centre, and also one trip from the mouth of the Chitina River to the neighbourhood of the mouth of the Kennicott. This entire trip was made without any accident, under the pilotage of Indians who have a most perfect knowledge of the navigable channels of these rivers.

If this proposed steamer route is adopted then travel into this new copper-bearing district, at least during the summer months, will be very much easier than it has been in the past; for, although the use of horses for riding is possible on the trails, yet so many marshes and swamps are found on the divides between the streams crossing the route, as to make travel especially disagreeable for the *Chi-cha-co*, or tenderfoot. Another advantage that will accrue from navigation on the rivers, will be the reduction in cost of freighting supplies and machinery into the country. At the present time, all supplies must be taken in over the snow and ice during the winter months, when, owing to the climatic conditions, freighting is a most arduous and hazardous undertaking, and the cost is naturally proportionate. During the summer months freighting over the trails must be done by pack-horse, and the cost for this service is so great that only absolutely necessary supplies can be thus taken in.

So far as my information goes the earliest exploration of this section of Alaska, known as the Copper River district, was undertaken by the Hubbard-Elliott party, the members of which ascended the Copper River during 1898, and wintered near the mouth of the Tonsina River. The sufferings and hardships experienced by the members of this party were so great that most of the men died from scurvy and other diseases during the winter, but the remnant pushed on during the following summer, and while some of them made discoveries of high grade copper-bearing ore on Elliot Creek, a branch of the Kotsina River, other explorers located mineral claims near the Kennicott River. Among these was the property known as the Bonanza, of which the press has from time to time published very glowing reports, taken from descriptions furnished by mining engineers and prospectors who have visited this property.

One of the most detailed descriptions of this property, and undoubtedly the most reliable, having regard to the conditions existing at the time the examination took place, was that made by the United States' geologists, Messrs. Schraeder and Mendenhall. This report applied however, to conditions in 1903, at a time when very little development had been attempted, and since then a considerable deal of work has been done in opening up the property.

All the occurrences of copper ore so far discovered, have been found in the neighbourhood of the foot-hills adjacent to Mt. Blackburn, the altitude of which is given in the Government reports as 16,140 feet; Mt. Regal, altitude 13,400 feet, and Castle Peak, altitude about 10,000 feet.

The area that can be described as copper ore-bearing, occupies a semi-circle partially surrounding the bases of both Mt. Blackburn and Mt. Regal.

There are several rather unique features in respect to this zone of copper-bearing ore, some of which are: (1) As yet no occurrences of ore have been discovered except in close vicinity to the head-waters of the various streams. (2) Nearly all of the occurrences of copper-bearing ores are above timber line, which in this section appears to reach to an altitude of about 2,700 feet above sea level. (3) The district is comparatively easy for prospecting, because of the comparatively low elevation at which all growth of timber ceases, the ground being bare during the summer, except from rock slides. (4) The head-waters of all the streams are in glaciers, and as these glaciers have receded to a very great extent, the erosion on the ridges and bluffs in the vicinity of the head-waters of the streams has been quite extensive.

Generally speaking, the geology of this zone appears quite simple, and the series of rocks occur as follows: Most of the peaks and summits of the ridges and bluffs are limestone. This has very generally suffered from erosion, and consequently occurs in patches and apparently is the oldest rock formation in the district. This limestone is under-laid by greenstone in which, especially near the head waters of the Lakina River, occur intrusions of amygdaloidal diabase. These intrusions occur as dykes, masses and blankets in the greenstone, and so far as the Lakina River camps are concerned, it is usual to find that the intrusive rock carries values of native copper. This native copper occurs not only in the amygdaloidal diabase itself, but sometimes is found in the greenstone and near its contact with the intrusive rock.

So far as my own observations have gone, I found that this native copper was not only disseminated through the rock fairly regularly in small grains, but that it also occurred as nuggets. varying in weight from a few grains up to several pounds, In fact, in running one small open cut about fifteen feet long, five feet wide and five feet high in the face, the miners took out about two hundred pounds of nuggets of variable size, while the rock itself, as mined, carried about one per cent. in native copper in small grains, disseminated through it.

Judging from present mining developments in this district, it would appear that the predominating copper ores are bornite and chalcocite; the latter being found in a remarkably pure state, often carrying upwards of seventy per cent. in copper.

It is reported that the showings of chalcocite and bornite on Elliot Creek, and on the Bonanza property are quite remarkable with regard to both extent and grade.

The writer is, of course, not prepared to state whether the occurrences of copper-bearing ore in these localities just referred to occur under the same geological conditions, as is the case with those found near the head-waters of the Lakina River, but from available information is inclined to the opinion that the geology throughout the entire zone is very similar, and that a general description of one is applicable to the other sections, except that discoveries of native copper in amygdaloidal diabase, are not reported as having been made either on Elliot Creek or on the Bonanza property.

Generally speaking, near the head of the Lakina River, the occurrences of bornite and chalcocite copper ores are usually found as contact deposits between the limestone and greenstone, but this is not a universal rule. In fact some of the best outcroppings occur in fissures in the greenstone, but not very far removed from the contact between the greenstone and limestone.

It is quite difficult to make an examination of the actual contact, because the limestone has suffered so severely from erosion, that in the vicinity of the Lakina River most of the contacts are close to the summits of the ridges and at quite high altitudes and precipitously situated. It is also worthy of note that as yet no occurrence of bornite or chalcocite ores at low altitudes in greenstone is reported.

It is meanwhile observed that these different copper ores all occur on the same mountain on the west side of the head-waters of the Lakina River; the bornite and chalcocite occurring in veins in the greenstone at an altitude of about 5,000 feet above sea level, and the native copper in amygdaloidal diabase and also in the greenstone at the contact between these rocks at some 2,000 feet lower altitude.

On the opposite side of the river so far as explorations have been carried, no discoveries have yet been made of native copper, but the bornite and chalcocite ores occur there near the contact of the greenstone and limestone.

During the summer of 1907 a number of prospectors were engaged in exploring the territory between the head-waters of the Lakina River and the Bonanza mine, a distance as the crow flies of about 10 miles, and it is learned that many locations were then staked. Whether the mineral-bearing zone is continuous from the head of the Lakina River easterly to the Bonanza mine is a question that is yet to be answered. For my own part, while I am willing to concede that there is apparently a mineral-bearing zone extending easterly from Elliot Creek, a branch of the Kotsina River, easterly to a distance in an air line of about 60 miles to the Bonanza mine, yet I believe that it will be found after thorough exploration that there are large areas of absolutely barren ground in this territory.

In the mountains surrounding the head-waters of the Lakina River there are extensive areas of so-called iron capping, many of which have been located as mineral claims in the expectation that the capping or outcropping indicated the occurrence of copper-bearing ore, but a closer examination of some of these proved that this capping was not true gossan, but merely weathered diorite, very similar to occurrences of that character in the Appalachian Mountains in Georgia and Alabama, where it is locally known as brick-bat formation, because of the great similarity this weathered rock bears in color and structure to ordinary bricks.

It is this feature which gave the writer the impression that quite extensive areas in the mineralized zone will be found to be barren, and another feature was observed that helps to confirm this conclusion. It is that the lines of strike of the ore-bodies so far as observed, are usually north-westerly and south-easterly, while the zone itself in which discoveries of mineral have been made, extends from west to east. In fact, according to the latest published map, a line drawn from the Hubbard-Elliot group towards the east to the Bonanza mine would intersect nearly every prominent group of mineral claims in the zone.

In respect to the width of the zone in the Copper River district it may be said that at the present time, this is undetermined, but from the locations already made, I estimate the width from north to south to be about 10 miles; the most southerly locations of mineral claims carrying copper-bearing ore that came under my observation, occur on the Gilahena River, about 10 miles south-westerly from the head of the Lakina River.

Whether future exploration will develop the fact that there is any connection between the copper-bearing ores found near Taral, on the Copper River, and those occurrences near the Chitina River and its tributaries, can only be demonstrated by exploration. The Taral district occupies territory south of, and about 10 miles from, the confluence of the Chitina and Copper Rivers. At the present day there are such large areas of unexplored territory in this portion of Alaska, an in the immediate vicinity of the Chitina River and its tributaries, that it is fruitless to speculate as to possible relationship between the various known occurrences of copper-bearing ore.

OBSERVATIONS ON THE GEOLOGY AND ORE DEPOSITS OF CAMP HEDLEY, BRITISH COLUMBIA.

By Charles Camsell, Ottawa.

(By permission of the Director of the Geological Survey Department.)

(Nelson Meeting, Jan. 15th, 1908.)

Hedley is the most important mining camp in the Osoyoos Mining Division of Southern British Columbia, and is situated on the Similkameen River at the mouth of Twentymile Creek. The history of mining operations at this place dates from the year 1896, so that the camp is little more than ten years old. At the present time there are about 110 surveyed and crown granted mineral claims and many others on which the annual assessment work is still being done. Prospecting and development work on these claims were carried on for some years, but it was not until early in 1904 that actual extraction of gold began. The Nickel Plate and the Sunnyside, both owned by the Yale Mining Company, are the two most important claims and the only two on which actual mining is being prosecuted, so that the total production of the camp is to be attributed to these two claims. The ores from these two claims are treated by the Daly Reduction Company in a 40-stamp mill and a cyanide plant in the valley 3,500 below the mine. Gold is the only metal at present being extracted from the ores of the camp, but there are some indications promising a small copper production from other parts of the camp when transportation facilities shall be improved and other conditions are more favorable. The gold ore is an auriferous arsenopyrite, and of such a grade at present that it is not considered worth while to extract the arsenic at the same time; but with a gradually decreasing gold content and the exhaustion of the high grade surface ores such a contingency might eventually have to be considered by the mine operators of the district.

During the summer of 1907 the writer was engaged in a survey of the rocks of Camp Hedley for the Geological Survey Department and considerable study was given to the occurrence of the ore bodies. The work was not completed, but sufficient information was obtained to outline the geological history of the rocks and in some degree to work out the relations of these rocks to the ores.

There is only one series of sedimentary rocks, and these are the oldest rocks in the camp. No determinable fossils have yet been found in them, but from their lithological characters they have been referred to the Cache Creek group of Dawson's classification, and are therefore presumably Carboniferous.* The series in ascending order, as exposed within the limits of the camp, gives the following succession: (1) red, grey and black silicious and argillaceous beds interstratified in thin bands; (2) blue and white limestone, becoming impure at the top, and breccia; (3) silicious and argillaceous beds like the lower ones with probably some tuffs.

The limestones of the middle division hold the ore bodies that have so far proved to be of economic importance. These sediments dip to the westward at an angle which increases in that direction from 12 to 90 degrees. They are cut by a mass of monzonite lying in the central part of the camp, and also by a granite which is later than the monzonite. Dikes and sheets emanating from these two igneous masses, and particularly from the monzonite, penetrate the sediments in every part of the camp and alter them to such a degree as to make them difficult to recognize in the field. Some of these sheets may perhaps have been injected before the uplift and folding of the sediments took place, but it is likely that the majority of the igneous intrusions were later than these events.

Monzonite is the next rock in age to the sediments. This occurs in two distinct varieties in different parts of the same mass with all stages of transition between them. The more

*Geol. Survey of Canada; Report of Progress, 1877-78, page 85 B.

basic variety covers the widest area and occupies the central and western portions of the mass, while the acid variety lies along the eastern side and sometimes also occurs intrusive in the basic variety. The constituent minerals of the normal phase are orthoclase and plagioclase in about equal quantities, with hornblende, augite, quartz and biotite in varying proportions. All stages of transition from the basic to the acid variety can be found. Well marked contacts too are common, and these always show the acid variety as cutting the basic. From this core a great number of sheets and dikes of what is called andesite have been given off, and the same gradual transition in composition is noted in them as in the mass from which they emanated.

Figure 1 is a diagrammatic west to east section across the camp, showing the relation of the monzonite and the dikes and sheets which it gives off to the overlying sediments. The monzonite is shown as making a plunging contact with the sediments and the dip of the sediments on the east side is such that offshoots from the monzonite could readily penetrate the sediments following along the bedding planes of the latter as being the lines of least resistance. The section also shows a small area of the sediments lying as a roof pendant in the monzonite and which was not entirely absorbed by the monzonite before it solidified.

The monzonite, as well as the sheets and dikes, have exer ed great influence in altering the sediments that they cut, but the metamorphic action is stronger in the acid variety than in the basic, and all the ore bodies now being worked are situated at the contact of this acid variety with the sediments. The monzonite is the most important rock in the camp in relation to ore bodies and appears to be genetically connected with their occurrence.

The next rock in age is a body of granite lying at the foot of the hill overlooking the Similkameen River. This granite covers a very extensive area of country outside the limits of the camp, both to the north and south, as well as for about fifteen miles along the river to the west. This large area of granite is separated from the Coast granite batholith by an intervening belt of other rocks, but it is probable that the two may be closely connected with each other in the date of their intrusion. This granite resembles the Nelson granite in composition, and its constituent minerals are orthoclase, some plagioclase and quartz, with biotite and hornblende. The section exposed overlooking the river shows the granite at the base and for about 400 feet up. Above it are the tilted beds of the older sedimentary rocks with interbedded andesite sheets dipping into the granite and truncated by it.

Figure 2 is the actual section exposed on the side overlooking the river. It shows the batholythic character of the granite body, and its relation to the sediments and the interbedded andesite flows as well as to some of the later dikes. The section shows unmistakeably that the andesites were injected and the sediments tilted before the granite came up. Also in its irruption the granite magma would appear to have absorbed or assimilated the overlying sediments without the latter having undergone any disturbance or dislocation as a result of that irruption.

The granite-monzonite contact is well shown on the Metropolitan claim, and leaves no doubt of the relation between the two rocks. Granite boulders showing inclusions of monzonite are also commonly found in the bed of Twentymile Creek.

As a last phase of the granite irruption some aplite and quartz porphyry dikes have been given off.

Neither the granite nor the quartz porphyry dikes are thought to have been in any way instrumental in introducing any gold values. A quartz porphyry dike is associated with the ore body in the Nickel Plate mine, and in such a way that for some time it was thought to have some bearing on the values, but it appears almost certain that its connection with the ore body is accidental and it merely serves as a boundary to one of its sides.

Following the granite irruption, but with nothing to mark the period of their injection more specifically, are a great number of dikes of different compositions. These are rhyolites, lamprophyres, soft greenish dikes and many highly mineralized black dikes. Same of these have a fairly well defined north and south trend; while the black dikes, which are probably the most important of all the dikes in the camp, strike in various directions and appear to radiate from a common centre.

Gold is the only metal at present being extracted from the ores of Camp Hedley, and the Nickel Plate and the Sunnyside are the only two producing claims. Deductions on the history and mode of occurrence of the ores are drawn largely from a study of the deposits being worked on these two claims, though many others were personally examined. The conditions under which gold occurs are fairly uniform throughout the camp, so that with perhaps a few exceptions, the case of a typical occurrence of a proven ore body would be found to be repeated in other parts of the camp. The variations in the character of the ore bodies are often due only to the relative proportions in which the different sulphides are found. Arsenopyrite is common to them all, but in some cases chalcopyrite will be the dominant sulphide, and in others pyrrhotite. The cases, however, in which arsenopyrite is the principal sulphide are those which have proved to be the richest in gold values.

The ore deposits are thought to be primarily of contact metamorphic origin, and contact metamorphic deposits properly so called are deposits formed on the contact of an igneous with a sedimentary rock and as a result of the igneous intrusion. Later enrichment has however evidently taken place in the case of the Nickel Plate and the Sunnyside ore bodies so as to greatly increase the gold content in certain places, but at the same time this action has had the tendency to throw into some obscurity the original processes by which the values were first introduced.

As arsenopyrite is the most prominent sulphide with which the gold is commonly associated, these deposits are somewhat unique in so far as arsenopyrite has never yet been found in such proportion to the other sulphides in contact deposits of this character. Arsenopyrite is found to a certain extent in a great many contact metamorphic deposits, but in this case it frequently occurs to the exclusion of the other sulphides. As a rule it is found as secondary in importance to such minerals as chalcopyrite, magnetite or pyrrhotite; but in these deposits it occurs so abundantly that Weed * in a classification of ore deposits assigns them to a distinct type, of which this is the only representative.

The ore bodies, that have so far proved to be of economic value, lie in the middle division of the section already given,

*Reference "Ore Deposits near igneous Contacts". Trans; A. I. M. E., Vol. XXXIII, page 715.

that is to say in the calcareous beds and not in the silicious and argillaceous beds that both overlie and underlie them. The large eruptive mass of monzonite lying in the central part of the camp has itself been the cause of a great deal of metamorphism in the sediments where it cuts them, but besides this the large number of sheets and dikes of andesite which had their origin in the monzonite are responsible for much contact metamorphism. It is along these contacts and in the zone of contact metamorphism that ore bodies occur, and as limestone lends itself most readily to alteration and metamorphism, it is only natural to expect to find them there.

The granite appears to have had very little effect in mineralizing where it is in contact with the sediments, and the numerous later dikes, with the exception of perhaps the black dikes, are also of little importance in this respect.

The monzonite is the most active mineralizer, and the acid variety probably more so than the basic. All the most promising ore bodies are situated on the contact of the monzonite core or of one of its more acid offshoots.

The width of the zone of contact metamorphism varies with the composition of the intruded rock, the angle at which it is cut and the size of the igneous body. The silicious and argillaceous beds show very slight alteration as compared with the limestones, and the nearer the monzonite core the greater the alteration.

The monzonite has thrown out so many sheets and dikes in all directions, that it is almost impossible within the limits of the camp to obtain sediments that have not been affected by it. Near the central core the metamorphic action has been extreme. The lime carbonates become altered to lime silicates, and the result is garnetite, a rock composed almost entirely of garnets. Farther away the limestone simply becomes crystalline or is slightly altered to garnet, epidote and other lime silicates.

Locally the beds in which the ore bodies of the Nickel Plate and the Sunnyside occur are called quartzites, but it is more likely that they were originally impure limestones and now altered to the garnet-epidote-calcite rock. On the intrusion of the igneous rock which caused the alteration it is more reasonable to suppose that the formation of the new lime silicate minerals was due to an introduction of silica from the igneous rock rather than of lime.

The contact metamorphic minerals developed along these contacts are:—garnet, epidote, pyroxene, tremolite, quartz, calcite and some axinite. These act as the gangue for the ores, and in this gangue we find such ore minerals as arsenopyrite, pyrrhotite, chalcopyrite, pyrite and some sphalerite. The arsenopyrite and the pyrrhotite are the most common, and are found in all parts of the camp. Chalcopyrite occurs abundantly on a few claims, and sphalerite is rare. The latter mineral, however, appears on the footwall in some of the Sunnyside workings. Irregular bodies of hard cherty rock are also found in the zone of contact metamorphism, and are probably the result of a migration of silica from the igneous rock. Frequently the ore body shows a distinctly banded appearance due to alternating layers of garnet and epidote, and this same effect is also in some measure brought about by the sphalerite occurring in well defined bands.

The arsenopyrite is often disseminated through the gangue rock in crystallized individuals in which case it would probably be of primary origin. In the same specimen it will also be found as filling small narrow lines of fissuring, showing that some secondary action has taken place. The latter feature is often a good indication of high grade ore.

Gold values appear to be always associated with arsenopyrite, yet much arsenopyrite occurs throughout the rock in which little, if any, gold can be obtained. An assay of the sample is the only means of acquiring the slightest information as to its gold content, as free gold is rarely visible. In many cases it is impossible to distinguish a sample which will assay two dollars to the ton from one which will give twenty dollars. Again in the oxidized rock of the surface one can often wash a crushed sample and get a great number of very fine colours of gold in the bottom of the pan. In another sample no colours will be obtained, yet the one will give as good results on an assay as the other. As a rule, however, some assay values in gold will be obtained when arsenopyrite occurs in the altered sediments where they are cut by the acid variety of monzonite or its dike equivalent.

As to the original source of the arsenopyrite one does not have to look farther than the monzonite itself. It occurs in small quantities as an accessory mineral in the monzonite mass, but in the dikes and sheets of andesite it is so plentiful as to appear almost as an essential constituent. It does not appear in the sediments on the granite contact, but always at or near the monzonite and andesite contacts.

In a study of the original source of the gold the foregoing facts are significant, if we can be absolutely certain that the gold only occurs with the arsenopyrite and not alone or with some other sulphide as well. The solution, however, will require a more extended study of many ore bodies in different parts of the camp. The theory of an introduction of gold from the monzonite or its offshoots into the altered sediments at the time of the intrusion has much evidence in support of it, but in that case the values would probably have been sparingly disseminated throughout the contact zone. Developments in mining tend to show that other causes have since been instrumental in concentrating these values to make them of economic importance, for the ore bodies that are now being worked are undoubtedly the result of secondary enrichment. Without this enrichment it is hard to say whether they would have been payable deposits or not.

The Nickel Plate ore body illustrates to a remarkable degree this idea of secondary enrichment or concentration by downward moving waters. This claim is situated on the eastern slope of the hill and about 200 feet vertically below the summit. This slope is regular and gentle, and is uniformly covered with wash so that rock exposures are not frequently seen. Erosive action is not strong and the rocks as well as the ore bodies are decomposed in place; so that concentration can readily take place in the body of the rock without much of the heavier substances being carried down the slope of the hill by surface waters. In contrast to this, the western or Twentymile slope of the hill is steep and generally uncovered by wash so that erosion of the rocks goes on at a much more advanced rate than on the other side, and decomposition does not extend to such depth.

The Nickel Plate ore body lies in the sedimentary rocks about 2,000 feet away from the edge of the monzonite core. These sediments are, at the lower side of the claim, limestones which pass upwards into silicious beds. They dip at an angle of about 20 degrees in towards the monzonite. Into these sediments intrusive andesites have been injected, some of which follow the bedding planes of the sediments, while others cut the beds at different angles. The intrusive andesite with which the Nickel Plate ore body is associated dips in the same direction as the sediments, but at an angle of about 40 degrees, so that there is an angle of about 20 degrees between the dip of the igneous and the dip of the sedimentary rocks. The width of the andesite on the surface is about six feet, but this quickly increases with depth. The ore body lies directly on the andesite and extends upward into the zone of contact metamorphism. The rock in this zone of contact metamorphism is a greenish epidote rock which often carries much garnet distributed through it in well defined bands. This rock is also the gangue of the ores. A vertical black dike cuts the sediments and the andesite, and with the latter forms a V-shaped trough in which lies the ore body. The south boundary of this ore body follows a curving quartz porphyry dike, while to the north of the ore body is a zone of fracturing striking east and west, beyond which no pay ore is found. The gold is associated with arsenopyrite, and other sulphides occur sparingly. The highest values are found on the andesite footwall and there is a gradual diminution in values as the distance from the footwall increases. The position and character of the ore body point to downward moving waters as the dominant cause in the final stages of its formation, and possibly this concentration or enrichment represents the leached out values from many feet of overlying gold bearing strata, which have since been eroded away.

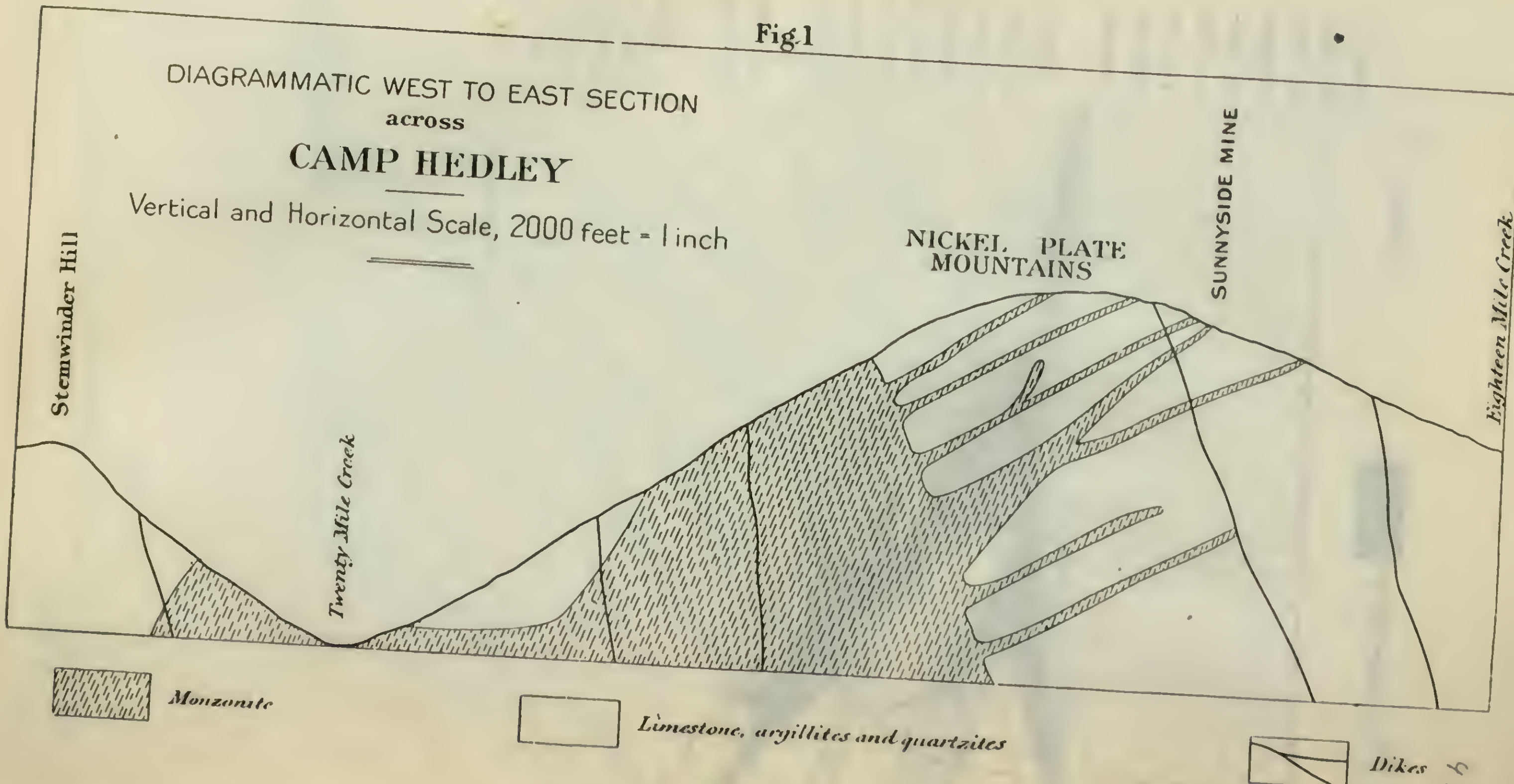
In all sections of the camp and in some of the outlying country small quantities of gold are known to be disseminated throughout certain contact metamorphic rocks. Often this gold content is very small and not sufficient to form ore bodies that would be considered payable, yet it has not been definitely determined that workable deposits which are primary in origin, and not concentrations, do not occur in the camp. Such primary deposits, even if of lower grade, have the advantage over the others of promising greater permanence and with such the future of the camp is more closely connected.

The conditions above given under which the well known Nickel Plate ore body occurs are known to exist in other parts of the camp, and enrichments are found in practically the same manner. With a general uniformity in the dip of the sediments and the large number of dikes of different compositions that cut all these, the conjunction of two of these dikes and of dipping strata to form a trough should not be very difficult to find. While enrichments are more likely to be formed under these conditions, every such trough should not be expected to contain an ore body, though all are worth prospecting and should be carefully examined.

By far the largest amount of ore mined has come from the Nickel Plate claim. This was first worked as a glory hole, but at present all the ore extracted comes from underground. The depth obtained has not yet exceeded 150 feet from the surface, and in the four Sunnyside workings the mining of ore is carried on within a few feet of the surface. The present output of the camp is in the neighborhood of 35,000 tons annually, all of which must be attributed to these two claims, and at this rate many years must still elapse before the ore bodies now known to exist are exhausted.

An interesting point developed in connection with the treatment of these ores is the finding at the end of a month's run of the mill of some platinum along with the gold. The manager for the Daly Reduction Company, Mr. F. A. Ross, from whom the information was obtained, is inclined to think that platinum occurs sparingly with the ores in the form of the arsenide, sperrylite.

Fig. 1


DIAGRAMMATIC WEST TO EAST SECTION
across
CAMP HEDLEY
Vertical and Horizontal Scale, 2000 feet = 1 inch
Stemwinder Hill
Twenty Mile Creek
NICKEL PLATE
MOUNTAINS
SUNNYSIDE MINE
Eighteen Mile Creek
Monzonite
Limestone, argillites and quartzites
Dikes

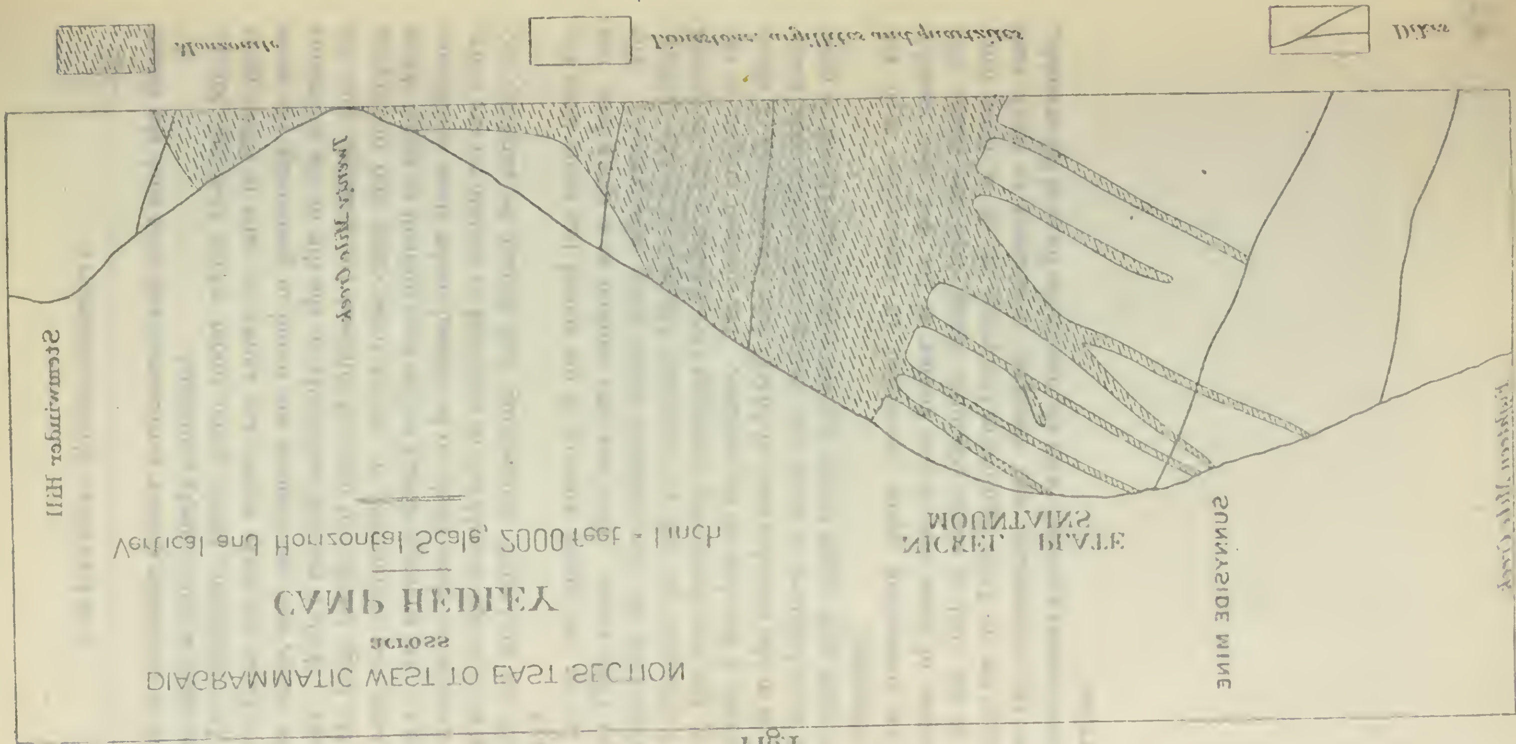
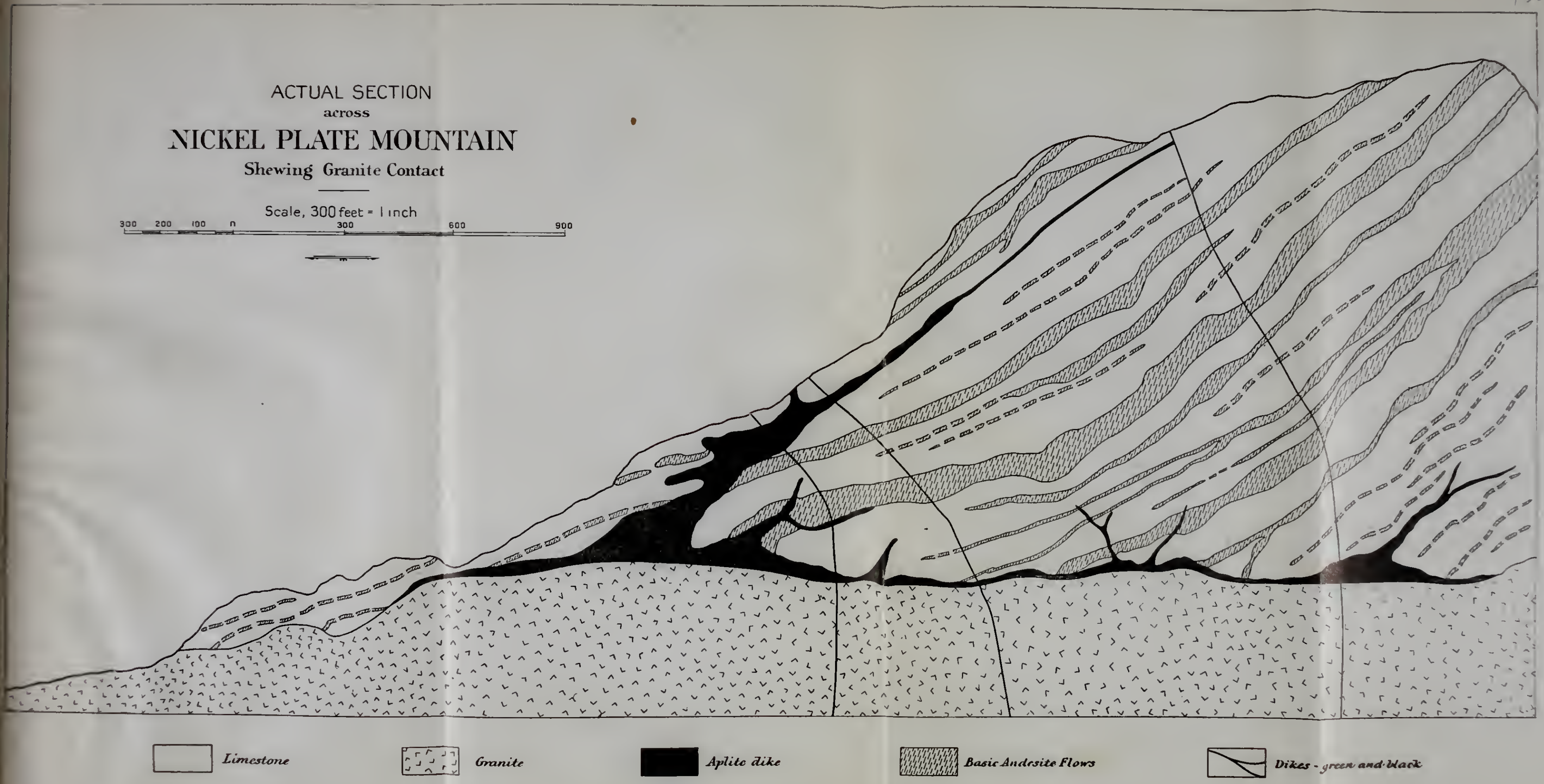

DIAGRAMMATIC WEST TO EAST SECTION
across
CAMP HEDLEY
Vertical and Horizontal Scale, 2000 feet = 1 inch
Stemwinder Hill
Twenty Mile Creek
NICKEL PLATE
MOUNTAINS
SUNNYSIDE MINE
Eighteen Mile Creek
Dikes

Fig. 1

Fig. 2


ACTUAL SECTION
across
NICKEL PLATE MOUNTAIN
Shewing Granite Contact
Scale, 300 feet = 1 inch
300 200 100 0 300 600 900
Limestone
Granite
Aplite dike
Basic Andesite Flows
Dikes - green and black

A PARTIAL BIBLIOGRAPHY OF PUBLICATIONS REFERING TO THE GEOLOGY AND MINERAL INDUSTRY OF ALBERTA, BRITISH COLUMBIA AND THE YUKON.

By J. C. Gwillim, Kingston, Ont.

The following classification of literature dealing with the exploration, geology and mining of these regions, is not complete. It has been compiled chiefly from three relatively accessible sources, namely, from the reports of the Geological Survey of Canada and the British Columbia, Provincial Bureau of Mines, and the Canadian Mining Institute "Transactions."

The inclusion of some purely geological reports of the more remote districts seemed advisable, as offering first aid to those who go into them with the purpose of mining.

The reports of the Geological Survey provide our chief source of information in respect to the economic geology of these areas; and it may be stated that Alberta, British Columbia, and the Yukon, have received a great service from the Canadian Geological Survey, from the days of Richardson and Dawson, to the present summer when eight field parties were working in these provinces. The publications of the Geological Survey are, in most cases, free, and will be sent on application by the librarian of the department at Ottawa.

The annual reports of the provincial mineralogist, contain much statistical information relating to production and progress, together with reports or summaries of the conditions in the respective mining divisions. There are also incorporated in these volumes, special reports upon mineral or coal areas, by the provincial mineralogist, the provincial assayer, and others competent to investigate them. The British Columbia reports, and also various bulletins on, and maps of the mining districts of the Province can be obtained free, or for a small sum, on application to the Provincial Bureau of Mines at Victoria.

The transactions of the Canadian Mining Institute appear to round out our field of information, by giving detailed studies of mines, mining geology, and mining operations. This is a source of information which is likely to increase as the Provinces develop. Volume V is especially valuable in papers relating to operations in British Columbia. It would make this paper too cumbersome if one ventured into a description of the material within the titles cited. Attention, however, may be called to those having an asterisk, as affording much detail information concerning the area or areas to which they refer. The work of Dr. G. M. Dawson is always valuable, and his observations cover a large portion of the country here considered.

Concerning the selection of papers and authors in this compilation, I am largely indebted to the Geological Indices of D. B. Dowling and F. J. Nicolas, also to the index of the Canadian Mining Journal, up to Volume VI. Any important omissions may be added. The list is lengthy, but it is a tolerably available one.

The abbreviations used, are:—

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NOTES ON THE PRACTICE OF ASSAYING IN BRITISH COLUMBIA.

By C. S. Baker, Greenwood, B.C.

(Nelson, B.C., Meeting, January, 1908.)

The Government of British Columbia recognizing the rapid growth of the mining industry and the importance to the Province of assayers, in whose work the investing public and the mining community could place confidence, enacted a law in 1899, entitled the "Bureau of Mines Act Amendment Act, 1899." This Act requires that all assayers, who intend to practice in the Province, satisfy a board of examiners on their proficiency in sampling and assaying. The Board accepts certain degrees or certificates from Universities and Schools of Mines in the Dominion and the Empire as tantamount to passing the examination. Prior to this date assayers could obtain, for their own satisfaction, a Government certificate under the Bureau of Mines Act, 1897.

At the present time there are two holding the certificate under the 1897 Act, and one hundred and twenty-nine under that of 1899.

The examination is held twice a year in Victoria and in Nelson, if a sufficient number of candidates enter from the upper country. It continues for about a week and covers those determinations which occur in day-to-day work and written papers on sampling, wet and fire assaying.

The mining regions may be divided roughly into: (i) the silver-lead-zinc ores of the Slocan; (ii) the copper-gold-silver ores of the 'Rossland, boundary and coast districts. It is the purpose of this paper to give a few methods of treating these ores, and although they do not as a rule offer any serious difficulties it is hoped that a few points of interest may be brought forward.

(i) The silver-lead-zinc ores and concentration products do not carry payable quantities of gold, so that silver, lead, zinc and occasionally iron and insoluble are the determinations usually made.

Silver is assayed by either the pot or scorification method. The former is more in favour in the district since it is found to give slightly higher results, and has the advantage of taking less time and the bead may be parted for gold. Scorification has the disadvantage of requiring a high opening up heat causing a possible loss of silver and the use of less pulp, which may not give as correct a sample.

The usual practice is to take 0.5 A.T. of ore and nitre; or 0.2 A.T., which, in most cases, gives a button of the required size. An excess of litharge is always used to decompose the sulphides. The button should weigh from 20 to 25 grms. and be free of impurities. The heat in cupellation should be such as to just show the presence of "feathers"; it is preferable to cupel at a slightly too high than too low a heat.

In control work for the lead assay the fire method is used, as the smelters settle on that result. It is, however, an unsatisfactory assay and the heat must be carefully regulated during fusion, which takes about an hour and a half. The muffle at the start should be at a low red heat and after twenty minutes when a violet flame can be seen coming from the crucible the heat is gradually increased to a full red heat, and finally the fusion is poured very hot.

The fluxes used are the mixed carbonates of sodium and potassium, a reducer of flour, iron nails and a cover of borax. Borax is used only as a cover in order to reduce the possibility of forming borate of lead to a minimum. The Battersea 10 grm. crucible is a convenient size to use.

Zinc is estimated by titration with potassium ferrosyanide and is found to give excellent results on medium and high grade ores. Low grade ores, say under 5 per cent., are not so satisfactory and tend to come somewhat high. The zinc occurs as blende and is completely decomposed by a saturated solution of potassium chlorate in nitric acid.

The procedure is to take 0.5 grm. of ore, dissolve in 15 c.c. nitric-potassium chlorate solution and evaporate down to complete dryness, which throws out manganese as the oxide. Cool and add 7 grms. of ammonium chloride, 15 c.c. ammonia and 25 c.c. hot water. Heat to boiling, filter and wash three times with hot water. Neutralize with hydrochloric acid and add exactly 10 c.c. in excess. If necessary bring bulk of solution up to 150 c.c. and add test lead to remove copper, a small amount of which is usually present. Place on hot plate and gradually increase temperature to 70°C and titrate. Uranium nitrate or acetate may be used as indicated. The traces of cadmium can be neglected. Similar conditions as to bulk of solution, excess of acid and heat, should be closely adhered to in the standard.

By dissolving the ferric hydrate, which has been filtered off from the zinc solution, in hydrochloric acid, iron can be determined by the Bichromate method, and finally the well-washed residue, when dried, ignited and weighed will give silica.

(ii). The copper-silver-gold ores of the Rossland, boundary and coast districts.

The ores of these districts are low grade in copper and average from one to two per cent.

In Rossland the gold values run higher than in the boundary.

It may be said that the cyanide process is used in all ordinary work, such as hand samples, daily smelter mattes, etc.; and the electrolytic or codide for control work.

The Battery method is simple and convenient, requiring less manipulation than the other methods and if put on in the afternoon can be weighed the following morning.

When no metals are present that would be deposited with the copper on the cathode, simple treatment with nitric acid is sufficient. If, however, interferences are present, precipitation with potassium sulpho-cyanide gives excellent results. The following method is to be recommended: Treat 1 grm. in 150 c.c. beaker with 10 c.c. nitric acid. Put on hot plate at low heat and raise temperature gently in order that the sulphur may be clean. Take down carefully to a syrupy consistency, if possible in water bath to prevent spitting. Cool and add 8 c.c. hot water and 2 c.c. hydrochloric acid; heat, and, when in solution, wash down watch glass and sides of beaker with 20 c.c. more water. Boil and filter;

the filtrate should not exceed 70-80 c.c. Heat and add saturated solution of sodium sulphite to reduce iron—avoiding a large excess. Now add 5 c.c. of 10% solution of potassium sulpho-cyanide. A white precipitate of cupreous thiocyanate is formed. Maintain at moderate heat until precipitate is settled. Sometimes a red colouration appears notwithstanding the iron being previously reduced. A further small addition of sodium sulphite will, however, remove this and is advisable. Filter very carefully, using two filter papers, one larger than the other, and not filling the smaller quite full.

This precaution prevents the precipitate creeping up the paper. Wash with boiling water and gently ignite filters. The precipitate copper is easily soluble in nitric acid and can be determined by placing on battery or titrating by the iodide method. All interfering metals have been removed. In a series of checks the following results have been obtained:

Taken 0.053 grms. electrolytic copper found. . . .52.93 mgrms.
" 0.1232 " " " " ...123 "
" 0.0107 " " " " ... 10.5 "

When copper is precipitated from a solution of the soluble sulphates by means of aluminium, it has been observed that it is extremely difficult to throw down the last traces of copper.

This may be obviated by the addition of hydrogen sulphide in removing the aluminium; about 15 c.c. of a saturated solution precipitates the last traces of copper and prevents oxidation of the finely divided metal.

In assaying copper ores for gold and silver it is necessary to flux off all the copper in order to obtain a pure lead button and thus prevent the absorption of gold in cupellation. This may be done by either first dissolving the copper in nitric acid, precipitating the silver with sodium chloride and scorifying the residue; or using a large excess of litharge in the pot or crucible assay. The latter method is based on the fact that oxide of lead can be used in a crucible, together with subsidiary fluxes such as: sodium carbonate, potassium carbonate, nitre and flour to give the determination of gold and silver results equal, if not superior, to scorification. If analysis of ore be known approximately, the charges may be calculated to give for all ores and mattes an uniform slag.

Experiments in control work prove the slag that gives the best results is the one that in section shown by breaking cone after cooling, shows a silicate of lead, copper and iron on outside, gradually changing to crystalline litharge towards the centre. At the proper temperature the slag is very fluid and gives a bright clean button and slag is entirely free of small shots of lead. The temperature of the muffle must be carefully calculated as there is danger in both extremes. If furnace is too cool slag will be wholly crystalline and will not pour well; if too hot, slag attacks crucible by taking up silica and leaves small pits in which shots may be retained and overlooked; it also increases loss by volatilization. The correct temperature is an uniform heat at starting, fairly red, and a rising fire; in thirty minutes colour of muffle should be bright red with charge all reduced and fusing quietly. Hold at this for ten minutes and pour.

Analysis of ore should be known as regards copper, silica, iron and sulphur. Reducing effects of sulphur and oxidising effects of nitre should be ascertained by trial assay. A trial assay is run on say .25 A.T. of ore using certain fluxes and button is weighed, from which the necessary amount of oxidising or reducing agent is calculated for the 0.5 A.T. charge. It is advisable to deduce this knowledge from experiments on variety of ore, with which one comes in contact and strike an average standard or standards for stock fluxes.

It is found as a rule with boundary ores upon 0.5 A.T.

1 grm. of flour will reduce 10 grms. Pb from Pbo.

4% sulphur will reduce 16 grms. Pb from Pbo.

4% antimony will reduce 3 grms. Pb from Pbo.

4% arsenic will reduce 6 grms. Pb from Pbo.

1 grm. of nitre will oxidize 4 grms. Pb to Pbo.

Amount of litharge to be used will depend on impurities to be fluxed off; chief of these is copper, which must be eliminated to reduce cupel losses—

From low grade ores (2 to 4% copper) 5 A. T. Pbo to 0.5 A.T. ore;

From matte (48–60% copper) 8 A. T. Pbo to 0.1 A. T. matte removes nearly all the copper.

To get a slag of composition previously described, silica must be added, after calculation of that in ore to make up the ratio of 1 part SiO_2 to 16 parts Pbo. The button should weigh about 16 grms., but will vary a few grms. according to temperature of muffle.

As an example an ore of the following composition may be taken:—

5.4% Cu; 29.4% SiO_2; 28.2% Fe; 13.1% CaO; 15.8% S.

This ore contains a considerable amount of copper and sulphur, which would require much nitre. Therefore it is advisable to take 0.25 A. T. of ore. Add 8 A.T. Pho, 0.5 A.T. $Na_2 Co_3$ and $K_2 CO_3$ and 18.3 grms. of SiO_2. Since 4% S would reduce 16 grms. of Ph if 0.5 A.T. of ore were taken, this charge contains nearly 16% S, but being only half as large, would give a button of about 32 grms. To obtain a button of 16 grms. we must, then, add 4 grms. nitre.

Mix charge thoroughly and cover with ½ inch of sodium chloride.

As regards the matter of covers, with same flux and under similar conditions two assays of a high grade gold ore gave:

With salt as cover 20.16 ozs. per ton.

With borax as cover 19.9 ozs. per ton.

It would seem that salt is the most satisfactory cover. Again buttons vary in size when borax is used, owing to its action varying at different temperatures.

Combined Wet and Dry Process for Gold and Silver in Blister Copper, Mattes or High Grade Copper Ores.

Weigh out 3 A.T. in separate portions of 1 A.T. for silver. Place in large beaker with 100 c.c. of water and cover with watch glass. Add 50 c.c. HNO_3 (sp. g. 1.42) and await finish of strong action. Now add 50 c.c. more acid. Boil to expel red fumes and remove from heat. Carefully and thoroughly wash down sides of beaker and watch glass. Add sufficient normal salt solution to precipitate silver, avoiding a large excess. Stir well and allow beaker to stand over night. Filter off chlorides through double filter papers and wash with cold water to free papers of copper. Wipe out beakers with moistened filter papers and add. Transfer filter papers to 2½ inch scorifiers in a dish of test lead containing about eight grms. Dry at about 300 C. When charring of papers is complete add 20 grms. of test lead and 1½ grms. of borax.

Scorify down to button of about 7 grms. and save slag.

Cupel buttons at low temperature and save cupels. If beads check to 0.75 ozs. per ton unite and part.

The slags and cupels are fluxed with litharge, glass and a reducer and button cupelled. This silver recovered, divided by 3 is added as a correction. (Usually 1.4 to 1.7 ozs. per ton.)

Gold—Weigh out 1 A.T. and divide into 4 equal portions of ¼ A.T.

Place in 3-inch scorifiers with 90 grms. of lead. Cover with ½ grm. silica and borax glass. Scorify until closed over and pour hot. Save slags.

Make up buttons to 65 grms. with lead and ½ grm. silica and again scorify and save slag.

Unite two and two.

Two buttons representing 0.5 A.T. are made up 90 grms. with lead and 0.5 grm. silica and scorified.

Proceed with slags and cupels as with silver and add correction.

Note.—Scorifiers used are of the shallow type. It may be mentioned that for mattes and ores less scorifying will serve to remove the copper.

As regards wet work, the determinations for iron, lead, sulphur, etc., used, are those described in the standard text books, but a method for insoluble in some refractory sulphide and carbonate ores may be described; it is interesting inasmuch as it gives results very close to fusions and in some ores the insoluble can be reduced as much as 6–7% lower than by the nitro-hydrochloric acid treatment. 0.5 grm. is weighed in 3-inch casserole, and while covered with watch glass is treated with 10–15 c.c. HCl.

Most of the sulphur is got rid of as H_2S. Evaporate to 7 c.c. and add 5 to 10 c.c. according to the amount of sulphides present, boiling nitric acid. The action is somewhat violent and during operation casserole should be closely covered. Evaporate to dryness, bake a little, take up with dilute HCl, filter, dry, ignite and weigh.

MINERAL PRODUCTION OF BRITISH COLUMBIA IN 1907.

By E. Jacobs, Editor Mining Record, Victoria, British Columbia.

The following notes on the mineral production of British Columbia, in so far as they relate to the year 1907, must be regarded as subject to correction after the official returns shall all have been received by the Bureau of Mines of British Columbia, and the customary statistical statement prepared by the Provincial Mineralogist and published in ordinary course in the "Annual Report of the Minister of Mines for British Columbia." It is believed by the writer, though, that when the finally revised figures shall be made public, it will be found that those given herein are not far from indicating the actual production of the year, calculated at the values adopted by the local Bureau of Mines.

Regarding the prices of metals, it may be observed that it is usual to mention each year in the "Annual Report" above alluded to, that "In calculating the values of the products, the average prices for the year in the New York Metal Market has been used as a basis. For silver 95 per cent. and for lead 90 per cent., of such market price has been taken. Treatment and other charges have not been deducted."

Following this custom, the prices so determined at which the value of metalliferous minerals has been arrived at are as follows: Silver, 62.06 cents per oz.; lead, 4.8 cents per lb.; copper, 20 cents per lb. Gold values used are not similarly subject to change each year; they are $20 per oz. for placer and $20.67 for lode gold. For the small quantity of zinc included an approximate value of $25 per ton has been taken. Heretofore, for years, coal has been valued at

$3 per ton of 2,240 lbs.; this year $3.50 is the value placed upon it, which change is warranted by the prevailing selling prices in the Province during the year. Similarly, the price of coke has been advanced from $5 to $6 per long ton for valuation purposes, but, in the opinion of the writer, the latter change gives a higher value to this product than market conditions, as affecting the Crow's Nest Pass Coal Company's collieries, which supply by far the greater part of the coke included in the following estimate, really justify.

The amounts showing the value of each metal in the following table are in round figures; they are not worked out in accurate detail.

APPROXIMATE QUANTITY AND VALUE OF MINERAL PRODUCTION IN 1907.

(SUBJECT TO REVISION)

Customary Measure		Quantity	Value
Gold, placer	Oz. troy	37,500	$ 750,000
Gold, lode	"	198,000	4,090,000
Total gold		235,500	4,840,000
Silver	Oz.	2,788,000	1,729,000
Lead	Lb.	47,500,000	2,280,000
Copper	"	41,700,000	8,338,000
Zinc	Tons	2,000	50,000
Total metalliferous			17,237,000
Coal	Tons, 2,240 lb	1,800,000	6,300,000
Coke	Tons, 2,240 lb.	223,000	1,338,000
Building materials, etc			1,150,000
			8,788,000
SUMMARY:—			
Metalliferous			17,237,000
Non-metalliferous			8,788,000
Total value of production			$26,025,000

Compared with the production of other years, the foregoing total value would appear to indicate a substantial increase, but, as a matter of fact, it does not disclose the actual position, since *in quantity* all the metalliferous minerals show a decrease (zinc only excepted, the production of which was too small to be of importance), while in value, copper was practically alone in reaching a higher total than in 1906. The total decrease in value of these minerals as compared with 1906 was about $1,213,000, against which there was an increase in the non-metalliferous minerals of $2,257,000, so that there was on the combined production a net increase for the year $1,044,000.

Taking the several minerals separately, the following comments may serve to better show the results achieved:

GOLD.

The year's production of placer gold was the smallest of any year since 1898. Cariboo, Quesnel and Atlin divisions, in which are the larger placer fields of the Province, each showed a considerable decrease in production, in all about $200,000. This result was particularly disappointing since it had been expected that the Guggenheim companies would operate at Quesnel and Atlin on a large scale and add materially to the output of those camps. Not only did they not do so, but it is understood they have practically abandoned those fields, notwithstanding that their preparatory expenditures had been comparatively large. It is considered probable that the Cariboo division will make a better showing next season, but the immediate outlook for the other placer fields is not regarded as promising a satisfactory improvement or increase in yield of gold.

In lode gold there was a decrease of about 26,000 ozs. Boundary mines produced 13,500 ozs. less than in 1906, Rossland mines 8,400 ozs., mines on the coast 5,400 ozs., and several other districts made smaller decreases. Against these, Nelson division increased its yield to the extent of 1,600 ozs. Similar causes to those which led to a decrease in copper production adversely affected the lode gold output, for the reason that gold occurs in association with copper in the chief producing mines of the Province, so that when copper-mining is checked the yield of gold is proportionately smaller. Nelson mining division alone showed increased activity in lode gold mining, and its prospects are favourable for a further advance in this connection. The Nickel Plate mine, in the lower Similkameen, is stated to have about maintained its average yearly production of $400,000 or thereabouts.

SILVER.

There was a net decrease in the yield of silver of about 202,000 ozs. The chief decreases were: East Kootenay 246,000 ozs., Boundary 224,000 ozs., and Coast 32,000 ozs., total 502,000 ozs. Against this the increases were: Slocan (including Ainsworth) 120,000 ozs., Nelson 98,000 ozs., Lardeau 79,000 ozs., Skeena 2,200 ozs., and Rossland 800 ozs., total 300,000 ozs. The decreases in both East Kootenay and the Boundary were in part due to stoppage of the coke supply during a part of the year, which prevented the continuous operation of the smelting works. The current year's production will in a large measure be determined by the result of the endeavours now being made to secure an extension of the period during which the bounty will be paid on lead mined in Canada, for much of the silver produced is obtained from ores mined chiefly for their lead contents. The market price of this metal will also result in a restricted production if it remains as low as during recent months.

LEAD.

The decrease in lead produced was about 4,908,000 lbs. East Kootenay, chiefly the St. Eugene mine, was 7,077,000 lbs. less than in 1906, while the Boundary was 91,000 lbs. short owing to its smaller mines, in which some lead occurs, having shipped but little ore during the year. Against these decreases there were increases approximately as follows: Ainsworth 320,000 lbs., Slocan 1,100,000 lbs., Nelson (largely from the La Plata mine) 750,000 lbs., and Lardeau 90,000 lbs., together 2,260,000 lbs. The fall in the market price of lead has proved discouraging to the lead mine owners, who are urging the Dominion Government to continue payment of the lead bounty beyond the period now provided for. Should this not be done the production of lead in the Province may be expected to further decrease, and that considerably.

Nearly half the lead produced was smelted at the Consolidated Mining and Smelting Company of Canada smelter at Trail, where a refinery is also in regular operation. Approximate production figures are: Consolidated Company's smelter, Trail, 22,500,000 lbs. Sullivan Company's smelter, Marysville, East Kootenay, 11,000,000 lbs.; Hall Mining and Smelting Company's Smelter, Nelson, 6,000,000 lbs.; contained in concentrates exported to Europe, 8,000,000 lbs.

COPPER.

The closing of the Boundary district copper mines, and others in the Nelson and Coast districts, respectively, during several weeks of November and December, effectually prevented an increase in the year's production of copper over that of 1906. There was also a restricted output during the spring, owing to a shortage of coke for the smelters and an occasional insufficiency of railway cars for ore and coke-hauling purposes. These adverse conditions resulted in a decrease of 1,302,000 lbs. as compared with 1906. When it is remembered that 78 per cent. of the year's production came from the Boundary District, the loss resulting from the closing of its mines during two to three months becomes evident.

Boundary's proportion of the total production of 41,688,000 lbs. was 32,535,000 lbs.; Rossland (Trail Creek division) produced 5,075,000 lbs.; Nelson division's share was 313,000 lbs.; while the districts was 3,052,000 lbs. Of the 1,140,000 tons of copper ore shipped by the Boundary mines those of the Granby Company contributed 625,000 tons, of the British Columbia Copper Company 235,000 tons, of the Dominion Copper Company 155,000 tons; and of the Consolidated Mining and Smelting Company 125,000 tons. Rossland camp's ore tonnage was about 280,000 tons, in the following approximate proportions: Consolidated Mining and Smelting Company's Centre Star-War Eagle group 132,000 tons, Le Roi 113,000 tons, Le Roi No. 2, 23,000 tons, and sundry smaller shippers 12,000 tons. On the coast the tonnage was approximately 100,000 tons, as follows: Britannia 57,000 tons, Tyee 12,000 tons, Outsiders 9,000 tons, Marble Bay 7,000 tons, Richard III 4,000 tons, Lenora 2,000 tons, and sundries 9,000 tons. The Queen Victoria, near Nelson; the Outsiders, at Portland Canal, and the

Ikeda, on one of the Queen Charlotte Islands, were new producers, and the Richard III and Lenora, Mt. Sicker, Vancouver Island, resumed ore shipping after having been non-producers for several years.

IRON AND ZINC.

There was no considerable quantity of either iron or zinc shipped during 1907. On Vancouver and Texada Islands a few thousand tons of iron ore were mined and shipped to Irondale, Puget Sound, Washington, U.S.A. The most important event of the year in connection with the iron ores of the Province was the examination by Einar Lindeman, a Swedish iron expert, of a number of claims taken up for iron ore on Vancouver Island and vicinity, for the purpose of reporting on them to the Dominion department of mines, Ottawa, which engaged him with the object of ascertaining whether or not iron ores occur in suitable quantity, variety, and quality, on the Coast to warrant the expectation that an iron-manufacturing industry will eventually be established there. Mr. Lindeman's report has not yet been made.

Shipments of zinc ore and concentrate were not large, and those made were from Slocan mines, several of which are, however, continuing to store the zinc concentrates made in milling ores for silver and lead. The uncertainty as to the final decision regarding the imposition of a duty on zinc ore sent to the United States remains an obstacle to much of this product being shipped to smelters in that country. A comparatively small quantity was exported to Europe from a Slocan mine. No recent progress appears to have been made in the direction of operating on a commercial scale the Canadian Metal Company's zinc smelter at Frank, southwest Alberta. Works for the treatment of zinc ores by the Snyder electric process are being built at Nelson, B.C.

COAL AND COKE.

The production of coal in 1907 was the largest in the history of coal mining in the Province. The net increase over 1906 was 282,000 tons (2,240 lbs.), this bringing the year's production of coal disposed of as such up to 1,800,000 tons. All three of the larger companies shared in this increase. There were about 419,000 tons made into coke. The respective approximate proportions of production were:

Company	Gross Tons of 2,240 lb.	Net Tons of 2,240 lb.
Wellington Colliery Co	824,000	727,000
Western Fuel Co.—		
Nanaimo and Northfield mines	504,000	504,000
Total for Vancouver Island	1,328,000	1,231,000
Crow's Nest Pass Coal Co	876,000	554,000
Nicola Coal and Coke Co., and other new mines	15,000	15,000
Total production in 1907	2,219,000	1,800,000

The Nicola Coal and Coke Company has been operating only about a year, and most of its comparatively small production was of coal taken out in opening its mine. Several other companies will shortly be in a position to mine coal in quantities up to a few hundred tons a day each.

The coke output of the year was 223,000 tons—207,000 from the Crow's Nest Pass Coal Company's ovens at Fernie and Michel, and 16,000 tons from the Wellington Colliery Company's ovens at Union, Vancouver Island.

BUILDING MATERIALS, ETC.

Activity in building operations in the larger cities of the Province had the effect of increasing the production of building materials—stone, brick and lime. An increase was also made in the quantity of Portland cement manufactured, the Vancouver Portland Cement Company's works near Victoria, Vancouver Island, having been enlarged and its output of cement considerably increased.

The official returns of exports of these materials to several Pacific Coast cities of the United States indicate a larger demand from that direction for the several varieties of excellent building stone occurring on the British Columbia coast.

CONCLUSION.

For purposes of comparison the following table showing mineral production for the years 1904, 1905 and 1906, is appended.

	1904		1905		1906	
	Quantity	Value	Quantity	Value	Quantity	Value
Gold, placer. . . . . .Oz.	. . . .	$ 1,115,300	. . . .	$ 969,300	. . . .	$ 948,400
Gold, lode. . . . . .Oz.	222,042	4,589,608	238,660	4,933,102	224,027	4,630,639
Total gold.	. . . .	$ 5,704,908		$ 5,902,402		$ 5,579,039
Silver . . . . .Oz.	3,222,481	1,719,516	3,439,417	1,971,818	2,990,262	1,897,320
Lead. . . . . .Lb.	36,646,244	1,421,874	56,580,703	2,399,022	52,408,217	2,667,578
Copper. . . . . .Lb.	35,710,128	4,578,037	37,692,251	5,876,222	42,990,488	8,288,565
Total metalliferous.		$13,424,335		$16,149,464		$18,432,502
Coal . . . . .Tons, (2,240 lb.)	1,253,628	3,760,884	1,384,312	4,152,936	1,517,303	4,551,909
Coke. . . . . " "	238,428	1,192,140	271,785	1,358,925	199,227	996,135
Other minerals (building materials, etc.)		600,000		800,000		1,000,000
Total production.	. . . .	$18,977,359		$22,461,325	. . . .	$24,980,546

A FEW NOTES ON THE ELMORE VACUUM PROCESS OF ORE CONCENTRATION.

By H. H. Claudet, Rossland, B.C.

Rossland Meeting, May, 1908.

In giving these few notes I will make no attempt to advance any theories concerning the process, nor give a reason for certain minerals being amenable to treatment and others not. All I wish to do is to give a general outline of its application and to include some of the most interesting cases.

I will describe the principles of the process by quoting from Mr. Elmore's article which appeared in the *Engineering and Mining Journal*, issue of May 11, 1907. "The process is based primarily upon the fact that, in a flowing pulp of crushed ore and water oil has a selective action for the metallic mineral particles as distinct from the rocky particles or gangue. This selective action is materially increased in some cases by the presence of an acid; and secondly upon the fact that the air or gases dissolved in water are liberated, partially or entirely, upon subjecting the same to a pressure less than that of the surrounding atmosphere. These liberated gases may be augmented by the generation of gases in the pulp or by introduction from an external source. The gases attach themselves to the greased mineral particles, being largely increased in volume as a result of the partial vacuum applied, cause the greased particles with their attendant bubbles of air or gas to float to the surface of the liquid."

I might further state that, for the purpose of explanation, one can regard the process as consisting of two distinct operations:

(1) Mixing the crushed ore with oil and acid.

(2) Concentrating or separating.

(1) The mixing takes place in a wooden trough of simple design, with revolving paddles.

(2) The concentrating or separation takes place as soon as the mixed pulp comes under the influence of the vacuum.

The whole operation is continuous and requires very little power and labour.

The process can be applied either to:—

(1) Direct concentration, i.e., crushing the ore to the desired mesh and treating direct without the aid of water concentration.

(2) The treatment of tailings.

(3) In certain cases, the separation of different sulphides, such as lead and zinc, zinc and iron.

(1) As an example of direct concentration, we have a mill working in East Kootenay on an ore composed of galena in baryta gangue, and the separation of these two minerals is excellent. Recent assays of mill products give the following:—Feed 14% Pb., concentrates 69% Pb., tailings 2% Pb. This plant has not been running long enough to allow us to arrive at the costs of operation, which necessarily must depend on local conditions to a great extent. The operating costs of two different vacuum plants which have been working for a long time are about 60 cents per ton of ore treated in one case and 75 cents per ton of ore treated in the other, exclusive of crushing. These figures are on a 1 unit installation and in bigger plants would be considerably less.

(2) In cases where mills are losing values in their tailings it is a cheap and easy matter to install the vacuum process without altering the original mill. This is being done with great success in various places.

(3) A very interesting feature of the Vacuum Process is that in certain cases it can be applied to effect a separation of different sulphides. I have here some samples of the products of a lead zinc ore showing the separation of the lead from the zinc, and you will see the excellent separation made in this instance. The ore assayed 39.5% Pb. and 19.7% Zn. with very small silver values. The lead concentrate assayed 81.0% Pb. and 6.5% Zn., representing a 90% extraction of the lead; the zinc concentrate assayed 48.5% Zn. and 4.1% Pb. representing 71% saving of the total zinc contents.

We have other cases of lead zinc ores giving equally good result, although I would not state that this separation can be made on every lead zinc ore; the only thing to do is to test each individual sample as no hard and fast rules can be laid down.

Another interesting case was the separation of zinc blende from iron sulphide. The ore assayed 19.6% Zn. and 17.6% Fe., and the concentrates assayed 46.5% Zn. and 11.4% Fe., representing 91% saving of the total zinc contents.

I hope to supplement the above brief account of the process with a more comprehensive paper on the subject at some future date.

SECONDARY COPPER ORES OF THE LUDWIG MINE, YERINGTON, NEVADA.

By E. P. Jennings, Salt Lake City, Utah.

(Ottawa Meeting, March, 1908.)

The Ludwig Mine is located near the western base of the Mason Valley Mountains, 500 feet above the desert and 5,000 feet above sea level.

The general geology of this desert range has been described in a former paper,* and it will be sufficient at this time to state that the portion of the range which includes the ore deposits is a highly metamorphosed series of limestones and clay shales resting on a central core of intrusive hornblende-granite.

These limestones and shales present the usual phenomena due to contact metamorphism; the limestones either being marbleized or changed to massive garnet-epidote rock and the shales to compact aggregates of quartz, lime-silicates, tremolite, hornblende, biotite and muscovite, with tourmaline near the granite contacts.

Copper ores occur disseminated through large areas of the garnet-epidote rock; also in fissures in the limestone and as bedded deposits between the limestone and metamorphic slates. The Ludwig ore body is a bedded deposit of iron and copper pyrites in a quartz gangue replacing limestone at its contact with a massive metamorphic rock, which forms the hanging wall.

The surface croppings of iron-stained quartz indicate an ore body 700 feet long and from 20 to 60 feet wide. The strike being N. 40 degrees E., with a dip of 60 degrees to the south east.

Masses of rich oxidized ore consisting of malachite, azurite, and chrysocolla, outcropped in the limestone foot wall 30 to 50 feet from the primary ore body and approximately parallel to it.

*Genesis of the Yerington Copper Deposits, Jour. C.M.I., Vol. x, p. 257.

These ore bodies were developed and mined 40 years ago by an open pit and a shallow tunnel driven along the strike of the deposit for 500 feet. Later a vertical shaft 400 feet deep was sunk in the limestone foot wall and several thousand tons of ore, ranging from 20 to 30 per cent. were shipped to the smelters. Last year the mine was sold to the Nevada-Douglas Copper Company, and active development of the primary ore body was undertaken.

The original shaft is located at the north end of the ore body; from this a cross-cut was run to the primary ore body, and from this point an incline was sunk which crossed the ore body near its northern end and passed into the hanging wall at the 550 foot level.

From the 500 station a drift was run 300 feet south along the contact of the ore body and the foot wall, which encountered small bodies of rich ore, mostly cuprite with iron oxide. Cross-cuts into the main ore body showed it to be leached; but unaltered pyrite and chalcopyrite was found in two winzes sunk 20 feet below these cross-cuts. A small amount of acid copper water came into one of the winzes, but the other, at the same depth, was dry.

No sulphides were found in the incline from the 500 to the 550 station, as the primary ore body was small and broken sufficiently to admit of the complete oxidation and leaching of all sulphides.

The hanging wall is a massive, fine-grained rock, composed of quartz, sericite, and lime-silicates, together with finely divided pyrite containing traces of copper.

Drifts were advanced north and south from the 550 station. The north drift encountered a body of oxidized ore a few feet from the station, which proved to be 20 feet wide and to extend upward 20 feet; a winze was sunk 50 feet in this ore which was largely soft, earthy, oxides of copper and iron, with finely divided metallic copper disseminated through the mass. Very little water was encountered in the winze.

The south drift was advanced 15 feet in the hanging walls and a cross-cut run to the primary ore body, which was found to be a crushed mass of quartz, country rock and unaltered sulphides. From this cross-cut the south drift was advanced 50 feet in the hanging wall near its junction with the ore body. Bunches of chalcocite were found along this drift, in the hanging wall rock. At the 50 foot point the main drift was turned 45 degrees to the right and passed into the original sulphide ore body which, for the first 150 feet, showed no signs of enrichment, and carried 4% copper; recently this drift has encountered bornite as a coating on chalcopyrite; the first evidence of enrichment of the primary ore body.

The chalcocite was followed 95 feet into the hanging wall by a cross-cut, the first 40 feet being in rich ore; beyond this point, the mineralization gradually decreased and the character of the hanging wall changed to garnet-bearing limestone. A raise of 40 feet on the chalcocite ore body showed a gradual change of the chalcocite to covelite.

The close proximity of the Ludwig vein to the copper deposits in the garnet rock, leads to the conclusion that it was due to the action of mineralizing magmatic waters whose source was the intrusive granite that metamorphosed the limestone and shales and deposited the copper in the garnet.

The Ludwig may, however, represent a later stage of activity of these waters, replacing portions of the limestone along zones of weakness at the contact with the shales, which were already more or less changed by the general metamorphism caused by the intrusive granite.

The Ludwig ore body is enclosed by an easily soluble limestone foot wall and a more or less shattered hanging wall, both of which are more pervious to the leach waters than the compact ore body. A portion of the acid, copper bearing water passed into the seams of the foot wall where it was precipitated as malachite, azurite and chrysocolla, though the latter mineral may be due to an alteration of malachite by alkaline silicate solutions.

These foot wall ores have furnished beautiful specimens; the malachite, azurite and chrysocolla being interbanded in delicate and intricate designs.

The leaching waters that passed into the hanging wall deposited copper as chalcocite; pyrite being the precipitant. This chalcocite was oxidized to cuprite, tenorite and metallic copper, the oxidization being complete in some instances and partial in others; earthy chalcocite being mixed with the oxides.

Covelite appears in one place as an alteration of the chalcocite, the blue sulphide forming a coating on the copper glance.

The vertical range of the secondary ores is not fully determined, but is known to extend to the 600 foot level, and recent deepening of the incline below the 650 foot level, shows the chalcocite to extend, at least, to this depth. Small amounts of water have been met in the incline and winzes; this water is acid and copper bearing, indicating that it is from the surface, and not the permanent ground water.

The future development, in depth, may furnish valuable data as to the genesis of ore deposits in fissures and contacts that are directly connected with ore bodies formed by contact metamorphism.

THE DUTIES AND RIGHTS OF ENGINEERS.

By J. D. Kendall, London, England.

This subject is introduced with the object of creating discussion, so that some common understanding may be reached as to what are the duties and rights of Engineers in certain frequently recurring circumstances. By way of initiating the discussion the writer proposes to make a few remarks on some of the more prominent branches of the subject.

The knowledge and ability possessed by Engineers may be utilized in different ways. (1) They may act for themselves only. (2) They may act for themselves and others, as the Engineers of syndicates or public or private Companies of which they are members, or (3) They may act for others only, as the Engineers of individuals, or of syndicates or public or private companies of which they are not members.

It is only proposed to consider this question under the second and third of the above heads, as the rights and duties of Engineers when acting for themselves do not differ essentially from those of other members of the community.

The subject may, perhaps, be best dealt with under different heads.

Duties

Services.—It is doubtless unnecessary to say, in a general way, that an Engineer's duty to his client, is to serve him honestly and to the best of his ability. Unfortunately this course of conduct does not appear to be always followed.

Secret commissions.—When an Engineer is acting for another or for others, he should not accept secret commissions in connection with the business he has in hand. The very fact of their being secret stamps them as immoral, and yet how often are they taken. Not long ago the writer heard of an Engineer bargaining for a commission—from makers of machinery—to the extent of 25% of the gross value of the machinery purchased, through him, for the mine he was managing. Men known to be guilty of accepting secret commissions should not be permitted to claim any connection with this Institute or any other associated body of Engineers.

Concealed profits.—It is also wrong for Engineers to purchase for clients, plant, machinery or general supplies from companies in which they are interested as shareholders, without the fact being made perfectly clear to their clients. This is often done but should not be permitted. Engineers should not, in the pursuance of their profession, have any other interest than that of their clients, which, in this particular case, is to buy in the best and cheapest market. A man's judgment may be warped, prejudicially to his employers, if he has conflicting interests of his own to serve.

When an Engineer is asked to report on a property that is offered for sale, and in which he is interested as vendor, he should state the fact at once to his clients, and if he afterwards make a report for his clients, the extent of his interest should be set forth in his report.

Share interest.—Many people think they are doing good business when they induce their Engineers to become shareholders in the property the latter are managing. In private companies this doubtless is so, but in public companies it may be very far otherwise. A man who is a large shareholder in a mine or smelter, and who is in a position to make reports that will probably become public, may use his position to increase illegitimately the value of the shares, if he wishes to sell, or to depreciate them if he wishes to buy. An honest man would not, of course, be influenced to act in the way indicated, but it will invariably be better for Engineers to refrain from becoming shareholders of any Company for which they are likely to be called upon to make reports that may influence the share market. If it be necessary that he should become a shareholder in order to give confidence to others, he should rigidly refrain from dealing in the shares.

Leakage of information.—When an Engineer is either managing a property or reporting on it for an intending purchaser he has no right to give any information so obtained to anyone, without the consent of his client or clients. Nor has any Engineer any right to communicate to another, information that might be prejudicial to his client regarding the property of which he has charge, or business with which he is in any way professionally connected, without first obtaining the consent of his client or clients.

Bribes.—Every attempt at bribery should be treated as an insult, for it is nothing else to an honest man. The known acceptance of a bribe will, it is to be hoped, always be considered by this Institute a sufficient reason for the exclusion or removal, from the list of members, of anyone who is known to be guilty of such dishonesty and unmanliness. Whenever a bribe is offered to a reporting Engineer the writer would strongly urge him to set out the fact at the beginning of his report.

Adopting reports.—An Engineer should not sign a report that has been prepared by another without making it perfectly clear to his clients in what capacity he signs. Frequently reports are signed by persons who have had nothing whatever to do with the preparation of them, but the fact is not stated, so that clients and the public—if the reports are published—are alike deceived.

Rights.

The Engineer has certain duties to his clients, on the other hand clients have certain duties to their Engineer. The latter may not inappropiately be looked upon as rights of the Engineer.

Fees—For competent and faithful service an Engineer is entitled to proper remuneration. He should not be asked to accept—and if he is asked, he should refuse—a contingent fee, unless the contingency be such that it cannot possibly be affected by any misrepresentation on his part. A very common form of the connitgent fee is this: "If I don't sell the property I will give you, say £200 for your report, if I do sell it I will give you £800". That is a kind of offer which should never be made to an Engineer, but whenever it is made he should instantly reject it. The acceptance of such a fee will destroy the value of his report in the mind of the public, no matter how much he may strive to do right.

Mangled reports.—There is a common practice nowadays of publishing favourable passages from the reports of Engineers, but keeping back unfavourable parts. It frequently happens that there are favourable passages in an Engineer's report, although in its entirety it is decidedly unfavourable. For that and other reasons which will readily occur to Mining Engineers it is essential that the whole of a report should be published or none of it. The Institute may do much useful work in protecting its members and the public in such circumstances by calling public attention to mangled reports. If an Engineer's report be too long or too technical to be published in full he should be asked to make an abbreviation, but whatever is published should bear the Engineer's signature and the date of writing.

I think that the membership of a Mining Institute should be somewhat of a guarantee to the public of competence and integrity and the Institute should do its utmost to protect its members from unfair practises on the part of clients and the public from irregularities in the conduct of Mining Engineers. To do this there must be a substantial preponderance of opinion as to what are unfair practises and irregularities. The knowledge of such preponderance can, I think, be best obtained by a discussion such as is proposed by the foregoing paper.

METALLOGRAPHY APPLIED TO ENGINEERING.

By William Campbell, Ph.D., Sc. D., New York

(Ottawa Meeting, March, 1908)

Metallography has been termed the science which studies the constitution of metals and alloys from the point of view of their structure, composition and physical properties. It does not necessarily deal with their extraction or formation which come under the art of metallurgy. We also class under this heading the study of the constitution of mattes speisses, the opaque constituents of ore-bodies, etc., rather than coin such new terms as mineralography and the like.

At the outset it ought to be explained that the following paper should really be entitled a few examples of the application of metallography. For the sake of those who are not familiar with the methods used in the microscopic examination of opaque material, a few remarks introducing the subject will not be out of place.

The preparation of the specimen consists in cutting off a suitable sized piece, say 1 inch square, by means of a hacksaw or sledge, and grinding down a flat surface with a file or emery-wheel or revolving disc such as is used in petrography. If a file be used as in the case of iron and steel a flat surface can be obtained by clamping the file (smooth or dead-smooth) in a vise and rubbing the specimen on it. Next the scratches from the file or emery are taken out by rubbing on emery paper No. O and OO commercial. Then the specimen is rubbed on a series of French emery paper No. O to OOOO, such as are used by die-polishers, changing the direction of rubbing when passing from one paper to the next. With certain material some of the papers may be omitted. The surface will now show a series of very fine, parallel scratches which are got rid of by polishing on a flat board or revolving disc covered with broadcloth and armed with well-washed rouge*. In most cases this final polishing can be

*W. Campbell, Notes on Metallography. S. of M. Quarterly xxv. 389.

done wet, but occasionally water will attack the specimen as in the case of certain alloys rich in iron-sulphide, etc. It is then necessary to either polish dry or else use a very thin oil. In most cases after washing off the rouge it is best to dry by covering with alcohol and mopping with an old handkerchief.

The specimen is mounted on a glass slide with plastic wax and examined for black or colored constituents such as slag in wrought iron, manganese sulphide and silicate in steel, graphite in cast iron, temper carbon in malleable, copper oxide or sulphide in copper, various metallic compounds in other alloys.

The structure may be further developed by etching. For steel and iron three reagents give satisfactory results:—

(1) A saturated solution of picric acid in alcohol. The pearlite is attached.

(2) Ten per cent. nitric acid in water. Shows up the grain of the ferrite or pure iron in wrought iron and low carbon steel.

(3) A solution of picrate of soda (2 per cent. picric acid added to a 25 per cent. solution of caustic soda) used at 100° c. Near the eutectoid point (saturation point) 0.6 to 1 per cent. carbon it is often difficult to distinguish between the veins and envelopes of pure iron or ferrite and the carbide, cementite. In the above solution cementite darkens.

By heat-tinting we can distinguish between carbide and phosphide of iron, also by etching with (3).

For alloys, various reagents have been used. For most work use:—

(1) Ten per cent. nitric acid: white metals, bearing metals, etc.

(2) Fifty per cent. nitric acid: copper-rich alloys, brass, bronze, blister and other grades of copper. Immerse till the structure shows up clearly.

Any good type of microscope can be used. It ought to have a fair working distance between the objective and the stage. A revolving stage is an advantage and so is one which can be raised and lowered by rack and pinion. In examining opaque material transmitted light cannot be used and the specimen must be illuminated from above by means of reflectors. With a one-

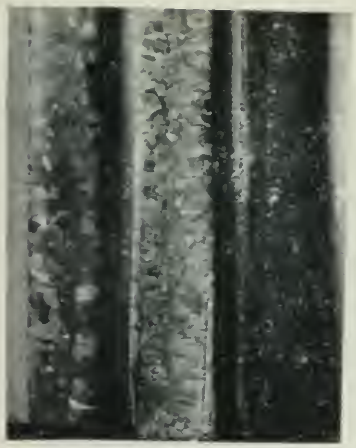

Fig. 1

Fig. 2

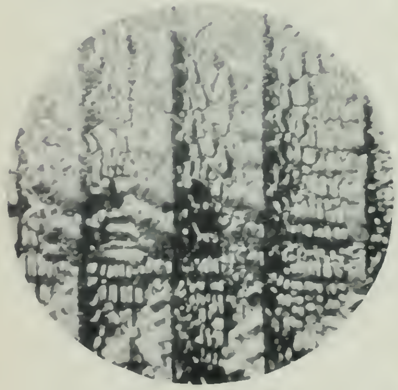

Fig. 3

Fig. 4.

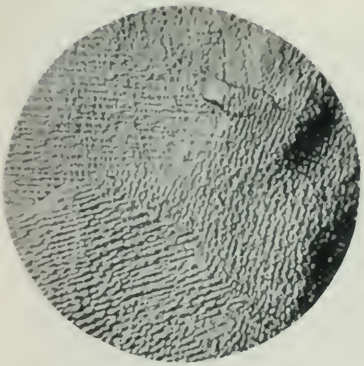
Fig. 5


Fig. 6.

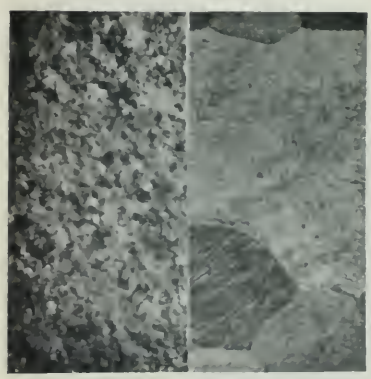
Fig. 7 and 8

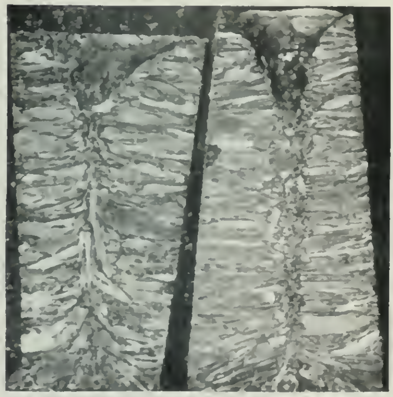
Fig. 9 and 10.

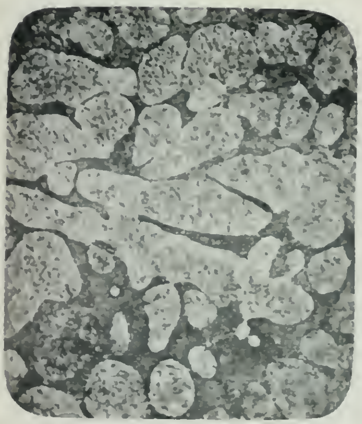

Fig. 11.

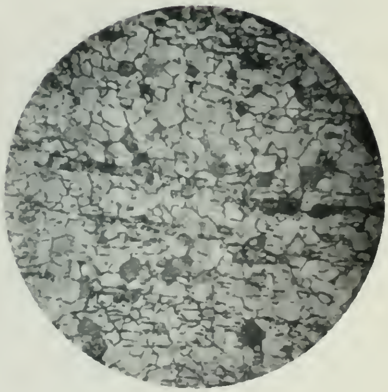

Fig. 12.

Fig 13.

Figs. 14 and 15.

inch objective the Sorby-Beck reflector can be used and with it we can get both vertical and oblique illumination. With higher powers the illuminator must be screwed between the objective and the nose-piece. It consists of a thin glass disc or a prism. Such reflectors are made by Beck, Nachet, Zeiss, Leitz, Bausch and Lomb and other makers. The principle of all is the same. The beam of light enters at an opening in the side of the tube, is deflected at 90° through the objective and illuminates the specimen.

Special types of microscopes have been designed for metallographic work, such as the Le Chatelier, Martens and Sauveur stands.

For illumination a Wellsbach light serves for low power work, whilst a Nernst lamp or arc-light is necessary for high-power work.

Now the final structure of our material is very important, but we are often liable to overlook the importance of the influence of all those changes which take place between the beginning of solidification and the final state. A great deal of information as to structure can be obtained from an examination of the structures of the more fusible metals* such as tin, lead, antimony, zinc, etc., as the following illustrations will show.

When ingots of metals are suitably etched they are seen to possess a definite granular structure. Fig. 1 shows the surfaces of three small ingots, that on the left being pure tin, that on the right pure lead, whilst the centre bar is impure tin. This definite orientation of grain is seen to be caused by differential etching or etch figures, the rate of etching depending somewhat on the orientation of the grain with respect to the surface, the final result being to show up the internal structure, akin to cleavage. Fig. 4 x 35 shows the structure of the base of a small ingot of lead, five or more distinct grains or crystals being seen, each having a rough surface built up of tetrahedra with distinct orientation in each grain.

Many metals show at their surface a definite crystalline growth in the form of skeleton crystals or dendrites, each metal

*W. Campbell, The Effects of Strain and of Annealing. Appendix iv to Sixth Report, Alloys Research Committee. Inst. Mech. Eng. 1904.
———Uber das Gefüge der Metalle. Metallurgie iv.

having its own characteristic form. They owe their origin to the fact that they are the framework of the first crystals or grains to form at the surface and subsequent cooling and freezing were accompanied by contraction and so they were left standing out in relief. Those on the surface of aluminium are very characteristic. Fig. 2 x 40 shows the dendritic structure of antimony, form the base of a small cake cast on stone.

The dendrites in the cavities and pipes of ingots are well known to all engineers, whilst to many in practice their appearance is an indication of the composition of the metal, e.g., cake antimony, test ingots of tin, test ingots in lead refining, etc.

The effect of the rate of cooling especially through the solidification range of temperature is of great influence on the structure of the metal or alloy. The slower the freezing the coarser the crystallization as in aqueous solutions. Fig. 3 x 16. shows the surface of a silver button cooled slowly in the crucible under a borax cover, whilst Fig. 5 shows the same silver (x 33) cast in a small iron mould. In Fig. 3 a very small fraction of the surface of a single grain with its distinct orientation is shown, but in Fig. 5 at twice the magnification, three grains are shown, also distinctly oriented by what have been called by some authorities the secondary grains.

A great deal has been said about "casting temperature" as if the temperature of the metal were a direct factor. Of course the higher the temperature of a metal the more gas it is capable of absorbing, &c., but apart from this side of the question, the main factor involved is the *rate of freezing*. A metal cast at a very high temperature would carry more heat into the mould and therefore freeze more slowly than one cast near its freezing point.

Lastly, in regard to what has been termed ingotism there has been great discussion as to how metals, especially steel, freeze. Fig. 9 shows a vertical section through a small rectangular ingot of zinc, cast wide end up, whilst Fig. 10 shows one cast small end up. Whereas in each the freezing has been mainly perpendicular to the cooling surfaces, the pipes and central cores are quite different, due in part to the location of the last liquid to freeze.

After a metal (or alloy) has solidified there are other factors which tend to change its structure. First we have re-arrangement in the solid state as the metal cools down, e.g., pure iron, steel, bronze, brass, etc. Next we have the effect of strain or mechanical work and then there is the effect of heat treatment or annealing.

When a metal is strained beyond its elastic limit, a slipping takes place within the grains. We have the "cry" of tin and zinc. This slip may show itself merely as lines or we may find a banded structure akin to twining. Fig. 6 x 30 shows the surface of a thin slab of tin cast on stone and strained by bending. Three grains are shown, but within each we see bands of different orientation due to the strain. The first lines or bands to appear are perpendicular to the direction of strain, but as the latter increases other lines and bands make their appearance, three sets of parallel bands in one grain being common. This slipping is intimately related to the orientation of the dendrites and etch figures and is therefore in some cases coincident with cleavage (c.p. twining of calcite).

When the strain has been severe as in the case of forging and rolling the grains are broken up and the coarse structure due to the original cooling is replaced by a much finer one, whose size depends primarily upon the amount of reduction. Fig. 7 x 33 shows some tin (whose original structure was similar to Fig. 4) hammered out to less than ⅛ in. thick. The coarse crystallization has entirely disappeared. Now on annealing such strained material a growth of grain takes place, the size of the final structure depending on the temperature, the time and the mass of the piece. Fig. 8 x 33 shows some hammered tin annealed for ten days below 200°c. There has been an enormous growth of grain, in this case equal to that of the original tin. In Fig. 8 the interior of the grains is seen to be finely striated. These are slip lines due to the strain set up in the cutting of the section. The same experiments have been performed with zinc, lead, cadmium, copper, nickel, gold and silver, etc. Rolling or hammering breaks down the grain, annealing restores it. The breaking of tie rods in reverberatory furnaces, the recrystallization of cold-rolled material and certain cases of "aging of mild steel" are all typical examples of this growth of grain in strained material.

On the subject of alloys metallography has shed a light which has helped to clear up most of our curious notions of their constitution. In the old days no one had examined the minute structure of an alloy and therefore one was unable to prove that the other party's "queer ideas" were all wrong. To-day we cut our specimen open and examine its structure to the limits of the microscope and we can as a rule follow its genesis step by step by the aid of pyrometric research and heat treatment. We call to our assistance the modern theories of Physical Chemistry on the subject of Solutions, the Phase Rule and the like. The result of which is that we now know a great deal about alloys; more than the engineer of to-day appreciates.

In the examination of alloys we find them to be composed of pure metals, compounds of metals and solid solutions, which are homogeneous but in indefinite proportions. Guthrie pointed out that the freezing point curve of many series of alloys is like that of the ice-salt series. The addition of one metal to another lowers the freezing point, giving us two curves in a binary series, which intersect at a point indicating the alloy with the lowest freezing point or the eutectic. The eutectic of copper and copper-oxide contains 3½ per cent. Cu_2O and freezes at 1064° C, some 20° below the freezing point of pure copper. The more copper oxide present, the greater the amount of eutectic or groundmass and the lower the freezing point down to 1064° C at 3½ per cent. Cu_2O. Fig. 11 x 60 shows an alloy with about 50 per cent. free copper (bright) surrounded by the eutectic (dark). Therefore the alloy contains about 1¾ per cent. Cu_2O, and begins to freeze about 1074° C, ending at 1064° when the groundmass freezes. On the other hand if there is more than 3½ per cent. Cu_2O present, the excess will freeze out first as dendritic crystals as seen in Fig. 13 x 60.

The copper-copper sulphide series show a similar, structure the eutectic occurring at about 4½ per cent. Cu_2S, but above 9 per cent. Cu_2S, they separate out into two layers; in other words we have copper bottoms produced. Industrial sulphides or mattes and speisses have long been of interest. Text-books give a wonderful series of compounds and definitions. But mattes and speisses follow the same laws as alloys of metals or salts. For example lead sulphide (970°C) and iron sulphide (1137°C) form an eutectic at 25½ per cent. Fe S at 784°C, according to

Weidmann*. Lead sulphide and copper sulphide form an eutectic at 51 per cent. Cu_2S and 550°C according to Friedrich†. Fe S and Cu_2S form an eutectic at 14% Cu_2S and 850°C according to Hofman‡. Blast furnace mattes are usually deficient in sulphur and we should expect some free metal. A first matte running 3 per cent. Cu showed a structure composed of dendrites and cubes of iron, dendrites of Fe S, surrounded by the eutectic or groundmass. A second matte with 40 per cent. copper showed cubes of free iron, dendrites of Cu_2S in the eutectic.

The speisses¶ are more complicated. Iron and arsenic form a compound Fe_2As, which forms an eutectic with iron at 830°C and 30 per cent. As. The alleged compounds Fe_5As_2 and Fe_5As do not exist, as can be seen when a piece of ordinary iron speiss is examined under the microscope. Similarly nickel and arsenic form a compound $Ni_5 As_2$ (998°C) which forms an eutectic with nickel at 898°C and 27 per cent. As. Lead and arsenic form an eutectic at 2½ per cent. As, 287°C. Copper and arsenic form a compound $Cu_3 As$, which with copper forms an eutectic at 21 per cent. As and 683°C. And so on.

Amongst the industrial alloys the bearing metals are of great interest. In the binary alloys of tin and antimony, when more than 8 per cent. of Sb is present, bright hard cubes of a compound Sb Sn appear. Fig. 14 x 35 shows an alloy with 20 per cent. Sb, in which white cubes occur in a dark plastic groundmass, which is a solid solution of about 8 per cent. antimony in tin. The material has been crushed down and the brittle cubes have broken across. To-day babbitt metal containing tin antimony and copper is in great demand. Fig. 15 x 35 shows an alloy with 5 per cent. copper which shows up as bright needles of Cu Sn §. According to many authorities the best alloy of this kind contains 11 per cent. antimony, 5½ per cent. copper and the rest tin. Second grade babbitt metal frequently runs over 40 per cent. lead and less than 40 tin, the antimony reaching over 15 per cent. Its structure is quite distinct from that of No. 1. The Cu Sn needles are missing, the bright cubes, etc., have greatly

*Metallurgie iii. 660.
†Metallurgie, 1907, 671.
‡Bull. A.I.M.E. 1907, 25.
¶Friedrich. Metallurgie, 1907.
§Journal Am. Chem. Soc. xxvi. 1904. 1306.

increased in amount, whilst the groundmass is now very coarse indeed and shows up the ternary eutectic containing lead. The microscope sometimes proves a rapid method of determination between No. 1 and No. 2 grades.

The brasses* (Cu+Zn) and the bronzes† (Cu+Sn) are also of special interest because like iron and steel they show changes in the solid state. The aluminium-bronzes‡ show the same thing. By quenching at different temperatures we can materially alter their structure and properties.

To the engineer, however, the alloys of iron and carbon are of the most interest due to their vital importance. They form one continuous series from wrought iron, mild steel for pipes and boiler plate, shafting, structural steel, light rails, heavy rails and tyre steels, machinery and tool steel, cast iron, gray white and mottled, pig iron, to spiegel-eisen. To-day most of us know all about analyses, phosphorus and sulphur must not be more than so much, we know the physical properties or some of them. We know what certain grades are good for and when they fail, we look around for some one on whom to lay the blame.

Now in metallography we take the knowledge yielded by chemical analyses, physical tests and so forth and add to these an intimate knowledge of structure or constitution. As to the constituents of iron and steel, there are several:—Ferrite or pure iron; cementite or iron carbide, Fe_3C.; pearlite, a mechanical mixture of these two, containing about 0.8 per cent. carbon (a steel of 0.8 per cent. carbon slowly cooled consists entirely of pearlite); graphite, both original and secondary after heat treatment when it is known as temper-carbon; and lastly Austenite. When steel is heated above its critical points, 700 to 900°C, it becomes a solid solution, ferrite and cementite mutually dissolving each other. In this state it is capable of being hardened by quenching. This solid solution we call Austenite. In addition we find a whole series of transition products, due to the breaking down of Austenite by tempering and the like, which are called Martensite, Troostite, Sorbite and Osmondite. Each has its own characteristic structure and properties.

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*Shepherd. J. Phys. Chem. viii. 421.
†Heycock and Neville, Phil.-Trans. A. 1903. 1.
‡Campbell Min. Industry xi. 668.

Just below solidification the series can exist in two forms. (a) The Graphite-Austenite series which is stable, (b) the Cementite-Austenite series which is meta-stable. Whilst on cooling down a series of transformations occur between 900 and 700°C and the Austenite breaks down into ferrite and pearlite, pearlite alone or cementite and pearlite depending on whether it contained less than 0.8, exactly 0.8 or more than 0.8 per cent. carbon in solution. Austenite can contain a maximum of 2 per cent. carbon in solution, which is the limit of steel, and when the carbon contents is above this amount the eutectic makes its appearance and we enter the region of cast iron. If this eutectic is composed of a mechanical mixture of steel and graphite we have gray cast iron, if of steel and cementite (Fe_3C) we have white cast iron, whilst a mixture of both gives us the mottled variety.

The following examples will serve to illustrate the different classes of material. Fig. 12 x 40 is a section of a piece of wrought iron used in the manufacture of pipe. It is composed of polygonal grains of ferrite and lines of black slag. The etching with 10 per cent. nitric acid in water has revealed the structure of the ferrite. When such material is strained slip lines occur in the ferrite, whilst severe strain breaks up the brittle slag and elongates the ferrite grains and on rupture produces the fibrous appearance at the fracture. As can be seen the material is not fibrous except in respect to the included slag. Fig. 16 x 90, unetched, shows a large area of slag with its characteristic structure of light-colored inclusions. The white groundmass is unetched ferrite. The presence of too much slag is a source of weakness. Fig. 17 x 40 is a section of a wrought iron boiler tube (sold as steel) which failed, undoubtedly due the presence of too much slag.

The main difference between wrought iron and low carbon steel is the absence of slag and the presence of small areas of pearlite which etch up dark with picric acid solution. Fig. 18 x 80 shows the structure of steel containing about 20 to 25 per cent. pearlite surrounded by white ferrite (0.16 to 0.20 per cent. carbon). Much of our wrought iron to-day contains areas of similar structure. Their presence may be due to the fact that the wrought iron absorbed carbon locally during the process of manufacture in the puddling furnace or finery hearth, which areas were rolled out during the subsequent working of the material. Or it may be due to the fact that the iron was manufactured by "piling" of mixtures of wrought iron and scrap steel. In the former case the areas of "steel" pass gradually into the true wrough iron by diffusion, in the latter they are generally separated by more or less slag. This often forms an easy method of distinguishing between these two classes of material.

In the examination of pipe the microscope offers a very certain method of distinguishing between butt and lap welding by following the course of the included slag.

In steel, as the carbon increases the dark etching areas of pearlite increase till at 0.8 per cent. carbon or thereabouts; the whole mass* is composed of grains of pearlite. Above 0.8 per cent. the excess cementite separates out as envelopes around the grain. The grain size is of great importance and depends upon the amount of reduction in the rolls or in forging or upon the heat treatment or both. Steel as cast has a very coarse structure, a medium carbon steel showing a linear arrangement of the ferrite resembling Weidmannstaten figures. On annealing at the proper temperature such a structure is replaced by one of fine texture*. Too high an annealing temperature will cause a coarsening of the grain. As an example of poor material we can take a case of an 8 inch crank shaft which failed. The structure of properly annealed material ought to resemble that of Fig. 18. The actual structure is shown in Fig. 19 x 50 which shows improper heat treatment. In the centre was found a large area of slag or oxide seen in Fig. 21, unetched, whilst the structure of the central part is seen in Fig. 20 x 50 where we have in addition to a coarse grain, a structure showing far too much carbon, say 0.5 to 0.6 per cent. In other words the steel was badly segregated.

The wear of steel tyres is a subject of some importance. A series of good and bad tyres of different makes were examined to try and find some indications of the cause of shelling out. One tyre of German manufacture showed a structure whose grain was similar to that of Fig. 18. Others showed a grain size as large as that in Fig. 20 when magnified 80–90 dias. When

*Uber die Warmebehandlung von Stahlen: Metallurgie, 1907. 772

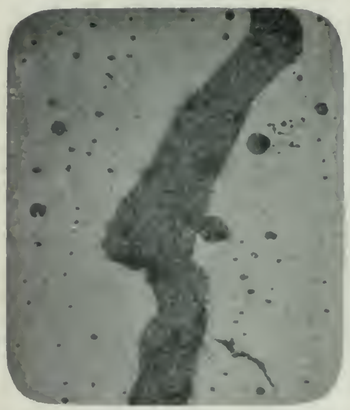

Fig. 16.

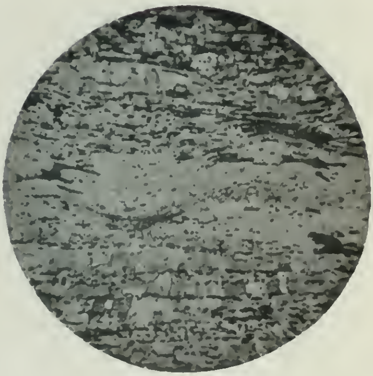

Fig. 17.

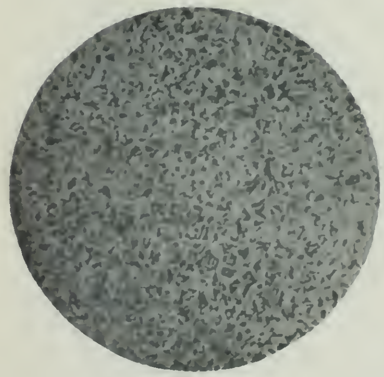

Fig. 18.

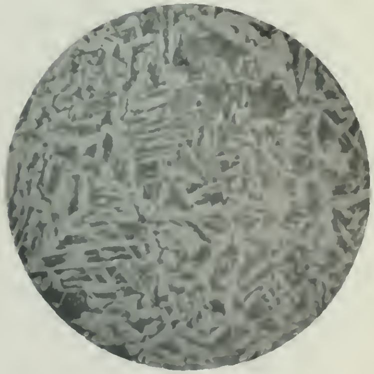

Fig. 19.

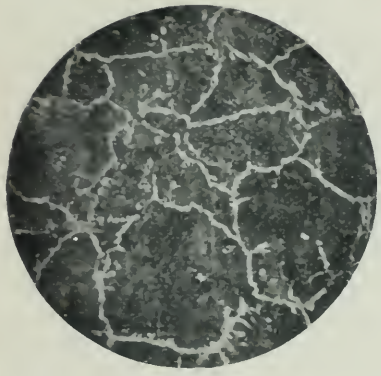

Fig. 20.

Fig. 21.

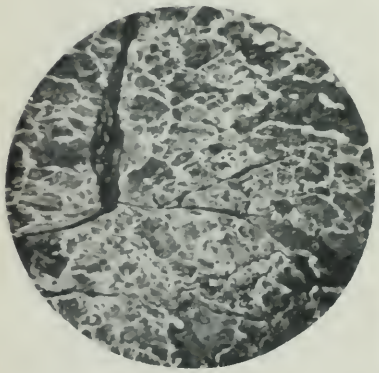

Fig. 22.

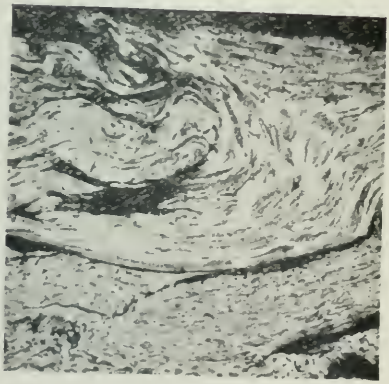

Fig. 23.

the faulty material was examined inclusions of slag or oxide were found. A typical example is shown in Fig. 22 x 90. The groundmass shows a small grain of ferrite and pearlite, with lines of black oxide, etc., undoubtedly the cause of failure. An extreme case is shown in Fig. 23 x 90, the section near the surface of the tyre. Such a structure would soon break off and yield a flat spot. In some cases no slag or oxide was present but a fine line of division was seen evidently due to a closed-up blow-hole or gas inclusion in the original casting.

The examination of high carbon steels* yields much information as regards to cause of failure, heat treatment, etc. In general heating to temperatures below the critical point (700 to 730°C) for any time causes a breaking down of the veins of cementite (c.p. Fig. 20: x 500) which tend to assume a globular form. The size of grain of the pearlite does not change until the critical point has been passed. Above the critical point the higher the temperature the coarser the grain of the pearlite and the more the segregation of the cementite into globules until at above 1000°C we find the cementite breaking down into ferrite and graphite.

The process of cementation, case-hardening, etc., can be followed by examining a series of blister steels withdrawn from the furnace after 1, 2, 3 — to 10 days, the carburization evidently taking place by diffusion through the solid solution Austenite.

Coming next to the cast irons, time does not permit to deal with their constitution by discussing the temperature-composition curves of the series†. A few examples, however, will serve to illustrate the different types of structure. In gray cast iron we are dealing with alloys of steel and graphite. Fig. 24 x 40 shows a piece of cast iron with 2.9% C. 1.44% Si. 0.23% Mn, unetched. Light dendrites of steel are surrounded by a groundmass or eutectic of steel and graphite which froze at about 1135° C. At high temperatures the steel was in the form of Austenite which of course rearranged itself into pearlite, etc., on passing the critical range (recalescence). With increase in carbon the dendrites decrease and finally disappear at the eutectic point

*W. Campbell. Proc. A.S.T.M. vi 211: Metallurgie, 1906. 741.
†Benedicks. Metallurgie, 1906. 303, etc.
‡tansfield. J. I. and Steel Inst. 1900. ii 317.

(4%+C). Fig. 25 x 50 shows this eutectic, a mechanical mixture of steel and graphite, the structure of very gray castings and naturally weak. The strength of gray iron will depend on the amount and size of the graphite flakes and on the structure of the steel background. Slow cooling, high silicon, low manganese, etc., all tend to give us gray iron.*

In white iron we are dealing with alloys of steel and cementite. Fig. 26 x 60 is a section of a piece of washed metal, C=3.75%, S=0.03, P=0.012, S=0.02% etched with picric acid. The steel (pearlite) shows up black, the cementite white. There are a few grains of steel in excess of the eutectic which forms the groundmass as a mechanical mixture as before. This eutectic of Austenite-cementite freezes at 1125°C—while at a lower temperature the Austenite is transformed into pearlite, etc., as before. Rapid cooling, low silicon, high manganese, etc., all tend to give us white iron.

When the carbon is in excess of the eutectic ratio in gray iron it separates out as graphite above 1135°C (Kish). In white iron it forms plates of massive cementite which are found enclosed in the groundmass. Fig. 27 x 60 illustrates this structure. It is a section of a piece of Spiegel-eisen, C=5%, Mn 10 — 20%. The cementite is a carbide of iron and manganese.

Mottled irons show grains of gray iron surrounded by envelopes of white, the gray apparently freezing ahead of the white. Some cases, however, clearly show that the original structure was all white, but subsequently some of the masses of cementite broke down into plates of graphite with envelopes of ferrite.

The process of malleablizing† consists in breaking down the cementite into ferrite and graphite, and getting rid of the carbon in solution in the Austenite by diffusion.

The latest development of metallography‡ is its application to economic geology. By its aid we can distinguish the relative ages of the various opaque constituents of ore bodies much more

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*Wust. Metallurgie iii p 1.
†Wüst. Metallurgie v. 2.
‡W. Campbell, S. M. Quarterly xxvii. 415; Economic Geology vol. i. 751.

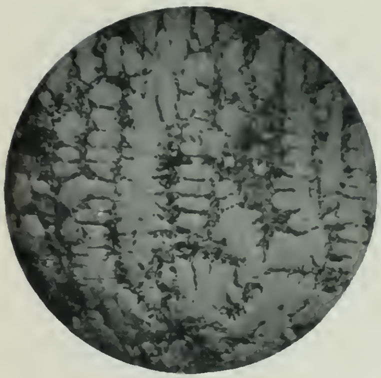

Fig. 24.

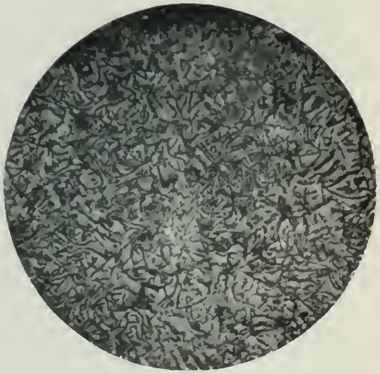

Fig. 25.

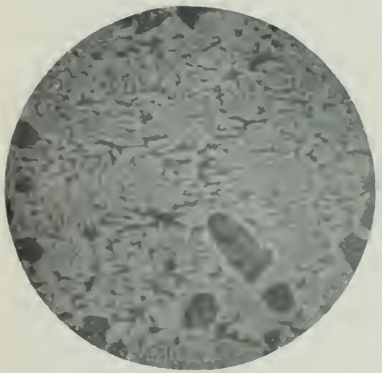

Fig. 26.

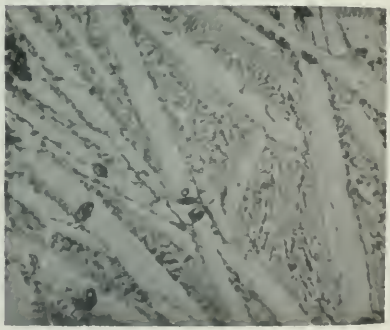

Fig. 27.

easily than can be done by hand specimens or in the petrographic slide, when dealing with complex and compact masses.

The ordinary specimens from Butte, Mont., are composed of iron-pyrites with more or less copper. Under the microscope the pyrite is clearly the oldest constituent. It has been broken and fractured and then eroded by solutions. Then in the interstitial spaces were deposited bornite and chalcocite. The chalcocite is apparently younger than the bornite for it cuts it in places. Very often when the specimen shows chalcopyrite this latter was the last to form because it is the groundmass of the pyrite, bornite and chalcocite. Fig. 28 x 40 shows a section with rough dark pyrite enclosed in a lighter mixture of bornite and chalcocite which are much softer and leave the pyrite standing out in relief.

The silver deposits of Cobalt, Ont., have been studied* in this way. We find that the first mineral to crystallize out in the vein was smaltite and this was followed by niccolite, for cubes of smaltite are found embedded in niccolite. Both the niccolite and the smaltite show signs of disturbance and are cut by veins of calcite. Fig. 30 x 50 is a section from the La Rose mine. Rough smaltite is seen enclosed in smooth-polishing niccolite, both of which are cut by thin veins of calcite which appears black on account of the vertical illumination. Of later age still is the argentite which cuts the calcite; while the silver cuts both argentite and calcite. The bismuth came down with or a little later than the native silver. Thus we can establish the order: smaltite, niccolite, period of disturbance, calcite, then argentite, native silver and bismuth. In addition we find crystals of cobaltite (?) incrusted on the rosettes of smaltite (cloanthite) embedded in the calcite, therefore, the cobaltite is slightly younger than the smaltite and older than the calcite. Mispickel occurs like cobaltite. It is well known that much of the silver is not pure. This is explained when it occurs as veins, for each vein has a thin envelope of a bluish harder substance which polishes somewhat in relief, probably a native alloy of silver.

Nickeliferous pyrrhotites have long been the subject of

*Campbell and Knight: Economic Geology. i 767.

discussion. Many hold that the nickel replaces the iron isomorphously. We have examined specimens from widely different localities and in each case the nickel occurred as pentlandite.* Chalcopyrite usually occurs also and we find the following order of succession holds good: pyrrhotite, pentlandite, chalcopyrite. Secondly, their origin is much discussed. Are the deposits of direct igneous origin or have they been deposited through the agency of solutions. The specimens we have examined show such a structure that they could not have separated from an igneous mass. They show no resemblance to nickel-mattes.

The process of decomposition and of secondary enrichment can be studied metallographically. Fig. 31 x 40 is a section of decomposing chalcopyrite from the Cochise District, Arizona. The bright areas are chalcopyrite, surrounding which are envelopes of chalcocite, the whole set in a groundmass of iron oxides. On etching with nitric acid the structure is even more pronounced. Fig. 29 x 40 shows such an etched section. As before the bright areas are chalcopyrite. Around them the envelope of chalcocite has been deeply attacked, whilst the black areas in relief are the oxides of iron. Veins of carbonate of copper occur at intervals in the oxide areas. The whole structure closely resembles that in "Kernal Roasting."

Another important line of work is the study of certain complex mineral species to determine their constitution. We can ascertain in many cases whether a mineral owes its peculiarity of formula to a definite combination or to the presence of foreign bodies as in the case of a mechanical mixture. In the majority of specimens examined there is found more or less admixture of foreign matter. Chalcopyrite includes chalcocite or pyrite, sometimes even galena. Tetrahedrite includes quite a number of other minerals and so on. Steel galena when examined is found in many cases to owe its fine structure to the presence of a second mineral. Each grain is surrounded by a fine film of quartz in one case, calcite in another, tetrahedrite in another, blende in another and so on. In many cases the galena was deposited, then crushed and the second constituent then deposited.

*Campbell and Knight: Economic Geology. ii. 350.

Minerals often show the effects of strain when etched, especially galena and pyrrhotite.

In conclusion an apology must be made for the heterogeneous nature of this paper, but the excuse lies in the heterogeneity of engineering. An attempt has been made to show how the engineer may make use of metallography, a subject which is now part of the regular course at the School of Mines, Columbia University, and is being rapidly developed at other places. I can only add that I shall be more than glad to demonstrate the methods and their application to any of the members of the Institute who may happen to be in New York.

NOTE—The above paper was illustrated by over 100 lantern slides, a few of which are here reproduced.

4

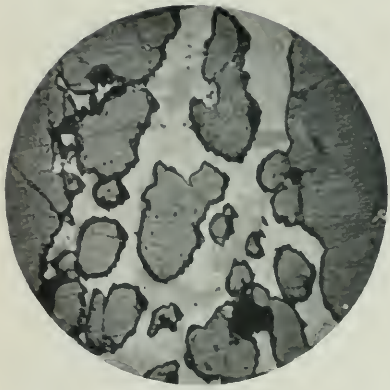

Fig. 28.

Fig. 29.

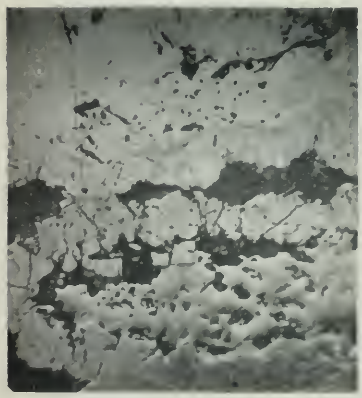

Fig. 30

Fig. 31

NOTE ON A SYSTEM OF CONVENTIONAL SIGNS FOR MINERAL OCCURRENCE MAPS.

By Elfric Drew Ingall, A.R.S.M.

(*By permission of the Director of the Geological Survey of Canada.*)

(Ottawa Meeting, 1908.)

Previous to the inauguration of the Exhibitions Branch of the Department of Agriculture, the Geological Survey of Canada was entrusted with the preparation of Exhibition exhibits of ores, minerals, etc., illustrative of Canada's economic resources in this respect.

These were always accompanied by maps of various kinds whereon the locality of all the known deposits of minerals of commercial value were shown. These were mostly large manuscript wall maps upon which the deposits were designated by conventional signs, which were selected, however, largely at haphazard, and depended upon the inventiveness of the particular draughtsman employed for the occasion.

On being entrusted with the work of the Mines Section of the Survey—on which, after its inauguration, devolved the preparation of such maps, etc., I felt that the method of using such conventional signs might be systematized, and as a result of this effort, submitted the schedule herewith illustrated to Dr. A. R. C. Selwyn, then director of the Survey. His endorsement bears date December, 1890.

Since then this set of signs has been officially used by the Geological Survey not only for manuscript maps for wall-exhibition, but on the regular series of published map sheets.

So far, however, this set of signs has existed in manuscript only, so that it is thought advisable to publish them with a view to their wider adoption and as perhaps useful to others who might find them suitable for similar purposes.

The general principles followed are:—

Firstly—All well established signs have been retained, *e.g.*, those for iron, copper, lead, etc. These, which chiefly pertain to the metals, have been used in the past on maps issued by various Surveys, etc., and originated with the Alchemists of old. Whilst retaining these signs, however, the various ores of the metals are shewn throughout the system by addition of strokes, lines, etc.

Secondly—For each set there is a general sign, so that the useful constituent may be shewn where perhaps that is all that is known of the deposit, *e.g.*, where a copper ore deposit is known without being able to specify whether the metal occurs in the form of native, sulphuret, carbonate, etc.

Thirdly.—In each set care has been taken to retain throughout the general appearance of the main sign so that the general nature of the mineral or ore occurring at the spot designated on any map or plan will be plain from a distance, whilst a closer inspection will reveal the specific mineral, ore or constituent.

Fourthly.—It will be noted that related groups have a generally similar appearance, *e.g.*, the carbon minerals are all circles with completely or partially filled in centres. Similarly the structural minerals are all squares solidly filled in for the heavier, such as granite, &c., and hollow for the carbonate rocks such as limestone, marble, etc., etc., and so on.

The combination of signs in some of the metallic ores may seem rather elaborate, but any attempt to shew them by groups of chemical symbols would be even more so and this method has the advantage of being a conformable part of a complete system. Then, too, for most non-metallic minerals the complexity of their chemical formula would prohibit this method. If the method herewith illustrated were generally adopted, the preliminary drawback of the need of constant reference to the explanatory legend of the map would soon be eliminated, and as the signs became generally known no more difficulty would be encountered than in the reading of the purely conventional signs of the alphabet of any language.

It is suggested that where possible or advisable, *e.g.*, in large manuscript wall maps—by printing the signs in different colours for different minerals or classes of minerals still greater clearness might be attained. This method would, however, be only applicable in special cases. In printed maps, however, of regular issues it might be suggested that well authenticated deposits of proved value might appropriately be shewn by the proper signs, but of larger size than those used for more doubtful deposits.

In making up the map signs herewith illustrated care has been taken in designing the proportions of the parts of each sign so as to make the detail always subordinate to the general appearance.

The signs are illustrated in the accompanying engravings, and are arranged into four main groups of affiliated minerals and a number of important sub-groups. These groups contain the following minerals:—

THE METALLIC CLASS.

1. —Gold—quartz.
1a.— " —placer.

2 —Platinum.

3 —Iridium.

4 —Osmium.

5* —Silver—general sign.

6* —Mercury—general sign.

7* —Copper —general sign.
7a — " —"native" ores.
7b — " —sulphuret ores.
7c — " —oxides and carbonates.
7d — " —unallotted.

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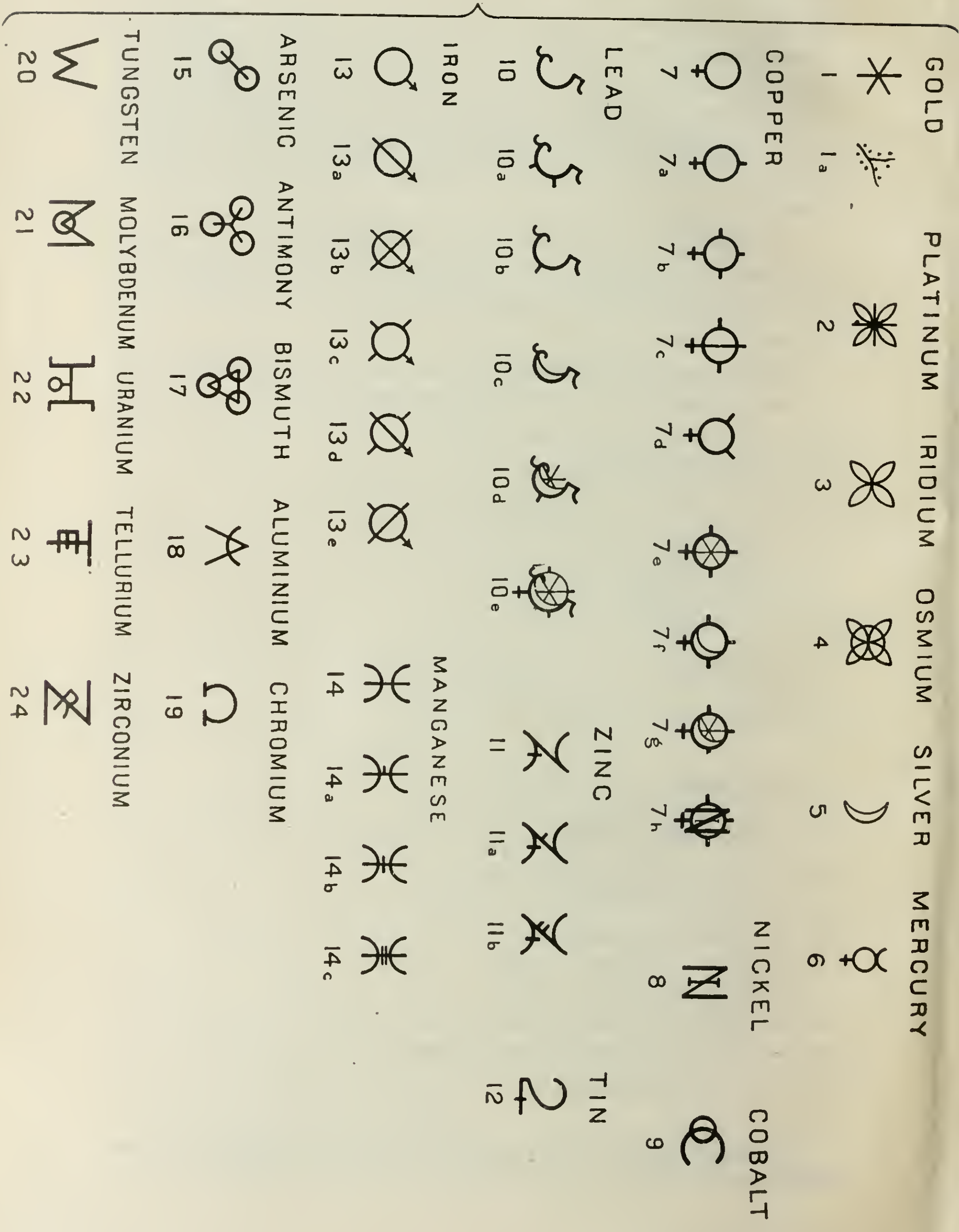
* These signs have been extensively used and originated with the Alchemists.

METALLIC


GOLD
1 1a
PLATINUM
2
IRIDIUM
3
OSMIUM
4
SILVER
5
MERCURY
6
COPPER
7 7a 7b 7c 7d 7e 7f 7g 7h
NICKEL
8
COBALT
9
LEAD
10 10a 10b 10c 10d 10e
ZINC
11 11a 11b
TIN
12
IRON
13 13a 13b 13c 13d 13e
MANGANESE
14 14a 14b 14c
ARSENIC
15
ANTIMONY
16
BISMUTH
17
ALUMINIUM
18
CHROMIUM
19
TUNGSTEN
20
MOLYBDENUM
21
URANIUM
22
TELLURIUM
23
ZIRCONIUM
24

7e —Copper —sulphurets with gold.
7f — " " silver.
7g — " " gold and silver.
7h — " " nickel.

8 —Nickel—general sign.

9 —Cobalt—general sign.

10* —Lead —general sign.
10a — " —carbonate ores.
10b — " —galena ores.
10c — " —argentiferous ores.
10d — " —galena with silver and gold values.
10e — " —galena with copper, silver and gold values.

11* —Zinc —general sign.
11a — " —sulphuret ores (blende).
11b — " —oxidized ores.

12* —Tin—general sign.

13* —Iron—general sign.
13a — " —hematite ores.
13b — " —magnetite ores.
13c — " —limonite and other hydrated ores.
13d — " —carbonate ores.
13e — " —clay ironstone.

14* —Manganese —general sign.

14a — " —oxide ores.

14b — " —hydrated oxides.

14c — " —earthy ores.

---

* These signs have been extensively used and originated with the Alchemists.

15 —Arsenic—general sign.

16 —Antimony—general sign.

17 —Bismuth—general sign.

18 —Aluminium—general sign.

19 —Chromium—general sign.

20 —Tungsten—general sign.

21 —Molybdenum—general sign.

22 —Uranium—general sign.

23 —Tellurium—general sign.

24 —Zirconium—general sign.

THE NON-METALLIC CLASS.

Abrasive Materials Group.

1 —General sign.

2 —Grindstone, etc., quarries.

3 —Infusorial earth (Tripolite).

4 —Pumice stone.

5 —Emery and Corundum.

Mineral Pigment Group.

6 —General sign.

7 —Barite.

8 —Ochres.

9 —Unallotted.

NON - METALLIC

Mineral Fertilisers Group.

10 —Phosphatic (General sign.)

11 —Apatite.

12 —Nitrates.

Refractory Material Group.

13 —Asbestus.

14 —Actinolite.

15 —Talc.

16 —Unallotted.

17 —Soapstone.

18 —Potstone.

19 —Graphite.

20 —Mica.

Miscellaneous Group.
(non-metallic).

21 —Salt.

22 —Salt Springs.

23 —Mineral Springs.

24 —Lithographic Stone.

25 —Borax.

26 —Quartz.

27 —Gypsum (Plaster Quarries).

28 —Fluorite.

29 —Unallotted.

30 —Gems and Semi-Precious Stones.

31 —Sulphur ores (General sign).
31a —Sulphur (pyrites).
31b —Sulphur (native sulphur).
32 —Selenium.
33 —Bromine.
34 —Iodine.
35 —Unallotted.
36 —Strontium.
37 —Magnesium.
38 —Felspar.

CARBON CLASS.

Fuels Group.

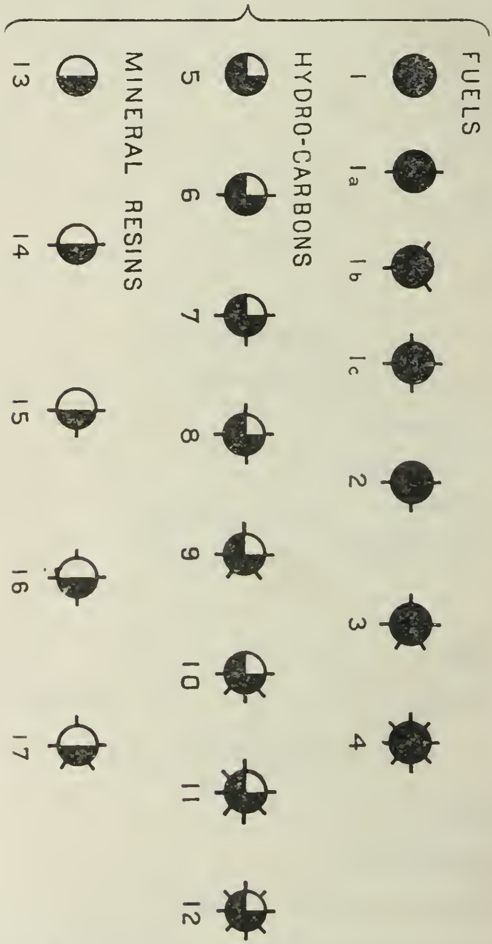
1 —Coal —general sign.
1a — " —bituminous.
1b — " —lignite.
1c — " —anthracite.
2 —Peat.
*3 —Petroleum.
*4 —Natural gas.

Hydrocarbon Group.

5 —General sign.
6 —Bituminous Shale.
7 —Asphaltum and varieties (hard).
8 —Albertite and relatives (Grahamite, Gilsonite, &c.)

* Petroleum and natural gas should more properly be classed with the hydrocarbons, (*i.e.*, mineralogically), but their economic affiliation is with the fuels.

CARBON GROUP



9 —Anthraxolite.

10 —Unallotted.

11 —Ozocerite, Elaterite and soft plastic varieties.

12 —Maltha.

Mineral Resins Group.

(Mostly oxygenated hydrocarbons)

13 —General sign.

14 —Tasmanite = Resiniferous Shale (See Bituminous shale above.)

15 —Unallotted.

16 —Unallotted.

17 —Succinite (Amber.)

STRUCTURAL MATERIAL CLASS.

* *Building Stones Group.*

1 —General sign for building stones (including ornamental stones and quarries of same).

2 —Sandstone, Quartzites, etc.

3 —Granite, Syenites, &c.

4 —Serpentine, &c.

5 —Slate.

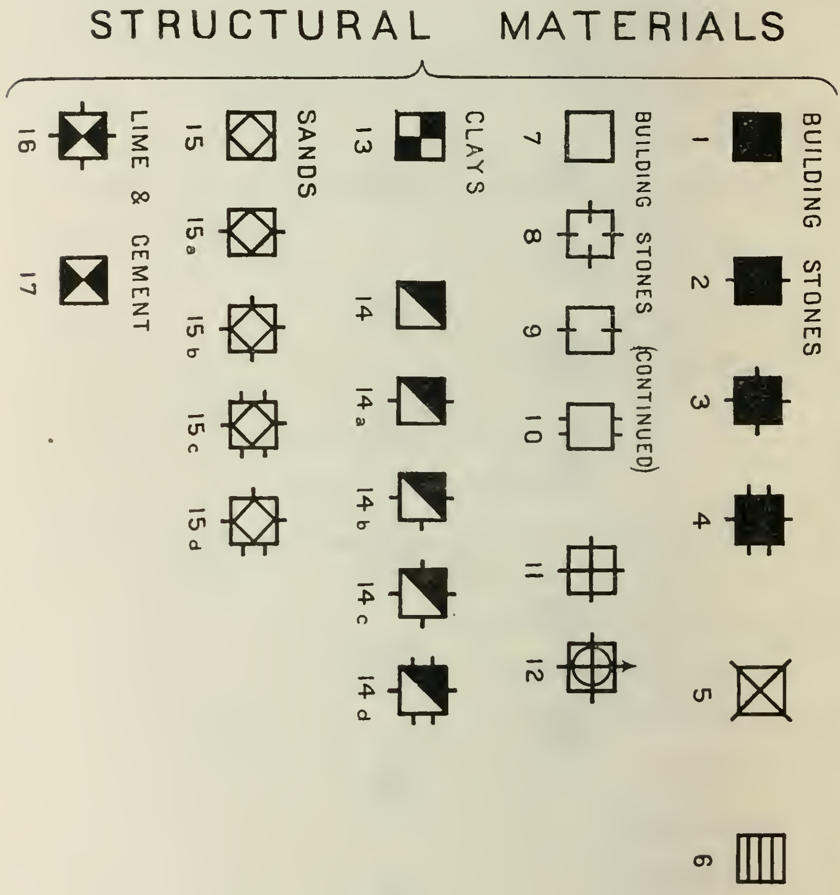
6 —Flagstones.

7 —Limestone.

8 —Marble.

9 —Chalk.

* It will be noted that the heavier building stones are shewn with solid squares, the lighter with hollow rectangles.


STRUCTURAL MATERIALS
BUILDING STONES
1
2
3
4
5
6
BUILDING STONES (CONTINUED)
7
8
9
10
11
12
CLAYS
13
14
14 a
14 b
14 c
14 d
SANDS
15
15 a
15 b
15 c
15 d
LIME & CEMENT
16
17

10 —Calc-Tufa.

11 —Dolomite.

12 —Ankerite

Clays Group.

13 —Marl.

14 —Clays —(general sign).
14a — " —brick.
14b — " —Terra-cotta.
14c — " —China (Kaolin).
14d — " —Fire.

Sands Group.

15 —Sands —(General sign).
15a — " —glass.
15b — " —moulding.
15c — " —unallotted.
15d — " —unallotted.

16 —Cement works and materials.

17 —Lime works and materials.

GEMS AND PRECIOUS STONES.

(Materials Applicable to Jewellery.)

In regard to sign No. 30 of the Miscellaneous Non-metallic class the triangle there shewn is the general sign covering all the gems and semi-precious stones adapted to the jewellers' art. This class comprises such a wide range of material that it would be impracticable to distinguish between the varieties by any modification of the general sign as elsewhere in the system. To meet this need a classified list of the chief gems and materials applicable to jewellery is given below. Each species has a capital letter.

The varieties are further distinguished by small letters. Thus by using the triangle sign and inserting the distinguishing capital and small letters in its centre the particular gem, &c., as well as the variety can be shown.

AA. Diamond

A. Corundum—(Al_2O_3).

a. Sapphire = Blue
b. Ruby = Red.
c. Amethyst = Purple.

B. Beryl—(BeO, Al_2O_3).

a. Emerald = Green.
b. Aquamarine = Pale-blue.
(Also yellow and white).

C. Chyrsoberyl—(BeO, SiO_2, $Al_2O_3SiO_2$).
(Different shades of green, yellowish green and white.)

D. Spinel—(MgO, Al_2O_3).

a. Spinel = Ruby-red.
b. Balas Ruby = Rose-red.
c. Rubicelle = Orange-red.
d. Almandine Ruby = Violet.
e. Sapphirine = Blue.
f. Pleonaste = Black.

E. Topaz—(Fluo-silicate of Al_2O_3).

F. Chrysolite—(MgO, FeO_2,SiO_2).

a. "Peridote" = Yellowish-green.

G. Tourmaline—(Silicate of Al + Fe, etc., with B_2O & F).

a. Peridot of Ceylon = Yellow.
b. Brazilian Emerald = Green.
c. Rubellite = Carmine.

d. Brazilian Sapphire	=	Light-blue.	
e. Indicolite	=	Indigo-blue.	

H. Zircon—(ZrO_2SiO_2)

a. Hyacinth	=	Transparent-red.
b. Jacinth		
c. Jargoon	=	Colourless and smoky

I. Idocrase—(or Vesuvianite)—$6(2RO, SiO_2)\ 2Al_2O_3SiO_2$.

J. *Garnet Group.*

a. Pyrope	= Deep Crimson	MgAl Garnet
b. Almandine		Fe Al Garnet
b.′ Precious Garnet	= Deep red.	
b.″ Melanite	= Black.	
c. Spessartite	= Deep Hyacinth or Brownish red	Mn Al Garnet
d. Essonite ("Cinnamon Stone")	= Light cinnamon brown to yellowish.	Ca Al Garnet
e. Grossularite	= Green	Ca Al Garnet
f. Ouvarovite	= Greenish-white	Ca Cr Garnet

Felspar Group—

K. Orthoclase—

a. "Sunstone."

b. "Moonstone."

c. Microcline.

d. Amazon Stone (green).

e. Perthite.

L. Albite—

a. "Moonstone."

b. Peristerite (with play of colours like Labradorite).

M. Oligoclase—
 a. "Sunstone."
 b. "Moonstone."

N. Labradorite.

O. Sodalite—(Silicate of Al + Na & Na Cl).

P. Lapis-Lazuli—(Silicate Al, Ca & Na with Fe & Na probably as sulphides).

Q. Quartz—(SiO_2).

 a. Rock crystal.
 b. Amethyst (purple).
 c. Rose quartz.
 d. Cairngorm (yellow to brown smoky).
 e. Cat's-eye.
 f. Aventurine (with spangles of mica)
 g. Chalcedony
 h. Carnelian or Sard
 i. Chrysoprase (green)
 j. Plasma (leek green speckled with white)
 k. Bloodstone (green with red specks)
 l. Prase (leek green, dull)
 m. Agates
 n. Onyx, Sardonyx
 o. Opal
 p. Jasper

(g.–p.: Hydrated SiO_2)

R. Thompsonite—(Hydrous Silicate of Al, Ca & Mg).

S. Wilsonite—(Hydrous Silicate of Al, Fe, K & Mg.

T. Chlorastrolite—(Hydrous Silicate Al & Ca).

V. Jade—(Silicate MgO & CaO).

SECONDARY MINING EDUCATION.

By H. H. Stoek, Editor *Mines and Minerals*, Scranton, Pa.

Paper read before the Canadian Mining Institute, Ottawa, March, 1908.

The title Secondary Mining Education means a less advanced form of training than is given to mining engineers, but it is a phase of education that is none the less important. The term is applied to the education of foremen and bosses in distinction to the training of engineers, just as the lower grades of the public schools are said to be secondary to the High School; it thus means simply a difference in degree and kind.

It is not necessary at this date to argue for the advisability and necessity of such secondary training. The recent activity along this line of mining education is but one phase of the very general movement for industrial education which has been so prominent in America during recent years. The coal mining population in the United States during the past 35 years has changed almost completely, and now the work at the face is very largely being done by men from South-eastern Europe, commonly known as Slavs, but including, Huns, Poles, Italians, etc. These men were mainly agriculturists in Europe and had no knowledge of mining prior to coming to America. Still, they are frequently put into the mines soon after landing, and even before they can speak English. Hence, there is a great need of an unusually intelligent grade of foremen and bosses.

When I promised the Secretary of this Institute several months ago to prepare a paper upon Secondary Mining Education I had in mind the rather ambitious project of attempting to give not only an account of the developments in the United States and Canada, but thought of giving such data as could be secured by correspondence from Europe, so as to compare the foreign progress with what we have done on our side of the Atlantic. Unexpected absence from the office has made it impossible for me to secure the desired data from the Continent of Europe. This will necessitate therefore a description of what has been done in Canada and the United States, based mainly upon personal observation and such fragmentary information from other countries as could be obtained in the time available.

The first legal necessity in the United States for secondary mining education was the passage in 1871 of the first general mine law for the anthracite mines of Pennsylvania. This law was enacted as a result of an accident at the Avondale shaft near Wilkes-Barre, by which 108 men were killed because of the absence of a second opening. This mine law provided for the appointment of mine inspectors based upon an examination. The law applied however, only to the anthracite region of Pennsylvania, and as there were only a few inspectors, no impetus was given to a general movement for mining education.

Mr. Eckley B. Coxe, who was foremost in working for the passage of a mine law and who was always looking toward higher things in connection with mining, was, also, so far as I can find out, the pioneer in secondary mining education in America as he was in so many other things looking to the betterment of mining conditions.

In 1879, Mr. Coxe in a presidential address before the American Institute of Mining Engineers outlined a plan for a night school for boys and men who had to work during the day. This was not intended as a competitor of the public schools, but to supplement them and was meant for those who could not attend the public schools. This school was established at Drifton, Pa., Mr. Coxe's home, May 7, 1879, being patterned after the German Steigerschule and has been in continuous operation ever since. The school was moved to Freeland, a larger town about one mile from Drifton, in 1893, and in 1903 an excellent building was erected for it. Classes in Elementary Mathematics, Physics, Chemistry, Mechanical Drawing, First Aid to the Injured and the Science of Mining have been carried on by a resident principal assisted by the engineers associated with the mining interests with which Mr. Coxe was connected. Since the death of Mr. Coxe and the absorption of his mining interests by the Lehigh Valley Coal Co., this school has been supported by his widow, and by other contributors. During its history not only have large numbers of young men, and older men as well, been prepared for the State examinations for mine inspector, mine foreman and assistant mine foreman, but quite a number of young men have received their preliminary training for entrance into technical institutions of higher grade, and a number of graduate engineers point back with pride to the Drifton school not only as their place of preparation, but also as having given them the incentive for obtaining a higher education along engineering lines. The courses have gradually developed until now there is not only the night school with elementary courses in Mining and Mechanical Engineering, but also a day college preparatory course. The tuition is 50c per month payable in advance. There is no age limit and no particular entrance preparation required, entrance depending largely upon the judgment of the principal.

Secondary mining education in the United States not only had its inception in the coal regions, but it has undoubtedly made greater development there than in connection with metalliferous mining, because certificated mine positions are now generally found in connection with coal mining in nearly all of our important coal mining states, while, so far as I know, there are no certificated positions in connection with metalliferous mining.

The greatest impetus to secondary technical education was undoubtedly the passage of a general mine law in Pennsylvania in the year 1885 by which it was provided that mine foremen, assistant mine foremen and fire bosses should pass an examination before being allowed to act in such positions. This law has served as the basis for similar laws that have since been passed in nearly all of the coal mining states of the United States. In some states hoisting engineers are also required to pass such an examination. The general nature of these examinations is similar to those held in Nova Scotia and in British Columbia for similar positions.

The means of preparation for such examinations as well as for the general and special education of the better class of miners and mine officials are the following:—

Short Courses in Mining Colleges,
Secondary Mining Schools,
Night Classes,
Lecture Courses,
Correspondence Courses,
Field Courses for prospectors,

Short Courses in Mining Colleges:—A number of mining schools have short courses varying in length from a few weeks to two years. The courses of only a few weeks in length are modeled after the short agricultural courses given by many institutions during the winter months, but the agricultural and mining conditions are by no means the same. The farmer has usually a slack period in the middle of the winter when he can easily leave home, but there is no such definite slack time in most mining sections.

The more extended courses usually include two years of resident work, the requirements for admission being merely an elementary knowledge of mathematics and English. The subjects taken up are usually Surveying, Mechanical Drawing, Elementary Physics, Chemistry and Mechanics and General Mining Principles. Some of the courses thus offered are well planned and some men have undoubtedly been benefited by these courses, but their value is limited, because so few of the men for whom they are designed have the time or the means to give up their daily work to carry on such courses, especially since the institutions offering them are frequently located outside the mining regions, thus rendering night classes and Saturday classes such as carried on in England impracticable.

The short course in mining established by the Ohio State University about 1881 or 1882 was one of the pioneer short courses, if not the earliest.

Secondary Mining Schools.—The only school of this kind which has thus far been tried out is that at Drifton, already described, and the results there obtained are certainly worthy of being copied by others. The only similar effort in a metalliferous region, of which the writer is aware, is the mining school at

Platteville, Wis., established by the last legislature of Wisconsin, and put in force January 1, 1908. This is known as The Wisconsin State Mining Trade School. It is under the control and management of a board of three members known as the Wisconsin Mining School Board, one of whom is the State Superintendent of Public Instruction, and the other two are required to be residents of the district in which the school is located. The course of instruction as provided by law is two years in length and embraces "Geology, Mineralogy, Chemistry, Assaying, Mining and Mine Surveying and such branches of practical and theoretical knowledge as will in the opinion of the Board conduce to the end of enabling students of said school to obtain a knowledge of the science, art and practice of mining and the application of machinery thereto." The course of study is under the general direction of the Dean of the College of Engineering of the University of Wisconsin, who acts, however, only in a consultive and not in an executive capacity. No fees are charged to students from the State of Wisconsin. The school is located in the zinc regions of Wisconsin and the intention of its founders was evidently to cater distinctly to the needs of this region. It is, however, contiguous to the coal regions of Illinois and Iowa and may draw from the coal mining industries of these States. Thus far there have been 12 day and 3 night students registered. As an experiment in secondary mining education, the progress and development of the school will be watched with much interest.

An effort made to incorporate such a school in connection with the Colorado School of Mines met with such opposition from the Alumni of that institution that the project was never put into force.

Night Classes.—In Nova Scotia a very systematic series of night classes is being carried on. This work has been thus described for the writer by Mr. F. H. Sexton, Director of the Department of Technical Education for Nova Scotia. "For purposes of instruction there are five colliery districts, and in each district there has been appointed the best man available as a teacher, the salaries being from $1,000 to $2,000 per year for eight months' work, the teacher devoting all of his time to this work. He holds classes for different localities in his territory almost altogether in the evening, but he sometimes has day classes for the men who are on night shift, providing a sufficient number apply for such instruction to warrant the forming of a class. The instructors must be practical men, possessed of a manager's certificate which is the highest grade attainable in Nova Scotia, and if possible shall have had teaching experience in the public schools." "We strive to carry on the classes on an educational basis and are not conducting them with a view of cramming the men to pass the examination. The examining boards are entirely separate and are not connected with the schools nor are they under the jurisdiction of the Director of Technical Education, so that there can be no charge of unfairness in setting the examinations so as to include a limited scope of questions based on a narrow field of instruction.

Quoting from the calendar of these schools:—"The coal mining schools are especially intended for coal miners and coal mining officials who wish to acquire a greater knowledge of the science and art of coal mining, and for those who wish to procure the Government certificates of competency for manager, underground manager or overman. The instruction is offered outside the working hours of the men, classes beginning at 7.30 p.m. No fees are charged.

"The engineering schools offer to ambitious men who operate the machinery around the different collieries a chance to possess themselves of a more complete grasp of the principles of steam and mechanical engineering and provide instruction for those who are working for first, second or third class certificates of competency as stationary engineers.

Preparatory classes in Arithmetic, English and Composition are held in each locality where coal mining or engineering schools are conducted whenever ten or more applicants apply for such a school to fit them for entrance into the technical classes.

The classes for overmen and underground managers include the following subjects:—

Modes of Working.—Sinking, Methods of Mining Coal, Supporting Excavations, Haulage, Pumping, Winding and Surface Arrangements.

Ventilation.—Theory, Practice, Lighting and Dealing with Gas.

Surveying.—General, Land Surveying, Mine Surveying.

The classes for managers include the following:—

Geology.—General and Structural.

Mechanics.—General, Properties of Steam, Steam Boilers, Steam Engines, Air Compressors and Hydraulics.

Mining Act.—Special Classes, Mechanical Drawing, Electricity, Steam Engineering.

General Information.—Steam Engines, Boilers, Pumps.

Night Classes in the United States are usually held under the auspices of such organizations as the Y.M.C.A., and the general character of this work is so well known that it does not need elaboration. In the mining regions many efforts have been made to give courses especially adapted to the needs of the miners and foremen, but there are no data available to show quantitative results while there is a wide variation in the qualitative results depending on local conditions.

The first systematic and distinctly mining work of this kind has been carried on in Pennsylvania recently by a special Y. M. C. A. Secretary for the coal mining regions, Mr. C. L. Fay. About two years ago an educational movement designed for coal mining men was undertaken by Mr. Fay which is substantially as follows. The bituminous coal fields of Pennsylvania have been divided into districts. In each district a district mining institute is held annually consisting usually of an afternoon session for the reading and discussion of papers. At six o'clock a supper and social session is held, followed by a number of after dinner addresses treating upon the specific work of the Y. M. C. A. Institute. An evening session is then held which may consist either of short papers and discussions similar to those held during the afternoon, or it may be devoted to more pretentious addresses on educational or mining matters by well known local men. Music is sometimes introduced, and a charge of $1.00 per man is levied to pay for the supper, printing, etc.

The purpose of these institutes is to arouse interest in mining education and the immediate result aimed at is the appointment of local committees to establish night classes in various centers throughout the region affected by the institute. These classes are taught by local mining engineers, superintendents, foremen or bosses, or other qualified teachers, and for text books they have the privilege of using the pamphlets of the International Correspondence Schools, although there is no other connection whatever between this institute movement and these schools. These classes meet weekly, and in addition to the regular class session, papers are read upon mining subjects. Local institutes are also held every 2 or 3 months. This movement has within the past few months been extended to the anthracite region of Pennsylvania, and the following statistics regarding the growth of it have been furnished by Mr. Fay.

Thus far twelve district institutes have been organized in the bituminous region of Pennsylvania and three in the anthracite region, while three more are in process of organization in the anthracite region. At the fifteen district institutes thus far held there has been an average attendance of over one hundred men at each. As an outgrowth from the district institutes five local institutes have been organized, meeting monthly, with an average attendance of forty. There have also been formed fourteen mining classes, meeting weekly, with an average attendance of twelve men. One institute has been formed in Ohio and a movement is on foot to extend the movement quite generally. A similar series of institutes has been formed at its mines in the Northwest by the Canadian Pacific Railroad.

Lecture Courses under the Auspices of Corporations.—The most comprehensive movement of this kind is a series of lectures inaugurated by the Philadelphia & Reading Coal Co. about three years ago. Six centers are chosen at central points throughout the region mainly controlled by the Philadelphia & Reading Coal and Iron Co. and one lecture each week is given in each of these centers. The same lecturer goes from place to place and gives his lecture each night in a different place, and of course, to a different audience. The attendance is made up mainly of superintendents, foremen, bosses and the better grade of miners, and while not compulsory, it is very generally known that men are expected to attend whenever possible. In this way, a lecturer reaches an audience of at least one thousand men each week. Many of the lectures are illustrated with the stereopticon and the schedule of subjects includes practical topics such as the following: Treatment of Mine Timber; the Care and Management of Colliery Machinery; the Mine Mule; the Generation of Electricity; Mine Pumps.

The lecturers have been college teachers, outside specialists and the engineers connected with the company. The aim of these lectures has been not so much the fitting the men to pass an examination as to give them a general knowledge of mining, and to make them better employees.

A number of the other anthracite mining companies have held occasional lectures upon such subjects as Explosives, but none has taken up the matter systematically, as has the Philadelphia & Reading, excepting along the line of drilling and training first aid to the injured corps.

A number of the companies have taken up this rescue or first aid work and the success attending it should lead to more systematic work along general educational lines by the same corporations. Other corporations throughout the country have no doubt carried on similar work, but there is no record of it so far as I know.

Correspondence Instruction.—The passage of the Pennsylvania mine law of 1885 not only created a general demand for secondary mining education in the United States, but this law was also the cause of the beginning of technical instruction by correspondence in America. Mr. T. J. Foster, who had for some years prior to 1885 been editor of the *Mining Herald* in Shenandoah, Pa., was very active in having an educational requirement incorporated into the law of 1885. In the *Mining Herald* he had for years printed technical articles upon mining by such well known engineers as Mr. C. M. Percy of England, and others. These articles were intended to assist the ambitious and studious men about the mines, and after the passage of the law of 1885 they were especially designed for those wishing to fit themselves to pass the State examinations. In 1887 the *Mining Herald* which had been previously a weekly newspaper with a technical mining department was changed to the *Colliery Engineer*, a distinctly technical mining publication, and in 1888 the headquarters were moved to Scranton, Pa. Men preparing themselves for State examinations were urged to ask questions or to answer such questions as were asked by others upon subjects pertaining to mining, the questions and answers being published each month in the *Colliery Engineer.* This feature of the paper immediately became so popular that it was apparent that this medium alone could not supply the instruction and assistance needed in connection with the State mining examinations. Consequently, in August, 1891, the *Colliery Engineer* Company began the preparation of leaflets for the use of men studying to pass the examinations for foreman, assistant foreman and fire boss. The subjects of these leaflets were Mine Surveying, Mine Gases, Ventilation, Mining Methods, Mine Machinery, etc. Since October 16, 1891, when the first student enrolled in mining by correspondence, over 35,000 persons have taken up correspondence mining courses in the International Correspondence Schools alone. These men are about equally divided between coal and ore mining and are scattered through every country in the world, large numbers especially being found in South Africa, Australia and the other English colonies.

As to the results of correspondence instruction, the writer does not wish to give a personal opinion, but will quote from others. In connection with a paper upon "The Value of Correspondence Instruction to the Mining Man", read before the American Mining Congress held in Joplin, Mo., November, 1907, over one hundred letters were sent to prominent mining men throughout the United States and Canada asking for answers to certain questions submitted to them. Two of these questions, especially applicable to the present discussion, were as follows:—

(1). What is your opinion of the value of correspondence instruction to others with whom you have come in contact as regards their efficiency about the mines?

(2). In the State examinations, how do students of mining by correspondence compare with other applicants who have not taken correspondence courses?

It is difficult to tabulate answers received to question (1) since the opinions are expressed in such different terms. Fifteen answered simply that they have the highest opinion of such instruction. A large number of others say that men who have taken such courses are more reliable, have more fixety of purpose, are more ambitious, take a greater interest in the affairs of the company, give their superiors less trouble, are up to date in their methods, and that men with such instruction are much above the average of their fellow workmen. One Chief of Department of Mines writes: "It has brought about greater efficiency among mine managers, it brings young men to the front who would otherwise remain working at the face, and enables the older men to keep up with the times and with the advancement in mining life."

The replies to question (2) stated without exception that students of mining by correspondence lead those who had prepared by themselves for such examinations, and that they give better answers and show greater reasoning power. A member of an examining board from British Columbia states that correspondence students stand foremost in the examinations in that section.

Correspondence instruction offers a successful means of obtaining a technical knowledge of mining to many men who have no other way of obtaining such a knowledge. It has been tried out successfully in America, in England, in South Africa, and in Australia under varying conditions and must be considered henceforth in connection with any general educational scheme.

SUMMER SCHOOLS FOR PROSPECTORS.

So far as the writer has been able to ascertain, the only attempt made in America to provide for the prospector field instruction by a teacher has been carried on first by the Kingston School of Mining and Agriculture, of Kingston, Ontario, and later by the government of Ontario, Canada. In 1890 the Government of Ontario appointed a Royal Commission on the Mineral Resources of Ontario. In the report of this commission, published about 1893, there appears the following recommendation:—

"In order that the mineral resources of the province may be successfully and economically developed it is desirable that measures should be taken for the practical and scientific training of all who may engage in the industry. Prospectors and explorers are found to be very deficient in the kind of information which would enable them to prosecute their arduous labors to the best advantage; and your commissioners recommend for that purpose the adoption of a scheme such as has been tried with gratifying results in the colony of New Zealand, and fully explained in Appendix L."

The work was first taken up by the Kingston School of Mining, and the following quotation from the first annual report of that school, submitted April 18, 1894, is of interest.

"Some explanation is called for concerning the Special Classes and Courses alluded to.

"The Governors felt that in the circumstances of the Province, it was well to consider not only the few who aim at taking the complete course that leads to the degree of Mining Engineer, but also the many practical miners scattered over the country, who desire to learn something more than they have gained by hard experience of the industry to which they have devoted their life-work. They therefore (1) advertised a special eight weeks, course, to begin on January 9th of this year, for mine foremen, assayers, prospectors and mining men generally, and on the day named a class of seven men presented themselves to begin work. The number may seem small, but the school is only beginning, and is therefore not widely known yet, but the success of the course has been so marked that the governors are well satisfied with it, and they confidently anticipate a much larger class next year. The satisfaction of the men themselves may be judged from the responses made by them at a public meeting held in the school, at which certificates of attendance were presented to them, with expressions of approval on the part of the faculty of their great diligence and intelligence and their assiduity in studying daily from morning to night. (2) In the next place, learning that there were men who wished to gain some knowledge of minerals and mining, but who could not attend during the day, lectures were given at night, illustrated by experiments, diagrams and specimens. Twenty-three registered in this class. (3) In the next place, it was felt that in some way the school should be taken to mining men unable to come to the school. As the result of a visit to Marmora and a lecture by a member of the staff, a requisition was sent in to the Bursar, signed by seventeen, who agreed to pay $4.00 each for a fortnight's course of practical instruction. This petition was granted, and the class at Marmora proved a decided success. Persons interested in mining, resident in Sudbury, are endeavouring to form a similar class there. This experiment has had a large measure of success in New Zealand, and it was recommended to the Legislature in the report of the Royal Commission appointed in 1890 by the Government of Ontario."

The course consisted in:

(1) Enough chemistry (with experiments) to make the class understand what a mineral is, and to be able to calculate the metallic contents of ores from their formulæ.

(2) Enough mineralogy to enable the class to recognize the more common minerals by simple tests, and also to understand how to look up minerals in a mineralogical work and the usual system of classification.

(3) Enough geology to enable the prospector to know how rocks are formed and the names and composition of those usually met with.

(4) The class then were given lectures on the common ores and the rocks with which they are associated, so far as the subject could be illustrated by specimens.

(5) Finally, prospecting and boring were the concluding subjects of the course.

Blowpipe was given every morning from 9 to 11, or more often until near 12 o'clock. Great interest was taken in blowpiping, and before concluding the class understood the tests for the commoner elements, and was able to do cupellation of gold or silver by the blowpipe.

The afternoon was occupied by a lecture from 4 to 6, and on some days between 1 and 4 o'clock the class had practical work in examining the ore heaps at the reduction works, crushing and panning ore, and short trips to investigate the geological formation of the district and the occurrence of ore bodies in connection therewith. One longer excursion was taken to see the veins and works of the Consolidated Gold Mining Company, and tests of the veins at some places were made by panning. The class collected many samples of ore, vein-matter and rocks.

One day was occupied by instruction in assaying gold and silver ores, both by the crucible and by scorification.

The lectures were illustrated by about 500 geological and mineralogical specimens, including ores with accompanying rocks.

A good many colored diagrams were also used and greatly assisted the student.

The Legislature of Ontario in 1894 appropriated $2,000 to organize summer mining schools in the northern districts of the province, and the work was entrusted to the faculty of the School of Practical Science of Toronto. Accordingly, in the summer of 1894 the Principal of the school inaugurated the work at Sudbury and Copper Cliff, the public school house being used at Sudbury, and the band room at Copper Cliff. The classes were held in Sudbury on Monday, Wednesday and Friday at seven o'clock p.m. At copper Cliff classes were held on Tuesday, Thursday and Saturday, and, since two shifts were worked, two classes per day were held at 3.30 and at 7.00 p.m. respectively. These first classes continued from July 9th to August 16th, and from August 20th to Sept. 21st classes were held at Rat Portage on Tuesday, Wednesday, Thursday and Friday evenings at 7.00 p.m. Text-books were used at first and until the classes obtained a fair idea of the subjects taken up, when certain books were recommended for those who seemed to advance still further. Instruction was given by lectures, and where blackboards were not available, large sheets of blank paper and colored chalk were employed. The course of instruction included:

Mining Geology.

Ore Deposits.

Mineralogy, including practical blowpiping and the identification of minerals.

Lithology, with special reference to the rocks of the region.

Lectures were also given in Elementary Chemistry bearing upon the other subjects in the course.

No fee was charged, but $2.50 was charged for a blow piping outfit, which then became the property of the student. The time was divided so that one-half of each meeting was devoted to practical work and the other half to lectures. Special stress was laid on the value of field tests, and the lectures throughout were illustrated as far as possible with Canadian minerals. The Sudbury class contained 8, the Copper Cliff class 19, and the Rat Portage class 24. In addition to these regular attendants many others attended occasional classes.

A detailed account of the instruction under the various head-ings given above can be found in the Fourth Annual Report of the Bureau of Mines of Ontario for 1894, page 218.

At various times during the early years the instruction was jointly under the School of Applied Sciences in Toronto and the Kingston School of Mines, but since 1902 it has been mainly in charge of Dr. W. L. Goodwin, President of the Kingston School of Mining. In his report in 1899, Dr. Goodwin said: "There can be no doubt that these outside mining classes are serving at least two purposes, first, to call attention to minerals in general, and the valuable minerals in particular, and secondly, to give professional and occasional prospectors correct ideas as to how to find out the value of a discovery."

The identification of mineral specimens has always formed the ground work of the instruction in these summer schools. As carried on at present, forty mineral specimens are furnished to each student, and an effort is made to familiarize him with the macroscopic determination of these minerals. From ten days to two weeks is devoted to each camp. In his report for 1904, Dr. Goodwin says: "It is evident that summer schools succeed better in the more isolated camps of moderate size than they do in most places which have grown to the dimensions of villages or towns. In the smaller camps the men live together and move as one body. In the larger camps they are more or less scattered, and it is hard to get them to assemble after a day's work." In 1905 Dr. Goodwin reports that about 550 received instruction in summer classes, nearly all of whom received sets of forty specimens each. In connection with the work additional sets of minerals were distributed to many who had heard of the work, but who could not attend the classes. During 1906, 930 received instruction, and about 30,000 mineral specimens were distributed. In his report for 1907, Dr. Goodwin says: "Now that the high schools have taken up the study of Geology and Mineralogy, it becomes necessary to consider whether the summer mining classes may not be discontinued in the near future, or their character be changed so as to convert them into summer schools of Applied Mineralogy and Geology, held in some mining centre or centres during the months of July and August, so that they might be attended by teachers. The older prospectors and miners of the province have been pretty generally reached during the twelve years since the classes were started. It may be urged that very few prospectors and miners ever reach the high schools. For this reason and on account of the great importance of the subject, some steps might be taken to put a practical acquaintance with the elements of mineralogy and geology within the reach of every boy in Ontario. There are boys in every county who take to such studies naturally and eagerly. It is not necessary to make such subjects a necessary part of the curriculum required for high school entrance. An enterprising teacher in a country or village school will find time and energy to lead a willing lad through a simple course of observation and testing, if the specimens and a good book are available."

Secondary Mining Education in England.—The conditions in England are somewhat different from those in the United States since mine foremen or overmen are not required to pass a government examination, although mine managers are. The managers are responsible for the control, management and direction of the mines, and in the absence of the manager the under-manager has the same responsibilities and is subject to the same liabilities as the manager.

In response to a letter of inquiry addressed to the late M. Walton Brown, Secretary of the Institution of Mining Engineers, asking for information upon secondary education in Great Britain, Mr. Brown wrote as follows:—

"The education of managers and under-managers respectively, who hold first and second-class certificates, is supplied (1) by attendance at universities, mining colleges and schools, (2) by night classes provided by the universities, mining colleges or schools, or by the county councils who have a well worked out system of county lectures; (3) by correspondence; and (4) by home study without outside assistance. In addition, the county councils and many of the large mining companies inaugurate courses of lectures on first aid to the injured, and a smaller number facilitate education by classes in mining and engineering subjects."

It will thus be seen that with the exception of the lectures carried out by the county councils in England, the same methods prevail there as in the United States. The evening courses at the Wigan Mining and Technical College are probably representative of the general evening method. These include three exercises per week of two to two and one-half hours each from seven to nine o'clock, one subject being considered each evening. The course for the four years includes the following subjects:—

First year, Mining Mathematics, Mining Drawing, Coal Mining. Fee 1s. 6d.

Second year, Mining Mathematics, Mining Physics and Chemistry, Coal Mining. Fee 12s. 6d.

Third year, Mining Mechanics, Mine Surveying, Coal Mining. Fee 15s.

Fourth year, Mining Electricity, Geology, Coal Mining, including laboratory. Fee 15s.

In addition an ambulance class for mining students meets on Saturdays at 6.30 p.m. The fee for a course of ten lessons is 2s. 6d.

As an example of Saturday lecture courses, those carried on by Armstrong College, Newcastle-upon-Tyne are probably representative. This course extends over three winter sessions and involves attendance for about twenty-four Saturday afternoons from three to five o'clock or from four to six. Each series is as far as possible independent of the others so that the student may enter any of the courses. The fee for the series of four courses given each session is £1 10s. It is desirable that the students be not less than 17 years of age, and students entering the course must possess a knowledge of Arithmetic, Algebra and Mensuration. Colliery owners very frequently pay the fees and the train fares for some of their employees attending these lectures. The subjects are arranged as follows:—

Term beginning:—		Time
Oct. 5th, 1907—	Steam Engines,	3–3.50
	Theoretical Electricity.	4.5–4.55
Jan., 1908—	Electrical Engineering,	4–4.55
	Haulage & Winding.	5.10–6 p.m.
Oct., 1908—	Transmission of Power,	
	Pumps & Ventilation.	
Jan., 1909—	Metallurgy of Iron & Steel,	
	Mining Machinery.	
Oct., 1909—	Machine Drawing,	
	Chemistry of Fuels.	
Jan., 1910—	Strength of Materials,	
	Experimental Mechanics.	

DISCUSSION.

MR. THOMAS W. GIBSON (Deputy Minister of Mines, Ontario):—I would like to say that some effort has already been made in Ontario in the direction of Secondary Education. In the summer season, the Ontario Department of Mines has been sending to the mining camps instructors who hold classes among prospectors and miners and who give instruction in elementary geology and chemistry, especially in the practical work of mineral determination. The instructors deliver lectures occasionally at the villages and towns and in the mining camps, but their main work is to instruct classes of miners and prospectors. The instruction is continued for a week or ten days at a time in particular centres, and has been found to be of considerable value in giving the miners and prospectors a more systematic and intelligent idea of the minerals in which they are interested. The work has been going on for some ten or twelve years, and I think it has been successful.

DR. PORTER:—One point made by Mr. Stoek, is of such great importance that it seems to me it should be accentuated if possible. He spoke of the change in the attitude of the labouring class in Pennsylvania particularly; but what he said applies to the whole mining industry of North America. I doubt whether many of us have realized, as clearly as does evidently Mr. Stoek the importance of educating our foremen and other subordinate mine officers in order to make them more efficient for their work. It seems to me this work of secondary education is of almost equal importance to what may be called higher education. Mr. Stoek has pointed out that several attempts have been made to carry on both higher and secondary education in certain of the higher seats of learning. It is a most worthy aim, but, as one professionally engaged in the higher education of mining, I can see very great difficulty in doing two such different classes of work well. Therefore, while we should strive to do what we can, I imagine the best work can be done by organizations such as that of the Reading Railway System and by the correspondence schools to which Mr. Stoek has referred. I should like him to give us as full information on this subject as he can, because it is quite as important to Canada as it is to the United States. We are only a little way behind the United States in our difficulties. In the course of a few years we shall have here the same class of people, and a discussion of the methods adopted in the United States and of the methods which have been attempted abroad must necessarily be of interest to Canadians. As Mr. Stoek is no doubt better informed on this question than the rest of us, I would ask him whether he would not try to apply the same method of education to metal mining. It is a common idea that any one can do metal mining, and that it is only in coal mining that the special education of foremen is necessary. Of course, owing to the great danger of gas in coal mining, the State first insists upon an educational standard in colliery foremen. But it would be a good thing if a standard should also be established for metal mining. I believe it would be for the benefit of the industry. I am sure the Institute is grateful to Mr. Stoek for the manner in which he has treated this subject.

MR. J. C. MURRAY:—There are several very important movements in this direction about maturing now. Mr. Stoek referred to the development of technical education in Nova Scotia, and Dr. Porter himself is identified with a very important movement in British Columbia. The University Bill has received its second reading in the B. C. Legislature, and apparently a provincial university there will become an accomplished fact. I would like to hear from Dr. Porter as to what the immediate probabilities are in British Columbia. We have also Dr. Woodman here, who has been identified with technical education in Nova Scotia, and possibly both of these gentlemen could give us information on this point.

DR. PORTER:—I am afraid I have nothing to say with regard to the proposals in British Columbia. Certain members of the Government of British Columbia have done me the honour to consult me to a certain extent with regard to the extension of technical education. The Government now has a bill before the Legislature of British Columbia, but as it has not yet passed, I do not think it would be proper to discuss its provisions, still less to attempt to say what the bill will accomplish. My connection with this matter in British Columbia is almost a fortuitous one. For many years I have been engaged not only in university teaching, but also in a certain sort of field teaching, and on several occasions I have taken field classes into the British Columbia mining districts. The authorities in that province happened to light on me as someone whose advice might be of value, but I am not authorized to speak for the British Columbia Government or Educational Department. There is no doubt, however, that they are in earnest and that they are beginning a work which will have far-reaching consequences.

MR. DONNELLY (Kingston):—Queen's College, Kingston, was the first college in Canada to institute a system of education along these lines. In 1895 they commenced a course for prospectors and I happened to be a member of the first class. We had four, teen members, some of whom came from South America and California, and we got a course in chemistry, geology, mineralogy and assaying. I never saw more earnest men than there were in that class. The university gave that course for several years with great benefit to prospectors and mining men, but the classes became so large that, notwithstanding the increased building accommodation, the college had to cancel them. I have met a number of men who have obtained their knowledge of mining in this manner, and it has done a great deal for those who, either because they have not the means or have not the educational foundation necessary, have been prevented from taking a college course. In a number of cases, however, those who came for only a prospector's course changed their minds and took a full course and obtained their degrees.

DR. J. E. WOODMAN (Dalhousie College), Nova Scotia:—I have no authority to speak regarding the system of technical education in Nova Scotia; but, doubtless, many of you know that for many years the Nova Scotia Mines Department has carried on night schools in colliery centers, for candidates for the positions of overman and underground manager. There was never a sufficient teaching force or students' body to admit of steady classes for the position of colliery manager, and the candidates always studied individually with successful managers. The system had many drawbacks, but may have been the best possible at the time.

The first attempt at collegiate instruction seems to have been in 1902, when Dalhousie University formed the basis for a modest mining school, which soon expanded to include civil engineering. This was good and thorough as far as it went; but it was soon found that the province was not in a position to support a technical school by private subscription. Hence, a year or two ago, the local government took up the question with a view to forming a complete system of its own. As now planned, this system includes a two-year collegiate course in mining, civil, mechanical and electrical engineering and two varieties of secondary schools. The former has a curriculum covering the last two years of training, other colleges furnishing the non-professional first two years. The secondary system consists, first, of a series of trade schools in industrial centers, and second, a reorganization of the old miners' night schools in colliery towns. Both these appear to be making satisfactory progress. The college has of necessity not yet started, but may do so in a small way within a year. The chief defect in the system at present appears to consist in the lack of continuity between the various types of secondary schools and the college. For the miner, who is often a man of family and always dependent upon his daily wage, cannot afford two years away from work to attend one of the several provincial colleges. This defect, however, may be remedied when the whole system gets into working order.

STUDENTS' PAPERS

THE "WHITE BEAR MINE," ROSSLAND, B.C.*

By H. H. Yuill, McGill University, Montreal.

The "White Bear Claim" adjoins the "Black Bear Claim" of the Le Roi grant to the west, and covers the locality through which the westerly extension of the Le Roi and Black Bear veins should pass if these veins preserved their general course in this direction.

There has been a considerable amount of exploratory work done in trying to find the extensions of these veins. In 1902, when the present management took charge, a shaft had been sunk to 350 ft., and an aggregate of 1,000 ft. of cross-cutting done on the 150, 200 and 350 ft. levels. These workings were all in a formation in which none of the pay veins of the camp had been found, and, as no ore had been encountered, the company decided to sink the shaft deeper. At 420 ft. they passed out of the overlying formation, which is an overflow of altered basic volcanic rock, into the porphyrite formation in which the pay ores of the camp occur. A station was cut at 680 feet, called the 700 ft. station, and cross-cuts were run easterly and westerly from the shaft.

In the westerly cross-cut a low grade vein was found, which was called the "West Vein." It has a northwesterly and south-easterly course or strike. This "West" vein belongs to the second system of veins found in the Rossland Camp, that is, it is part of a different system from that to which the Le Roi, Black Bear veins belong, as the latter have a general south-westerly and north-easterly strike, practically at right angles to the West Vein. The strike of the West Vein corresponds very closely to that of the vein encountered in the Evening and Giant Claims. It may be the south-easterly extension of one of these.

In the easterly cross-cut three veins were encountered. No. 1 and No. 2 were small and of low grade ore. No. 3 was a large vein of low grade ore with a few streaks of higher grade

*Paper entered for the "Student Members' Competition, 1908," and awarded First Prize and President's Gold Medal.

ore in it. These veins have the same general strike as the West Vein, and undoubtedly belong to the same system, although a contrary opinion was held by the consulting engineer of the company at the time of the discovery of these veins, Nov., 1902. The following extract from his report will be of interest in this connection:

"At this time there are in round figures about twelve hun-"dred linear feet of workings on the 700 ft. level. These work-"ings have run through and exposed large bodies of low grade "ore in which streaks of higher grade ore were occasionally "encountered. From a study of the work done on this level I "have reached the conclusion that it is a wide fissure zone, pro-"bably 250 feet in width, running through the 'White Bear "Claim' in the gabbro formation, occupying the position that "the westerly extension of the Le Roi and Black Bear veins "should.

"It is possible that this wide fissure is the junction or union "of these two veins mentioned, in their westerly continuation, "and that in the interstices of the broken rock filling this fissure "zone has been deposited making the mass, taken as a whole, "a very low grade ore body. Streaks and bunches of high grade "ore here and there through the low grade mass have not been "found of sufficient size to be extracted by themselves.

"If this view of the behavior of the Black Bear and Le "Roi veins within the White Bear Mine be correct, it is pro-"bable that the values disseminated through the wide zone "developed on the 700 ft. level will become concentrated within "narrower limits at greater depths and make into bodies of "paying ore.

"The behaviour of the ore shoots in other veins in this camp "shows that they generally scatter through the country rock "as they approach the surface. This fact tends to strengthen "the opinion that the values may be concentrated at a greater "depth in the White Bear."

The management, acting on this report, sunk the shaft to 900 ft., cut stations at 800 ft. and 950 ft., and ran cross-cuts easterly and westerly as on the 700 ft. level. (See map.) They developed the West Vein, but, finding it to be very low grade, directed all their energies to locating the ore bodies east of the

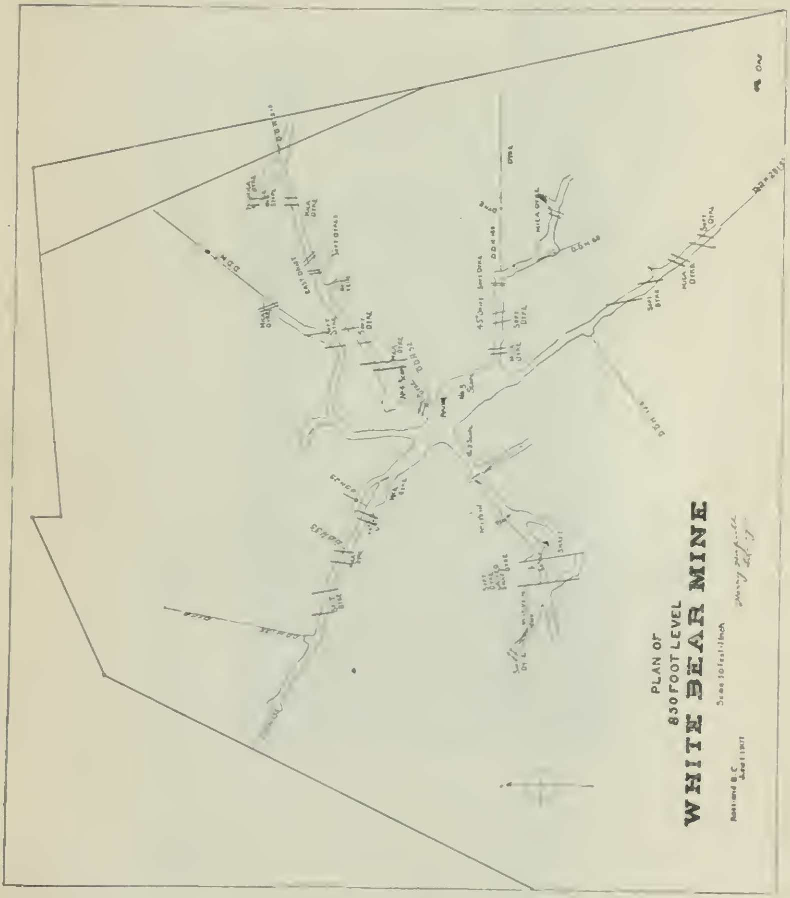


Plate I.

ORE POCKETS

WHITE BEAR MINE

Scale 8' = 1"

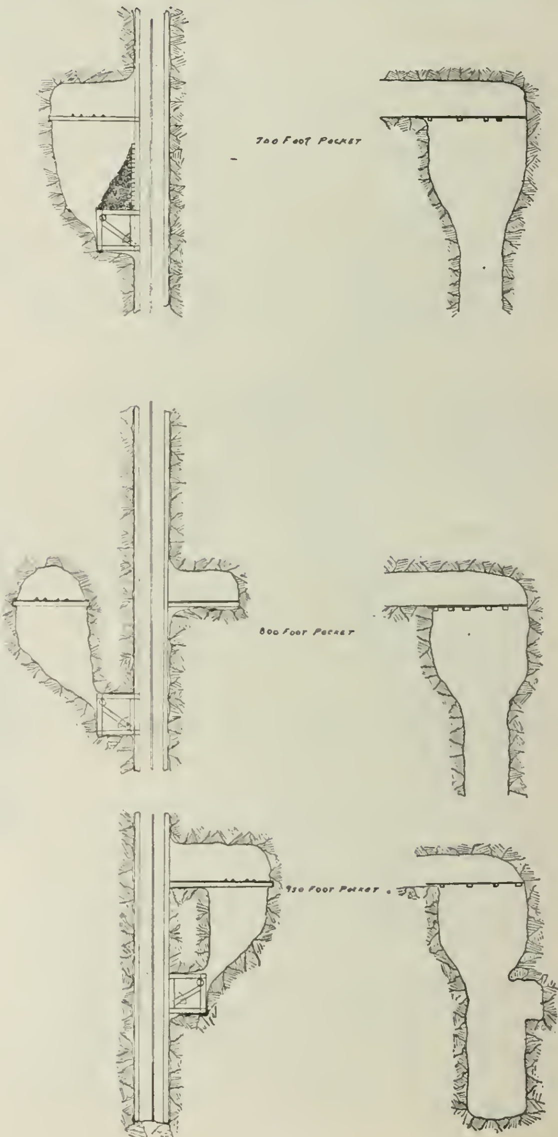


Plate II.

Rossland, Central Transformer Station
60,000 V.—20,000 V.

shaft. The veins of the 700 ft. level were found to continue to the 800 and two of them to the 950 ft. level, but No. 3 was not located on the 950 ft. level. Therefore, the management raised to the 800 ft. level from where they thought ore should be if it were continuous and in place. At 900 ft. they struck ore and ran a drift. The highest grade ore in the mine has been taken from this intermediate level.

The greater part of the work done prior to the summer of 1907 had been development work, consisting mainly in cross-cutting and diamond drilling, but as the surveys and maps were not kept up to date, it was perhaps not as effective as it might have been. This summer, after the maps had been made complete, it was seen that the old workings did not open up the locality on the 950 ft. level, through which the No. 3 vein should pass. A couple of machines were then put to work on the 950 ft. level, and after driving about 35 ft. the ore body was located (Aug. 1).

This ore is as high grade as that in the intermediate. I think this incident demonstrates the advantage of prompt surveying and mapping. The cost of the raise might have been saved and the time could have been utilized in stoping the ore, which would not only have paid for itself but would also have helped to defray the expense of some further development work.

The ore consists of country rock more or less impregnated by pyrrhotite, accompanied in places by small proportions of chalcopyrite, pyrite, arsenopyrite and quartz. The pyrrhotite when it occurs by itself, even in solid masses, as it does on the 700 ft. level, carries but little gold. The chalcopyrite is the principal carrier of gold, and ore of commercial value occurs only in those localities where chalcopyrite and pyrite, sometimes with arsenopyrite, have been deposited with the pyrrhotite. In certain parts of the mine the ore carries some lime which slacks when exposed to the air.

As is the case in all the other mines of the camp, innumerable shattered zones and dykes are encountered, often accompanied by faults, which in some cases cut the ore off. Frequently, however, the ore continues right through the dykes. Two kinds of dykes are found: 1st—The hard mica dykes which are mica lamprophyres, *i.e.*, basic dykes in which mica is the conspicuous mineral. 2nd—The soft or black dykes, which are so greatly altered and decomposed that their identification is difficult. Possibly they are mica dykes which have decomposed to chlorite, but if so they are barely recognisable as such. The dykes are all mapped by the following method. Tracings are taken of each level from the mine map, and the dykes, faults and ore bodies are accurately plotted on their respective tracings, as encountered on each level by drifting, stoping or diamond drilling. Then, by placing any tracing over that of the level below the relative positions of the dykes, etc., may be ascertained. These so-called "Structural Maps" are found to be indispensable, and in ground of this character should always be kept up to date. (See Structural Plan of 850 level, Plate I.)

The rock is firm, and timbering does not have to be resorted to, except in drifts where fissure zones are encountered and in stopes where, whatever the strength of the ground, timbering is of convenience in mining. When an ore shoot is located, the sill floor is excavated and square sets are put in if the shoot is more than 15 feet wide; if 15 feet wide or less, stulls are used instead of square sets. Until recently the timbering was advanced stage by stage as the stoping progressed. However, the following method has been found to be cheaper and no less satisfactory. One floor only is timbered to allow for trams and chutes and to hold up the broken ore. The stoping is done from the top of the broken ore, enough being drawn to keep it a convenient distance from the backs. The ore is run from the chutes into mine cars, which are trammed by hand to the station where they are loaded on to the cage and hoisted. The management are now cutting ore pockets at the stations and propose to install a skip as soon as the ore pockets are ready. (For plans and elevations of these pockets see Plate II.)

The shaft was sunk vertically in a large soft dyke, called the shaft dyke, and is well timbered. It is 5′ x 8′ clear of the timbers, giving two compartments; one 4′ x 5′ for the cage, the other 4′ x 2′ in which the manway, air pipes, water pipes, electric wires and ladders have all been crowded. The timber, which is 10′ x 10′, is well preserved by the water, which is constantly running down the sides. This shaft is the only means of entry or exit to the mine, and, as a consequence, the number

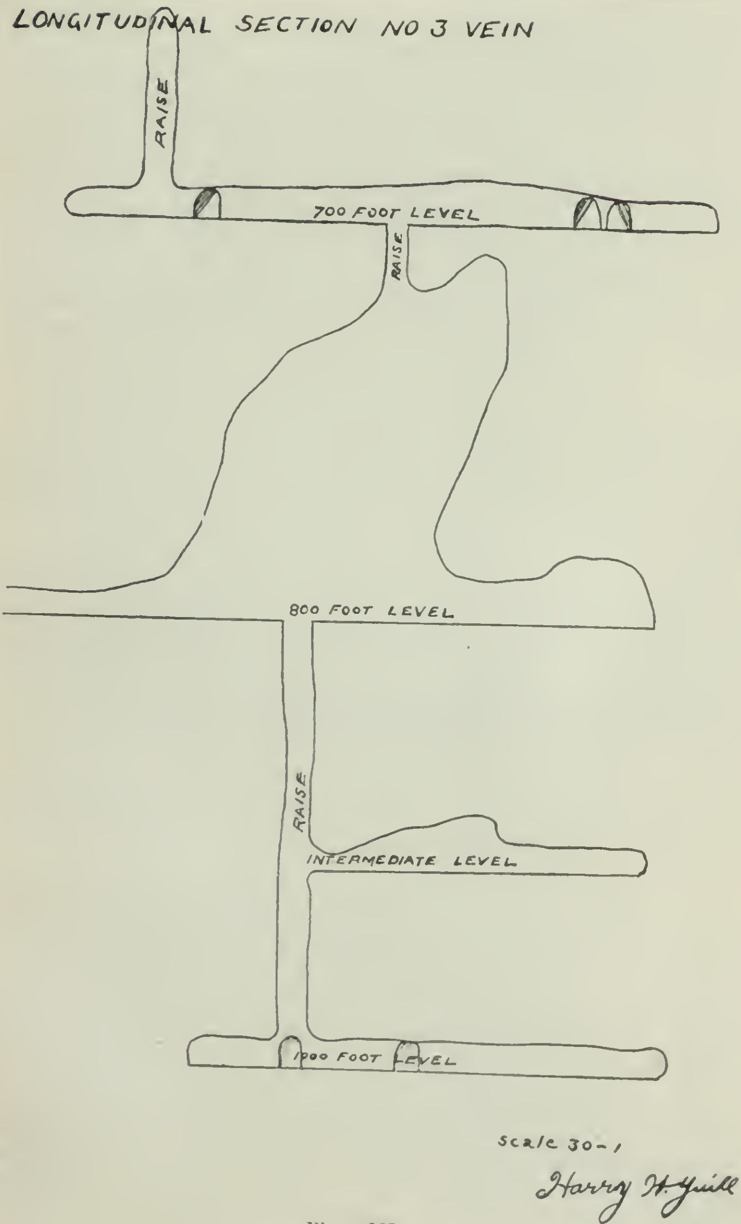

LONGITUDINAL SECTION NO 3 VEIN
RAISE
700 FOOT LEVEL
RAISE
800 FOOT LEVEL
RAISE
INTERMEDIATE LEVEL
1000 FOOT LEVEL
Scale 30-1
Harry H. Yuill

Plate III.

of men the company may work underground is restricted by regulations in the Mining Laws of British Columbia.

The management have decided either to make a connection with the Le Roi workings on the Black Bear claim or to make an upraise to the surface from some point in the workings. The cost would be about the same for either. It would take about 1,000 ft. of drifting from working No. 6 of the 850 ft. level (see Plate I) to connect with the Le Roi. The 1,050 ft. level in the Le Roi corresponds roughly with the 800 ft. level in the White Bear mine. The chief difficulty in making this connection would be the surveying. The surveyor would have to carry his bearing for over 3,000 feet from a base line of not more than 2—2½ ft. in length. This would render a connection with a drift in the Le Roi ground rather uncertain to say the least. Therefore, if this connection is attempted the drive will be aimed for one of the large stopes. This, although it would entail about 500 feet more work, would make the connection reasonably sure if the surveys of the two mines were properly connected.

The mine is equipped with five "Sullivan" 3⅝″ air drills, each weighing 380 lbs., one Rand 3½″, weighing 360 lbs., one Rand 3¼″, and one Sullivan 2″. The Rand drills, owing to the action of their rocker valve, give a very heavy forward thrust, but as the rock is very often much fissured the drills stick. The Sullivan drill has given better satisfaction because this difficulty is to a great extent overcome, as it has a much stronger lift. The Sullivan machine also seems to keep in repair better than the Rand. Air is supplied to the drills at a pressure of 90 lbs. to the square inch.

The miners work an eight hour shift. No work is done in the mine on Sunday. Twenty-five feet of drilling a shift is considered a day's work; this includes setting up, tearing down and blasting. It takes about 1½ hours to set up in a drift. Each machine drills 27 drills more or less per shift. The drills range in size from the 2½″ dia. starters to the finishers which are 1¼″ dia. A tripod is used only where it is impossible to use a bar.

60% Gelignite is the powder most used, although 40% and 60% giant powder are used occasionally. The Gelignite does not fill the workings with gas nearly as much as the other. As a general rule, one stick of powder is used for every foot of drill hole. A five foot fuse is used, which burns at the rate of two feet per minute. The cap is put in the second stick of powder from the face, and the tamping employed is the paper from the box in which the Gelignite is packed.

Mine fires are nearly always detected as each man has to count the reports from his blast before he leaves the workings. The most frequent causes of miss fire are: (1) Fuse spitting and igniting the powder. (2) Fuse not properly put in the caps. (3) Caps not properly greased before being used in water holes. When it is not possible to reshoot missed holes with safety the greatest care is taken not to drill too near the charged hole.

One sad accident occurred last spring in the mine. Two miners, after they had drilled their round and loaded the holes, had some sticks of powder left over. Instead of taking them back to the powder store room they put them in a hole which was not to be fired that shift. They then fired the other holes and left the fresh powder in this one hole, contrary to explicit orders. It happened next shift that they were transferred to another part of the mine and another pair of miners set to work in this place. The first thing one of the new men did was to thrust a drill into this hole to see how deep it was. The powder exploded, blew him to pieces and knocked his companion unconscious.

In drifting it takes two shifts to drill and blast a 6-foot round. The following are the details of costs per foot for drifting taken from the work done by contractors for the month of July, 1907:—

Detail.	Cost per foot.
Contract price	$ 6.50
Powder	3.09
Fuse	.13
Smithy	1.00
Power	1.00
Wear and tear	.25
Hoist wear and tear	.10
Hoist engineer and surveyor	1.21
Cage man and superintendent	1.15
Top man	.30
Total	$14.73

During the month the drift was extended sixty-one feet. The contractors did their own blasting and paid their muckers.

The details of work during August were as follows:—

DRIFTING.

Working	Level	Machine men	Car men	Shovellers	Powder in sticks	Fuse feet	Advance feet	Cars ore	Cars waste	Tons ore
North drift	1000	52	7	21	1147	460	41.0′	260	247	...
East drift	1000	50	$2\frac{1}{2}$	32	1323	455	42.0′	305	228	...
Totals		102	$9\frac{1}{2}$	53	2470	915	83′	565	475	363

The costs of drifting were:—

102 Machine men, at.	$4.00	=	$408.00
9½ Car men, at.	3.25	=	30.85
53 Muckers, at.	3.25	=	172.25
2470 ⅓-lb. sticks powder, at	.26 lb.	=	162.00
915′ Fuse, at per 100′.	.12½	=	1.15
			$774.25

$$\text{Total cost per foot} = \frac{774.25}{83} + \$5.01,$$ which covers power, smithy, superintendence, etc., = $14.33 per foot.

STOPING (AUGUST).

Working	Level	Machine men	Timber men	Car men	Shovellers	Powder sticks	Fuse feet	Cars ore
No. 39.	850	57	4	5½	8½	924	640	284
No. 4 Stope. .	850	54	11½	4½	29	568	510	471
45° Stope	850	28	. .	10	39	311	245	562
No. 2 Stope. ..	850	14	2¾	. .	½	280	200	13
Intermediate	1000	38	18	8	42	669	420	331
No. 3 Stope. ..	850	19	4½	. .	3	234	180	32
Totals		210	40¾	28	122	2989	2195	1693

Costs:—

210 Machine men, at.	$4.00	=	$840.00
40¾ Timber men, at.	4.00	=	163.00
28 Car men, at.	3.25	=	101.00
122 Shovellers, at	3.25	=	407.50
2989 ⅓-lb. sticks powder, at	.26 lb.	=	258.96
2195 ft. fuse, at .12½ per 100′		=	2.75
Total.			$1,773.21

The 1693 cars = 1,200 tons. ∴ cost per ton $= \frac{1{,}773.21}{1200} + .88 = 2.15.$

The $0.88 includes hoisting, smithy, superintendence, etc.

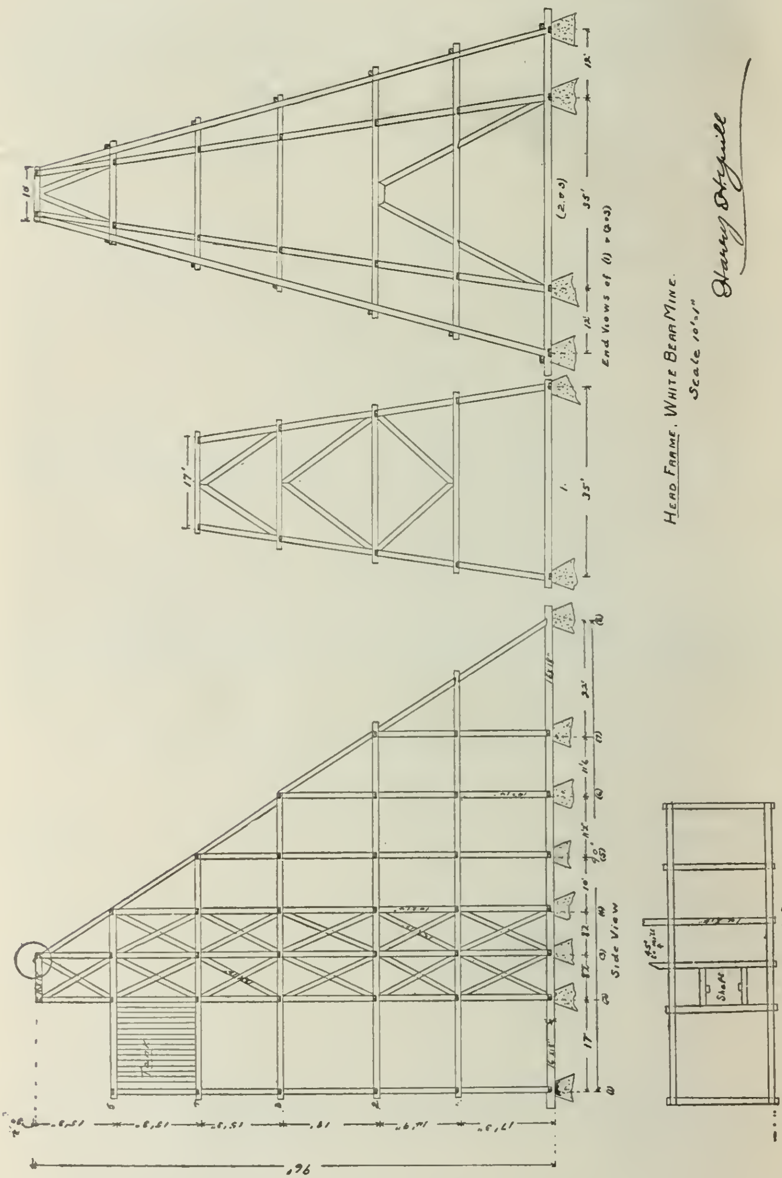
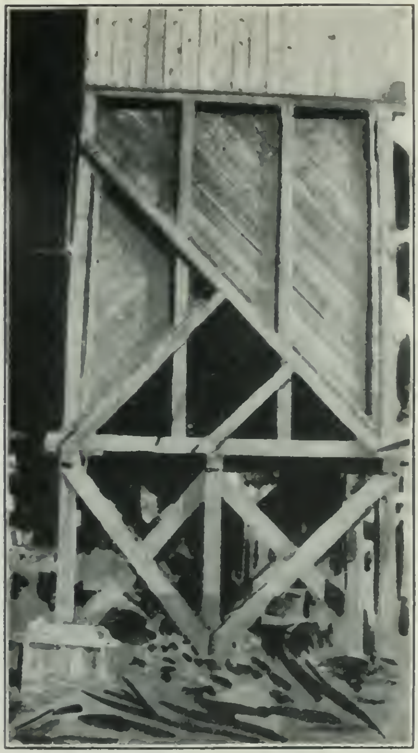


Plate IV.—Head Frame, White Bear Mine.

Machine Work (Underground).

Electric Hoist.



Ore Bins.

Compressor and Hoist House — Shaft House — Crusher House — Concentrating Mill

It will be seen from these tables that 1,563 tons of ore were hoisted in August. Of this, 563 tons were shipping ore, 200 tons waste and 800 tons milling ore which gave 80 tons of concentrates.

The ore is hoisted in cars to the third floor of the shaft house, or head frame (see Plate IV), which is 50 feet above the collar of the shaft. It is then trammed across an overhead passage (see photograph) 45′ long, to the mill where it is dumped on to a 2″ grizzly. The fines go to the bin containing the first-class ore and the rest on to picking tables, of which there are six. It is then washed clean and sorted into three classes, namely, first-class or shipping ore, second-class or milling ore and waste. The shipping ore is put in bins from which railroad cars can be loaded by chutes, the waste is trammed to the dumps. The second-class ore is put through two Blake crushers set to reduce to 2″ (see Plate IV), before going to the mill, which consists of three 10-stamp batteries (see Plate V) fitted with 20 mesh screens. It then passes through sizers (note accompanying sketch) and on to the Wilfley tables, of which there are six, three for fines and three for coarser material. The middles are elevated back to the tables and re-treated.

An Elmore oil concentrating plant was installed to treat the tailings, but the saving did not counterbalance the additional cost, consequently, the use of the plant was abandoned.

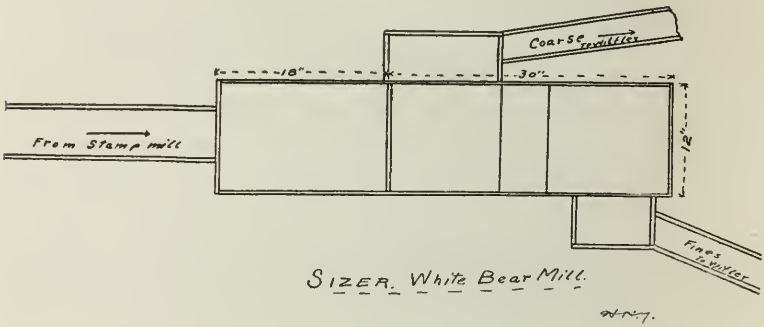
The following is the result of some experiments made in this mill by the representatives of the Elmore Concentration Company when the oil plant was first installed. They claimed that they saved 80% of the values in the tailings from the Wilfley tables:—

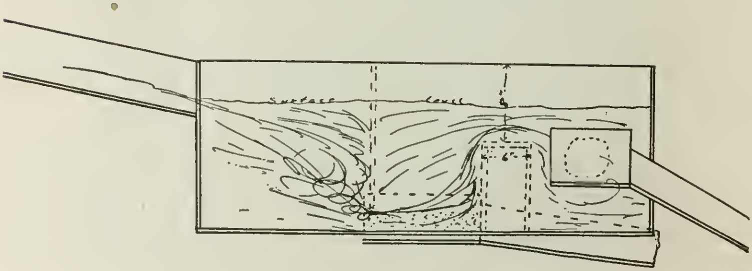
	Gold oz.	Silver oz.	Copper %	Gross Assay Value.
Feed	.09	....	.6	$ 3.60
Wilfley concentrates	.72	1.5	2.9	24.00
Wilfley tails and oil plant feed	.03	...	.5	2.10
Oil concentrates	.27	3.5	10.3	48.40
Oil tails	.01	....	.2	.80

Wilfley concentrates from.........	$3.60	feed	=	$24.00
Oil concentrates from............	2.10	"	=	48.40

The following brief description of the oil plant is condensed from published sources of information:—

"The plant consists of four units. The tailings, which were elevated from the tailings tank by means of two centrifugal





pumps, were led into mixers, of which there are three in each unit, one below the other. These mixers are long iron cylinders with inside baffle plates which slowly revolve, thoroughly mixing the charge with water and with a constant feed of oil from the oil storage tank.

"The oil, which has the property of picking up and retaining free gold and metallic sulphides, escapes through the pipe, while the tailings, wormed to the lower end, are discharged into the second mixer below, similarly to the third. The tailings from the third mixer go to the two settling tanks where any oil may float off and be recovered. The tailings escape through the bottom. The heads (mineral charged oil) and oil from the settling tanks are pumped to a tank, where a steam pipe heats the oil, then dropped into the first oil extractor. This is a centrifugal machine revolving at a high speed which separates the water and oil from the concentrates, the oil and water flowing into an oil settling tank from which it is returned to the storage tank. The oil consumption was 1½ gallons per ton."

The shipping ore and concentrates are shipped to the Canadian Mining & Smelting Company's smelter at Trail, 7 miles from Rossland. The freight and treatment charges average $3.25 per ton, 95% of the gold and silver values are paid, and 100% of the copper values less 4 cents per lb. of copper, which is the charge for marketing it.

The following is the form in which the smelter returns are reported; (the assays are checked by means of control samples which are taken at the smelter):—

Our Serial No. .... Trail, B.C. .. .. .190........

Shipper's Lot No. ....

The Consolidated Mining & Smelting Co. of Canada, Ltd.

In Account with

....

Spot Settlement of Ore. Quotation of........................190....

Arrived—No. Cars............No. Sacks............Wt. Sacks............lbs.

Gross Weight of Ore............lbs. Moisture............per cent. Dry wt. Ore ....lbs. Car Numbers..

Assay:—

Gold............oz. per ton, Silver............oz. per ton, Copper per cent. less P.C............., Lead............p.c., Zinc............p.c.,............p.c., ...p.c.

Quotations:—

New York Silver............New York Copper (elect.)............less 4c. per lb............London Lead £............less $20.00 per 2,000 lbs. = ...per 100 lbs.

Contents:—	Value. $ c.
..............Ounces Gold at $20.00 per oz., for 95 p.c.	....
..............Ounces Silver at .... per oz., for 95 p.c.	....
..............Pounds Copper at .... per lb., for 100 p.c.	....
Total Gross Value....................	....
Less Freight and Treatment at .... per ton	....

Basis Freight and Treatment:—

.... $ ....

.... $ ....

.... $ ....

Remarks:—

THE CONSOLIDATED MINING & SMELTING CO. OF CANADA, LTD.

Per ....

The average assay of shipping ore for 10 shipments made last spring was:—Gold, .173 oz.; Silver, .77 oz.; Copper, 2.2%; moisture, 2.0%.

Concentrates:—Gold, .4 oz.; Silver, .5 oz.; Copper, 1.8%; moisture, 12.1%.

Owing to the great scarcity of mill men this summer the mill was run during a great portion of the time by men inexperienced in mill practice. As a result the concentrates were not uniform, although mill samples for assay were taken regularly and systematically, and changes made in the adjustment of the tables and water flows when considered necessary.

Below are the results of samples taken when the mill had been running for only a few days after having been shut down for repairs. (1) "Fines" table, (2) "Coarse" table.

Sample	Gold oz. per ton.	Copper %
Battery feed	.2	.40
Concentrates feed	.2	.40
Sub. middles (silica) (1)	.01	.16
Sub. middles (silica) (2)	.022	.15
Middles (1)	.01	.44
Middles (2)	.03	.42
Tails (1)	.032	.27
Tails (2)	.04	.39
Concentrates (1)	.36	1.84
Concentrates (2)	.34	1.88

The sub. middles were clean silicious matter that formed quite distinct from the middles proper. It may be seen from the above figures that the tables were not working very efficiently. By sampling and readjusting and then sampling and readjusting several times the tables did better work than this.

The management have decided to regrind the middles and send them on to another table instead of passing them back to the same table without regrinding.

Electricity is the motive power used; it is supplied by the West Kootenay Power Company's plant at Bonnington Falls. The cost is about $30.00 a horse-power year.

The hoist is driven by an induction motor, R.P.M. 600, volts 220, H.P. 150. The speed of the hoist is governed by a controller similar to the controller used in street railway cars, with a very large resistance made up of cast iron grids. (See photograph.)

The 40 drill air compressor is a cross-compound Canadian Rand Drill Co.'s machine. Air 30½" x 24". It is driven by a 400 H.P. induction motor, volts 220, R.P.M. 300, phase 3, cycles 60.

Motors ranging in h.p. from 10–150 are used to run the crushers, stamp mill, concentrators and machine shop. Electricity is also used to light the plant and stations underground and for signalling.

Apart from the shaft the mine is dry, and pumping is necessitated only by the water which runs down the shaft. This water is pumped into the tank shown in the drawing of the "Head Frame," and is used to cool the compressor. The pumping is done by compressed air with very satisfactory results and low repair costs. The water used in the mill is pumped by a centrifugal motor driven pump from a pond formed by the exhaust from the Le Roi steam plant.

The superintendent, Mr. F. Demuth, has complete charge of the running operations. He was formerly foreman at the Le Roi for some time, and previously had had a long and varied experience in mining in the different camps of the Western States.

The men underground are under the immediate control of a shift boss, who reports to the superintendent at the end of each shift.

The surveyor does the assaying and the clerical work, and acts as a general assistant to the superintendent.

Many improvements and extensions are being planned with a view to obtaining an increased output. Work is now being done in two shifts. When another means of exit is secured more men will be employed, and possibly the shaft will be enlarged, which will permit two skips to run balanced.

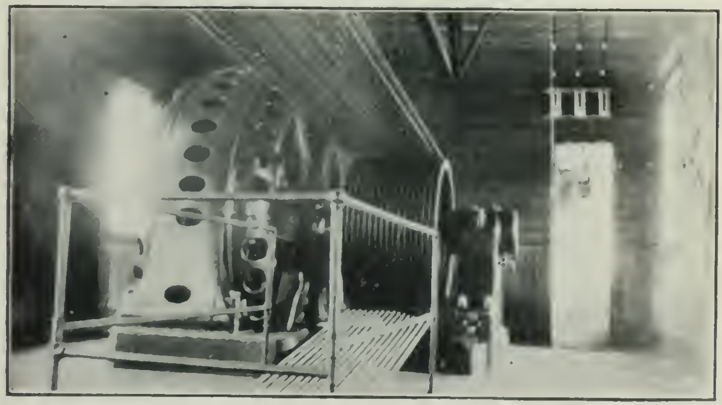
As stated before, up to the present all energies have been directed to finding the ore and proving the mine. Now that this has been done, the management find themselves very much handicapped by the fact that they have but one connection to the surface, and it is a one compartment shaft.

The only way a low grade mine like the White Bear can be made a good paying proposition, is by having a large output at a low cost per ton. It is, therefore, evident that the conditions under which the mine is being operated at present must be changed in order to do justice to the mine itself and to the interests of the shareholders.

The author was employed as surveyor at the White Bear mine during the summer of 1907. All maps, drawings and photographs are made from original surveys and measurements made during the summer. The assay values are from author's assays (except where otherwise stated). All cost and other data are also taken from personal observations.

GENERAL ARRANGEMENT OF THE SURFACE PLANT.

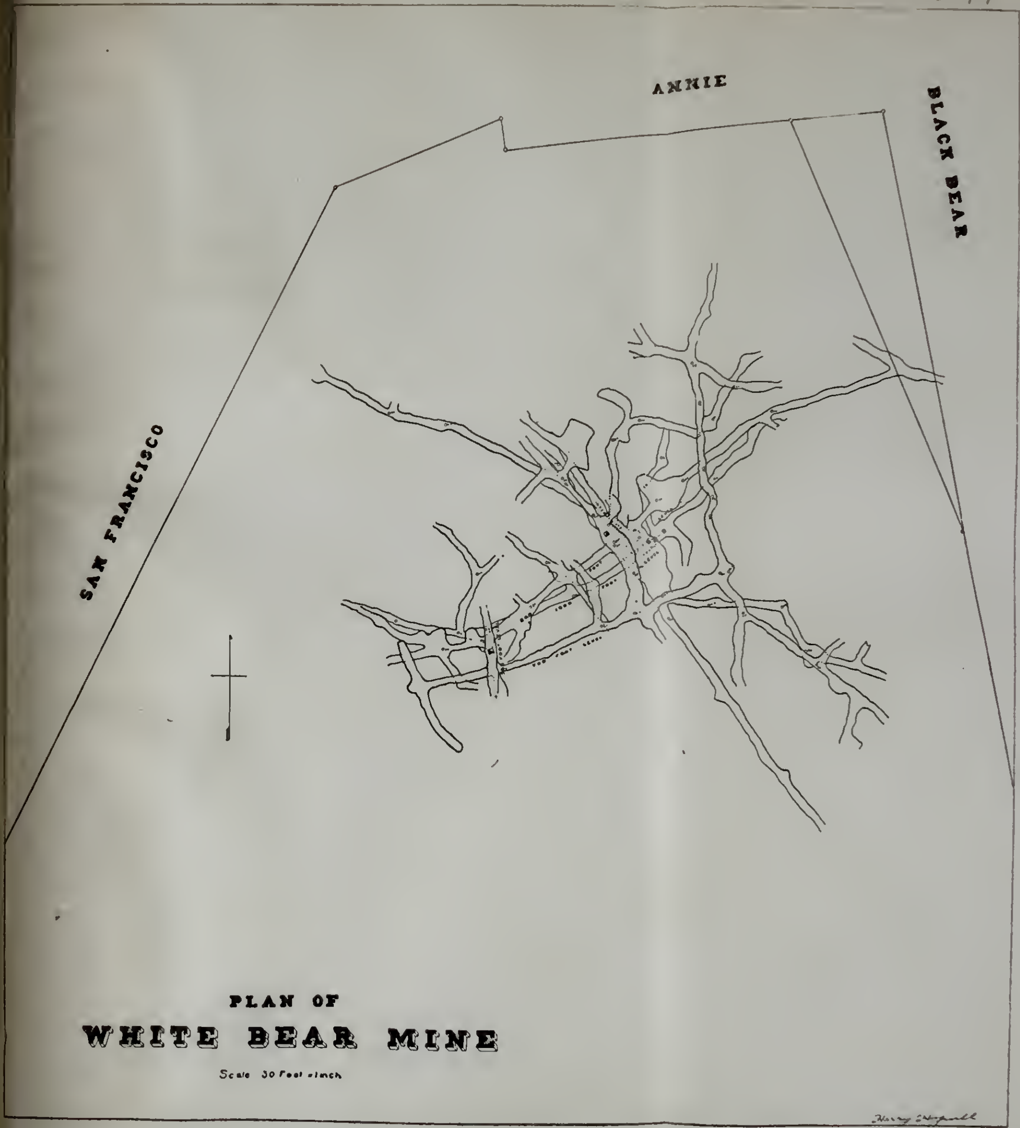
The high building is the shaft house, the low buildings to the right are the "Blacksmith and Machine Shops." Next to the left of the shaft house are the "Ore Bins." Then the concentrating mill begins, the crushers being contained in the building adjoining the ore bins. The other buildings contain the Stamps, Wilfley Tables and the Elmore Oil Plants.



Compressor Motor (400 H.P.)


SAN FRANCISCO

5-44 B


ANNIE
BLACK BEAR
SAN FRANCISCO
PLAN OF
WHITE BEAR MINE
Scale 30 Feet = 1 inch

MINING AND MINING METHODS OF THE YUKON.*

By A. A. Paré,

McGill University, Montreal.

The author spent three months in the Yukon District last season under rather favourable circumstances. The object of this visit was to become acquainted with the placer and gravel mining methods in the neighborhood of Dawson; also to visit the White Horse copper belt, the Windy Arm District and the Wheaton and Watson River country.

In the following notes an attempt will be made to characterize on the first two of these districts in the order in which they were visited, giving short geological sketches and, where possible, a short history; and in some cases details of methods and cost of mining and of the extent of the workings.

The Yukon Territory comprises nearly 200,000 square miles and is bounded on the north by the Arctic Ocean, on the east by the Mackenzie District, on the west by Alaska and on the south by British Columbia and a narrow fringe of Alaska.

The Yukon River heads in the Coast Range, near Skagway, and for a distance of 1,950 miles serpents its way through a very varied country, now widening out into a lake with extensive timber lands on either side, now dashing madly through dizzy canyons and narrow valleys shut in by mountain ranges from 1,000 to 2,000 feet in height, or peacefully winding its way through wide valleys with steep boulder-clay banks, finally to discharge itself in the Behring Sea near St. Michaels.

This river forms the main water way of the Yukon and would be navigable from source to mouth for 4½ months of the year, were it not for the break made in it by a very narrow canyon and the White Horse Rapids a little over 100 miles from its source, and, together, five miles in extent.

*Paper entered for the "Student Competition, 1908," and awarded the second prize of $25

THE WHITE HORSE COPPER BELT.

The White Horse copper belt is about twenty miles in extent, beginning 7 miles N.W. of White Horse and extending crescent-like to the S.E., crossing the White Pass and Yukon Railway at Dugdale 9 miles south of White Horse. About three miles almost directly north of the track the formation dips to the north under a range of Black Limestone mountains some 20 to 25 miles in width, which run in a N.W. direction paralleling the Yukon River for a distance of over 200 miles from White Horse, and cut through by the river in a number of places.

The geology of this copper belt has not as yet been determined. Mr. McConnell, whom the author had the pleasure of meeting while visiting the White Horse Copper mines, was then working up the geology of that district. The author also had the pleasure of accompanying Professor Mynard (geologist sent out by some large Philadelphia capitalists to make a report on the country). He did not, of course, get much information from them except of a general character, but the conclusions here drawn are from what the author observed himself in going through the country, assisted by his very limited knowledge of geology.

The eastern fringe of the copper belt is what is commonly known there as the Coast granites, the southern end of which is overlaid with scoria of recent eruption. Overlying the granites is a bluish white limestone very much cut up by intrusive dykes of what appeared to be diorites and porphyrites. The limestone was so shattered and altered that one would at first sight be inclined to look upon the limestone as intrusive, if such were possible.

In some parts of the district garnetite forms the gangue of the ore; in other parts what appeared to be an altered limestone, but what is locally called a felsite; and, again, in some other parts magnetite and hematite form the gangue of the ores. In some localities bornite occurred in tremolite. The copper here occurs as bornite chiefly, but chalcopyrite, chalcocite and cuprite also occur. Native copper is found in very small quantities.

Copper was first discovered at White Horse in 1898, two years before the town of White Horse existed and three years before the White Pass & Yukon Railway reached there. The discoverers were Jack Mackintire and Hanly (two prospectors from Circle City, Alaska), who staked out the Copper King and Aura respectively. Jack Mackintire was frozen to death driving the mail stage on the Atlin route about five years afterwards and Hanly left the country some years ago.

In the fall of 1898 Granger located the Copper Queen and bought a large share in the Copper King and also re-located the Aura.

In 1899 the Pueblo was staked by E. G. Porter. The British American Corporation staked out the whole country in concessions and took an option on the Pueblo for $1,000,000 and that year and the following spent some $25,000 doing development work. In 1900, however, the parent corporation in London went into liquidation.

In the meantime Pucket, Ward, O'Neil and Olie Dickson, prospectors and traders, staked the Anaconda and Rabbit's Foot, and did much fruitless work on both.

Not long after these discoveries Sam McGee and Jim Lauderdale staked the War Eagle and the Le Roi. Robert Lowe (M.P. for that district) purchased an interest in the last mentioned mines, or rather claims, and did a certain amount of representative work on each, and is said to have bonded them to a group of Spokane people for $75,000.

In 1901 Byron White, of Spokane, Wash., (a capitalist very largely interested in Slocan Mining District in British Columbia), bought up the old British American Corporation—the principal mines being the Pueblo, Tammerac and Carlyle.

Out of the first hundred tons of ore shipped from the Carlyle, Mr. White is said to have cleared all his expenses, amounting to some $10,000. Later shipments were also profitable and preparations are now being made to ship on a large scale.

All the above mentioned mines lie in the north end of the Copper Belt.

The Arctic Chief Group was the first property staked in the middle of the district. The owners, Bill Clark and Captain John Irving, did considerable work on this property. Bill Woodney staked the Grafter, and Angus McKinnon, the Best Chance; E. Garvais staked the Valerie. Desultory work has been done on most of these claims at some time or other until this year.

Bill Woodney bonded the Grafter to several parties, of whom the principals are Witney, Pedlar, Robert Lowe, George Armstrong and others, and the property has been bonded in turn to Robert Lowe for $105,000.

Last year Mr. Elmendorf, mining engineer from Spokane, bonded the Arctic Chief and Best Chance for some Spokane people.

Last winter Colonel Thomas (representing a Pennsylvania Syndicate, the principal men of which are said to be Messrs. Guffrey and Gayley, of Pittsburg) came to White Horse and bought up about 300 undeveloped properties and took options on about 100 claims—the principal ones being Copper King and Queen, which were said to be bonded for $120,000; Anaconda, Rabbit's Foot and a host of others adjoining these, bonded for $210,000.

The Corvet Group adjoining the Arctic Chief bonded for $20,000. The Iron Horse, Helena and Florence, occupying the ground between the Grafter and Arctic Chief, were also said to be bonded to Colonel Thomas.

At the extreme south end of the district Mr. Trethewey, a cousin of the pioneer of Cobalt, staked the Keewenaw Group, but no development was done on this group by him. The next claims to be staked in this district were the Black Bear and Brown Cub by F. F. McNaughton. As nothing was done on these also, they were re-located by Dr. Nicholson and Mr. Baxter and bonded by Colonel Thomas for a sum said to be about $20,000, very little work except surface stripping having been done on them, however.

The Keewenaw Group was re-located by a German, Carl Weik, who has done considerable development work on some of the most promising claims of this group.

The extent of development on the most important mines of this district can be judged from the following statistics of output.

Copper King.—The Copper King has shipped 500 tons up to date, but has for the present stopped shipment, and plans are being developed for shipment on a larger scale. They are installing a five drill compressor and steam hoist and are also putting up several good substantial buildings. Transportation to railway from mine is at present done in waggons at an extravagant cost of $2.00 per ton.

Grafter.—Up to date the Grafter has shipped some 1,500 tons and is shipping now at the rate of 30 to 40 tons per day. A shaft has been sunk about 150 feet and considerable drifting done. Average value of ore is about $30.00 per ton. Transportation to railway alone costs $2.50 per ton.

Arctic Chief has shipped 700 tons up to date, but is not shipping at present as considerable improvement is being made. They have about 400 feet of tunnel and two or three short winzes. It costs $2.50 also to ship to railway.

Pueblo.—The Pueblo up to date has shipped 1,000 tons and preparations for large shipments, as soon as transportation facilities are improved, are being made. The Pueblo ore is a hematite carrying from 3 per cent. to 7 per cent. copper, the average, however, is about 4 per cent. It costs at present $4.00 per ton to ship in waggons from mine to railway, a distance of six miles.

Should a spur of the W. P. & Y. Ry. tap this mine, the operators state that they would ship 500 tons per day. The author has no fears to the contrary as there is such a large surface showing the method of mining at present would be very much that of open cutting.

The average cost of mining in this district may be roughly stated as follows:—

Shaft sinking, 5′ x 9′ timbered, $40.00 per ft.
Drifting, 5′ x 7′ not timbered, $10.00 per ft.
Wages (8 hr. shifts), on surface, $3.50 and board.
Wages (8 hr. shifts), underground, $4.00 and board.
Shipping to R.R., $2.00-$4.00 per ton.
Freight from White Horse to Smelters, $6.00 per ton.

Smelter charges	$1.50 per ton. 1.3=10 per cent. loss on cu. ores. 3c. per pound for marketing.

All the ores are shipped to the Ladysmith and Britannia smelters.

COAL.

Coal was discovered a little over a year ago about 18 miles S.W. of White Horse and 10 miles from the railway line. The strike appears to be about N. 74° W. with a dip of about 42° to the N.W.

This coal area can be traced for about ten miles in extent, and occupies a strip about a mile wide. Except for a few small cross cuts, and a tunnel some 70 ft. long on a 9′ 8″ seam, virtually no development has been done. There is another 10′ 4″ seam above the one already mentioned and several smaller seams showing outcrops.

The coal is a semi-anthracite running as high as 83 per cent. carbon but also giving a very high percentage of ash. Seven per cent. ash is the lowest result yet obtained and from this it ranges to 23 per cent. in ash.

DAWSON DISTRICT.

In the Dawson District the author was able to visit the majority of the important properties on Bonanza, Eldorado, Hunker, Quartz and Bear Creeks, also the Twelve Mile River district where the Yukon Consolidated Gold Field Company have their sawmill, power plant and intake of their ditch. The visits to Bonanza, Eldorado and Quartz Creeks were made in the company of Mr. A. Beaudette, the Government Consulting Engineer at Dawson, to whom the author is indebted for most of his information.

The auriferous gravels of the Yukon Territory have not by any means been thoroughly explored, so no accurate information as to the extent of these can be had. The most probable estimate is put at about 2,000 square miles, warranting either or both placer and gravel mining. Of this whole area the Dawson District is by far the most important and has an area of about 800 square miles.

Mr. McConnell places the deposition as Post Tertiary and Tertiary periods and claims that only part of these deposits show glaciation. The origin of the bench gravels is explained substantially as follows:—

The gravels were deposited in the beds of large rivers and creeks; subsequently elevation took place, which contorted the schists and caused the waters to take new channels, leaving the gold-bearing gravels behind. Finally, the present streams cut their way to depths of 300 feet or so, making the present valleys and in some places cutting through their former channels and washing these down into the stream bed. These gravels are known as Creek gravels, while the original ones are known as Bench gravels.

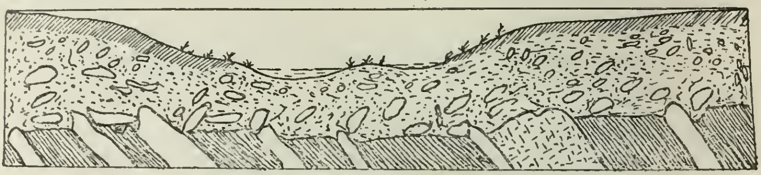
A very strange and interesting fact in connection with the gold-bearing gravels in the Dawson District is that some are frozen even as far down as 250 feet and some only to the depth reached by a single season of frost; and another strange fact is that in the frozen gravels the ice is free from detritus. The presence of ice to such great depths suggests a long period of very severe frost. The exact time of this severe frost is would be impossible to say, but it must have been previous to the formation of the creek deposits, which are not frozen. The absence of detritus in the ice, it is said, would suggest that the water was not in motion.

The gold-bearing creeks in this district which have suffered the elevation before mentioned are Bonanza, Eldorado, Hunker, Bear and Quartz Creeks, and those which do not show signs of such an upheaval are Dominion, Sulphur and Gold Run. The first mentioned have both creek and bench claims, while the latter have creek claims only; the composition of gravels, however, in both hill and bench claims is the same on all of the creeks.

The gold-bearing rocks all over the placer area are sericite schists containing small stringers or bands of quartz which are often mistaken for veins or lodes. In many places these schists are cut by andesites and porphyry dikes, which might have something to do with concentrating the gold. The gold does not occur disseminated through the quartz stringers, as might have been expected, but is found on the contact between the quartz and the schists. These quartz pebbles, of which the gravels mainly consist, contain little or no gold, so that what cannot be recovered by placer or gravel mining would not pay to lode mine.

There are several methods of prospecting in vogue in the Yukon, and the right one to be used in a particular case depends on the extent and position of the ground and the character and depth of the overlying soil.

The following is a list of the methods most generally used:—Adits, open cuts, drill holes, shaft sinking. An attempt will be made to give a short sketch of the particular conditions to which each is most suited.



Cross-section of a Creek Bed.

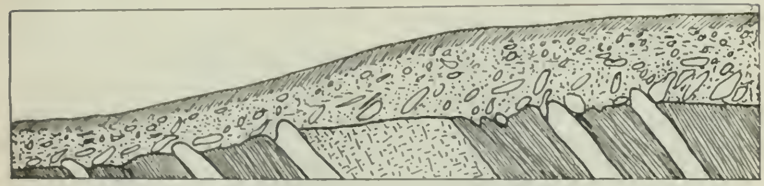
To do this let us consider the above cross-section of a creek bed. First we have a muck composed of frozen organic matter containing about 75 per cent. ice and varying from 2 to 30 feet in depth. In almost all cases this is quite solidly frozen. Below this we have a layer of frozen gravel or silt, varying from 2 to 15 feet and carrying a few colours. Underlying all this we have from 2 to 4 feet of "bed-rock pay," which is composed of the heaviest wash in the creek beds and contains the best pay. From the above section it is quite plain that before we can get any idea at all as to what we have we must get down through from 6 to 50 feet of waste material. The methods of attack here would depend simply on the depth. For all prospects where bedrock is not over 15 feet open cutting and ground sluicing would be used; when more than 15 feet deep shaft sinking and drifting would be resorted to—the Keystone drill could be used here also.

The dangers met with in shaft sinking are, first, the possibility of water getting in through partly frozen ground and drowning out the works; secondly, the possibility of asphixiation from the accumulation of gases produced by wood fires where wood is used for thawing the gravels, or gases produced by the decomposition of organic matter.

Surface development on the Pueblo Claim.

Marion Steam Shovel.

The discharge from the Peltons.



Cross-section of a Hill or Bench Claim.

The above cross-section is that of a hill or bench claim. First we have a little moss or muck varying from 6 inches to 1 foot in depth; below this, fine sand and quartz pebbles varying from 5 to 50 feet in depth and carrying a few colors; below this again we have a coarser material containing fairly large boulders of quartz, diorite, granite, etc., and varying in depth from 20 to 50 feet and increasing in value as bed-rock is reached. There is generally from 4 to 6 feet on bed-rock which carries the best pay. Such ground would be prospected by adits and tunnels.

In prospecting large tracts of land for dredging purposes the Keystone drill has proved a most efficient means of getting information as to extent and value of gold-bearing gravels.

The following is an approximation to the average cost of prospecting:—

Shaft singing	4′x6′ without timbering.	$4.00 per ft.
Shaft sinking.	4′x6′ with timbering	$8.50 per ft.
Adits or tunnels	4′x8′ without timbering	$1.00 per ft.
Adits or tunnels	4′x8′ with timbering	$7.00 per ft.

Thawing the frozen ground is quite a large item in the cost of shaft sinking; if this is done with wood it costs about 60c. per cubic yard; if steam is used it can be done as low as 35c. per cubic yard.

A prospecting outfit for two men, including provisions for one year, thawing apparatus, tools, etc., would be estimated between $500 and $750.

Provisions—		Tools—
Flour	350 lbs.	1 8-H.P. boiler.
Sugar	100 lbs.	2 steam points.
Rice	50 lbs.	2 axes.
Beans	50 lbs.	3 shovels.
Rolled oats	100 lbs.	2 gold pans.
Bacon	100 lbs.	1 stove.
Ham	100 lbs.	1 whipsaw and files.
Butter	50 lbs.	2 picks.
Milk	2 cases.	Planes.
Dried fruit	100 lbs.	Brace and bits.
Pepper	½ lbs.	Saws, hammer and nails.
Tea	10 lbs.	Dishes.
Coffee	10 lbs.	Candles.
Salt	5 lbs.	Large tub.

Spring operations in the Dawson District commence about April 20th and continue on till June 15th, this period being known as the spring freshet. The dry season lasts from about June 15th till August 1st, and during this period only creek propositions can be operated. The fall freshet begins somewhere about August 1st and lasts on until end of open season, which usually means about the end of September.

The duration of the spring freshet is getting shorter and shorter every year as development on hill and bench claims goes on, and the lumber industry increases. The moss and trees are removed from the hillsides exposing the snows and small glaciers formed during the long winter months to the sun's heat.

Several methods have been tried to obtain sufficient water during the dry season for a few hours run each day. One of these was the installation of a pumping plant, but because of the excessive cost of fuel it proved a failure.

A very extensive piece of work is at the present time in the course of construction which will furnish a water system whereby a constant water supply can be had to operate certain of the gold-bearing gravels in the Klondike district during the open season.

From the immense amount of data obtained by the Yukon Consolidated Gold Field Company, who have acquired all the most important gravel areas on Bonanza, Eldorado and Hunker, and who are now carrying out this gigantic piece of work, it was found that a constant summer water supply of 10,000 miner's inches can be brought from Twelve Mile River and its tributaries, a distance of some 59 miles, and that the cost of this enormous undertaking will not be prohibitive; also it was found that it will furnish water at sufficient elevation for hydraulic purposes. The company expect to complete this work about October 1st, 1908, and have everything ready for extensive operations in the spring of 1909.

At the time the author visited the Y. C. G. F. Co's workings on Twelve Mile River a flume 4′ x 3′ had been constructed from one of the intakes, of which there are two; the one just referred to is situated above the power plant on Little Twelve Mile Creek, the right fork of Twelve Mile River; the water from this flume was being used at that time solely in driving the Pelton wheels of their Electric Power Generating Plant. An iron pipe or penstock about 30″ in diameter at intake, ½″ thick, tapering down to 26″ at Peltons, and 2,000 ft. in length, with a fall in that distance of 674 ft., was used to convey the water from the flume to the power house.

The second intake to the main ditch is situated five and a half miles above the power plant on Tombstone Creek, the left fork of Twelve Mile River. The dimensions of this flume are the same as those of the Little Twelve Mile Creek flume. These two flumes discharge into a common flume at a point 200 ft. above the intake of the penstock conveying the water to the Peltons.

Two six-foot Pelton wheels working under a pressure of 300 lbs. per sq. in. are used to drive two Westinghouse Alternating current motors, K.W. 625, volt. 2200, amp. per ter. 164, phase 3, cycle 60. R.P.M. 450.

Two smaller Pelton wheels about 3 ft. in diameter are used to drive the direct current generators—K. W. 17. volt. 125, amp. 135, R.P.M. 1125—which are the exciters for the large alternators.

The voltage for transmission is stepped up to 33,000 volts and is carried by air line 33 miles in length to a distributing station on the Klondike River. It is received at the dredges at 4,000 volts and there stepped down to 400 volts. Only one of the Peltons is at present in use and is generating sufficient power for three dredges, also four large hoists which are being used to convey the lumber necessary for the construction of flumes —these are also used for installing the syphons. By next spring the power plant will be called upon to operate seven dredges as well as to drive the machinery for three hydraulic pumps. The cost of this whole electric plant is estimated at somewhere in the neighborhood of $200,000.00.

The main ditch, which is now well under way, will be about 59 miles in length, 19,400 ft. of which will be of iron piping, 5 miles of redwood piping, 15 miles of flume and the remainder ditching.

The inverted syphon to be installed across the Klondike River valley will be of ½″ iron, 42″ diameter and 15,000 ft. long, under a maximum pressure of 250 lbs. per sq. in. The inverted syphon to be installed across the Little Twelve Mile Creek in order to convey the water from Tombstone Creek into main flume will be of ½″ iron, 48″ in diameter and 4,400 ft. long, under a pressure of 300 lbs. per sq. in.

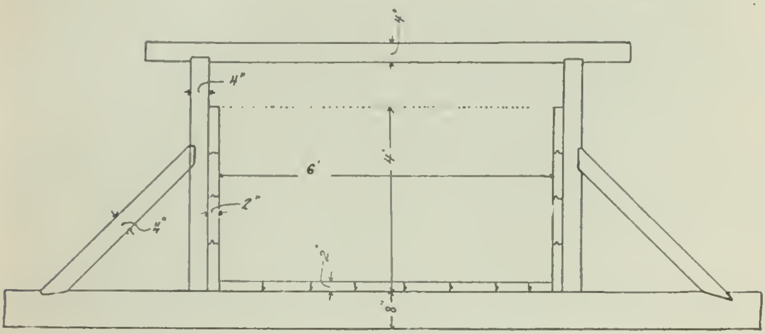
A third syphon, to be installed across a valley about 5 miles wide and 125 ft. below grade, will be of 2½″ redwood staves, diameter of pipe 48 inches, and the greatest pressure to which it will be subjected will be about 55 lbs. per sq. in.

The author could not secure any accurate information as to extent of flume, but it will be somewhere in the neighbourhood of 15 miles.

Width of flume. . . . 6 ft.
Height of flume. . . . 4 ft.
Grade of flume . . . .15 ft. per mile.
Capacity of flume. . 10,000 miner's inches.
Size of sills. . . . . . . .8″x8″
Size of caps . . . . . . .4″x4″
Size of posts . . . . . .4″x4″
Size of lagging. . . . .2″x10″x16′
Frames placed at 8-ft. intervals.
Estimate per 16 ft. of flume=1,000 sq. ft. of timber.

The timber used is native spruce from the valley of the Twelve Mile. The company's sawmill is situated on Twelve

Mile River five miles below their power house. Capacity of mill is estimated at 30,000 ft. per day and it is run by steam, having been installed a year or so before the installation of their electric power generating plant. This mill is expected to turn out some 7,000,000 ft. of lumber, which is all that can be cut in that



district. This amount will not, however, prove sufficient and they count on having to purchase between 2,000,000 and 3,000,000 feet more.

The remaining 35 miles of this water-way will consist of ditching, the data of which is given in tabulated form below.

Width of ditch at top	18 to 22 ft.
Width of ditch at bottom	12 to 16 ft.
Average of depth required	4 ft.
Greatest depth of excavation	12 ft.
Grade	1 in 1,000.
Side slopes	1 in 1.
Method of excavation	Steam shovel.
No. of shovels working	2.
Cost of excavation	15c. per cu. yd.
Cu. yardage per 24 hrs. per shovel	800 to 1100.

The type of shovel used is the Marion steam shovel—nominal capacity 1,080 cu. yds., dipper capacity 1½ cu. yds. The shovel is run on temporary rails and will do 5 ft. of length from one position. With the unskilled labour provided each shovel advanced from 250 to 300 ft. per shift of ten hours.

The writer also had the pleasure of visiting the Rothschild Co. dredging plant (known as the Canadian Klondike Mining Co.) at the mouth of Bear Creek. The extent of dredging property owned by this company is estimated at 48 square miles.

The electric power is generated by steam and the lay out of the plant is as follows:—

Three boilers of 150 H.P. capacity each, and burning in all 13 to 14 colds of wood per day, produce all the power required to operate the dredge and everything about the plant.

One Westinghouse Parson's steam turbine, rated at 400 K.W. and a speed of 3,600 R.P.M., to which was attached an Alberger condenser containing 681 tubes giving a cooling surface of 1,600 sq. ft. and working under a vacuum of 29 inches.

One generator, revolving field, capacity 400 K.W., 2,300 volts, 3 phase, 60 cycles, at a speed of 3,600 R.P.M., directly connected to the Parson's steam turbine.

One exciter, capacity 17 K.W., 125 volts, 133 amp., running at a speed of 1,125 R.P.M., and directly connected to the Parson's steam turbine.

They also have an induction motor for supplying power for pumping, etc., doing odd jobs about the plant.

The type of dredge used by this company is the Marion bucket dredge, operated by means of spuds and side lines and close linked buckets—64 buckets to the belt with a capacity of 5½ cu. ft. each. The average monthly capacity is about 83,000 cu. yds., capacity under favorable conditions 3,500 cu. yds. per 24 hrs. The lips of the buckets are made of manganese steel and have to be renewed every four months.

The stacker of the link belt type uses a belt conveyer about 3 ft. wide and made of a rubber composition. The life of this belt unprotected is from 5 to 6 months. If, however, an 18-inch belt is used over the large one, the life of the large belt is trebled.

The gravel is dumped from the buckets at the top of the dredge into an inclined rotating screen with four different sized perforations increasing in size as we reach the lower end of the screen. The inner surface of the screen was supplied with small flanges set at an angle to the longer axis of the screen, which prevented the materials from simply sliding down the incline afforded them. It not only served that purpose but was a very efficient mean of shaking up the gravels thoroughly.

The longer axis of this screen had a hollow jacket studded with perforations which admitted water under great pressure to the interior of the drum, thus assisting very materially in the disintegration of the fine sands and clays.

The rotating screen discharged all the coarse gravels directly on to the tailings belt. The sand and gravels which passed through were distributed into 18 sluices. These sluices were from 20 to 25 feet in length and had a very sharp elbow. The first 44″ of riffle was of protected cocoa-matting, 30″ wide, and the remaining portion was of 1¼″ Hungarian angle iron riffles laid on wood. A cocoa-matting generally lasts one season; that would mean in the Yukon about 5 to 6 months.

A clean up is made every 8 hours, during which intervals all the machinery is stopped and every part thoroughly oiled.

The matting is taken to the panning house and there thoroughly washed in a trough. All the coarse sands and gravels are sieved and thrown away after the coarse gold has been removed. The fine sands and silts are panned most thoroughly, sometimes twice over. After as much gold as possible has been removed in this manner the fine sands are run through a Muller containing mercury. As soon as the amalgam becomes thick enough the sand is run off over an amalgam plate, which catches any fine gold that has not been caught in the Muller. The amalgam is also run over this amalgam plate and thoroughly cleaned. It is then transferred to a retort. The sponge then formed is converted into a gold brick by being fused in graphite pots, and poured into moulds.

An approximation of the cost of dredging is given below:

Amount of wood per 24 hours.	12 at $12 per cord.
Labour, including board	$4.50.
Number of men per 24 hours.	9.
Number of men at power station	8.
Average capacity of dredge per 24 hrs. .	2,850 cu. yds.
Cost per cubic yard	13½c.
Cost of installing dredge	$150,000.
Cost of power plant	$150,000.

No work can be done on frozen ground and pebbles larger than 12″ in diameter cannot be lifted.

Hydraulicing is a term given to that form of mining by which water under pressure is used against a natural bank.

The conditions for hydraulicing are grade, water supply and dumping ground. Without all these three hydraulicing is only possible under great difficulties and at great expense. A condition most unfavourable in this country to hydraulicing is the frost in the ground. The sun's heat is the only economic means of overcoming this fact. If it is found that the gravels do not thaw quickly enough by the sun, a jet of water is shifted from one part of the face to the other at intervals of from 4 to 5 hours.

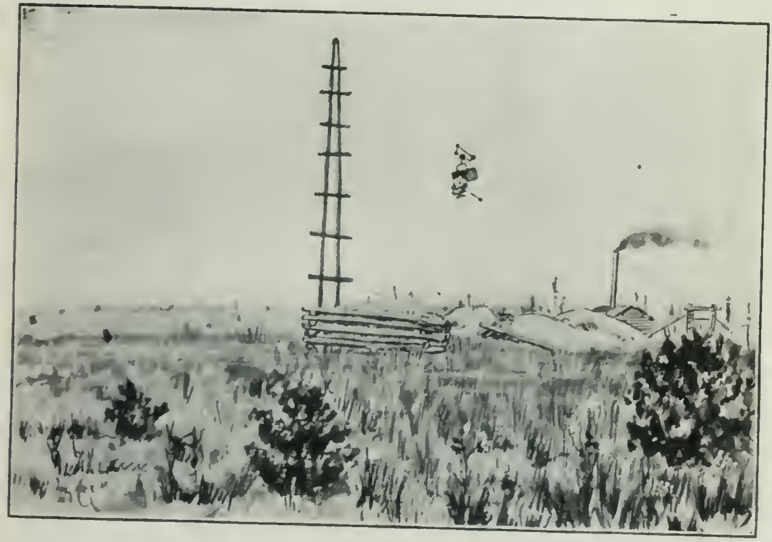
Hydraulicing is by far the cheapest method of removing the gold-bearing gravels when the water supply is ample and the head good. The greatest difficulty met with in this country is the short water supply, and in some parts of the Klondike district pumping hydraulicing is resorted to. One of these pumping plants is on Cheechaco Hill on Bonanza Creek and is known as the Pacific Coast Mining Co. The water is diverted from Bonanza at a point about half a mile above the plant and conducted to a sump hole by means of a flume with a capacity of over 500 miner's inches.

CONCISE DATA.

Capacity of pump	3,000 gallons per minute.
H. P. required.................	150 H. P.
Vertical height to be pumped ...	360 ft.
Length of transmission pipe	1,750 ft.
Diameter of pipe	12″ to 15″.
Cost of plant installed..........	$150,000.00.
Pressure at nozzle	160 ft.=69.44, approx. 70.
Sluices	24″ x 24″.
Grade	1″-1.5″ to 1′.

Sluices are provided with block and rock riffles. The tailings are kept on the side of the hill by means of cribbing shown in photo attached.

Ground Sluicing on 29 above Eldorado.



Self Dumper on No. 9 Quartz Creek, Dawson, Y.T.

COST OF UPKEEP OF PLANT PER 24 HOURS.

1 engineer per day	$10.00	
2 assistant engineers per day	12.00	
2 stokers per day	10.00	
2 roustabouts per day	8.00	
8 tons fuel at $10 per ton	80.00	
Board for 7 men at $2 per day	14.00	
Total		$134.00

COST OF HYDRAULIC OPERATIONS PER 24 HOURS.

1 foreman per day	$ 7.00	
2 labourers per day	8.00	
Labourers in cuts 1-10 average 4	16.00	
Cribbing—at about 5c. per cu. yd.	32.00	
Board for 9 men at $2 per day	18.00	
Total cost of upkeep of plant	——	81.00
Cost of operation per day		$215.00

Capacity, 1,500 cu. yds. per 24 hours at $223.00. Not including oil waste and repairs, etc., approximately 15c. per cu. yd. Taking everything into account, cost equals approximately 20c. per cu. yd.

The difference in cost between pumping hydraulicing and gravity hydraulicing is the difference in cost of upkeep, which would bring the cost down to about 7c. per cu. yd. for gravity hydraulicing.

The placer mining methods in vogue here are only the old crude methods used in other placer mining camps sufficiently altered to suit existing conditions.

A very interesting fact to notice here is that the most important gold-bearing creeks have very little grade, short water supply and are denude of timber; while those of less importance have conditions exceedingly favorable to placer mining.

The methods and costs of mining even on the same stream vary considerably, so that the best way to treat of them will be to explain some of the methods used and quote costs in a few special cases. The main cost, however, in any case is to excavate the material and place it in the washing plant.

The mechanical devices now constantly in use have decreased the cost of mining over 75 per cent. from the cost in former years.

In the Dawson District most of the gravels are frozen to bed-rock and it is only in exceptional places that pumping has to be resorted to in drifting operations. The creek gravels are shallow, and since the introduction of the open cut method very little drifting is done when the depth to bed-rock does not exceed 15 ft. This changes much of the winter works into summer workings.

By the method of open cut the miners take advantage of the water available during the freshets of the spring to ground sluice the overburden and expose the gravels to the sun to thaw. Very little grade is needed to allow the water to remove this silt or muck as the existing conditions are more or less favorable.

The considerable depth of the gravel deposits of Bonanza, Eldorado and Hunker Creeks made it necessary to work them originally by drifting. The values left therein do not warrant placer mining, although they would pay and are paying as dredging propositions.

Dominion Creek is one of the most important gold-bearing streams. Bed-rock here is very shallow and for the most part under 15 ft., so most of the work is open cut work, although considerable drifting has been done. It would make good dredging ground. The water supply is very short here, however, as on most of the creeks, but timber for fuel and timbering is quite abundant.

The same might be said of Sulphur and Quartz Creeks as was said of Dominion, except that on these two the ground is deeper and thus drifting is resorted to rather than open cutting.

Twenty thousand square feet is about the average area of ground drifted from one shaft. The approximate cost of mining such a piece of ground would be, taking average depth of ground at 35 ft., the shaft to be timbered:—

Shaft sinking at $4 per ft. for 35 ft.	$ 140.00
Timbering and drifting	170.00
Average output per day about 360 sq. ft, of bed rock for 56 days	
Firewood, 2 cords per day for 56 days at $10 per cord	1,120.00
Wages for 10 men:—Foreman, engineer, pointman, fireman and 6 miners at $66 for 56 days	3,696.00
	$5,126.00

This does not include prospecting and locating of pay, cabins, hoiler house and plant, wear and tear on machinery, etc.; to cover these 30 per cent. to 40 per cent. would have to be added to the bill of expense. This would give the following approximate costs:—

To work ground (20,000 sq. ft.).	$5,126.00
To plant, etc.	1,538.00
	$6,664.00

which amounts to 33.25c. per sq. ft. or 7.5c. per cu. ft. This would be working with steam hoist and self dumper.

If instead of a steam hoist and self dumper a windlass is used, the men work in pairs, one underground and one on the windlass, and unless the ground is deep the shafts should be not more than 100 ft. apart. Windlass drifts are very much smaller and lower than steam hoist drifts. The usual pay in these drifts would be taken as about 3½ ft.; the average number of buckets on a 3½ ft. face would be about 200 per day, and the average bucket would contain about 7 pans. Two hundred buckets would mean about 235 cu. ft., or an area of about 67 sq. ft. of bed-rock.

The following is an approximation of the cost of drifting 30,000 sq. ft. of ground in this manner, working from 4 shafts of from 20 to 25 ft.

4 shafts at $95.00 per.	$ 380.00
Odd timbering, probably	20.00
800 buckets per day will strip about 270 sq. ft. and require	
12 men: foreman, engineer, pointman, fireman and 8 miners at $78.00 for 112 days	8,746.00
Firewood per day, 1½ cords at $10.00=15x112.	1,780.00
Total.	$10,926.00

Add 15 per cent. for tools, steam fittings and dead work, etc.

To work ground.	$10,926.00
To plant.	1,637.40
Total.	$12,563.40

which amounts to 41.847c. per sq. ft. or 11.95c. per cu. ft.

Drifting operations during the winter consist in first sinking the shaft to bed-rock and then running drifts across the pay within limits of the property. At the end of the drifts the ground is breasted out at right angles to the drifts, and if frozen very hard steam points are set in and left for 10 hours, then the thawed material is excavated, wheeled to the shaft, hoisted to the surface and placed in dumps and left there till spring. Excavation always proceeds towards the shaft, the miners filling in behind them with waste material and large rocks, as a protection to themselves and the unexcavated material. As a rule very little timbering is needed.

Drifting operations in the summer are the same as for winter with a slight difference due to direct sluicing.

When there is very little water available, and while it accumulates or is being used by another, a hopper built on top of the sluice boxes is filled with pay ready to be washed when there is a sluice head of water available.

Where there is plenty of water the material is hoisted by means of a self dumper and dumped out on to an apron inclined so that the material when dumped thereon will slide on to the sluices by gravity.

All solidly frozen deposits of less than 15 ft. in depth should be open cut. If this is done by manual labor it is classified as placer mining, if mechanical contrivances are used it is classified under the head of gravel mining.

The operation consists in first stripping the ground of moss and muck by directing the stream into a ditch, and men with picks and shovels move the material into the stream which carries it away. This special method is known as stripping by ground sluicing, and is by far the cheapest when there is sufficient water available.

If there is not sufficient water for ground sluicing, stripping and scraping of waste may be done by either steam or horse scrapers, at a cost of about 55c. per cu. yd. for steam and 60c. to 70c. for horses. The water in these workings is controlled by means of duplex pumps, or when a stream is available Chinese pumps are often employed.

In open cut work sometimes the pay can be shovelled directly into the sluices, or may be shovelled on to a platform and then into sluices, or shovelled into wheelbarrows and wheeled up to a self-feeding hopper, or hoisted to these hoppers by means of self-dumpers.

Shovelling directly into a sluice not over 5½ ft. in height and using a pick to loosen bed-rock, one man will do 4½ cu. yds. in 10 hours.

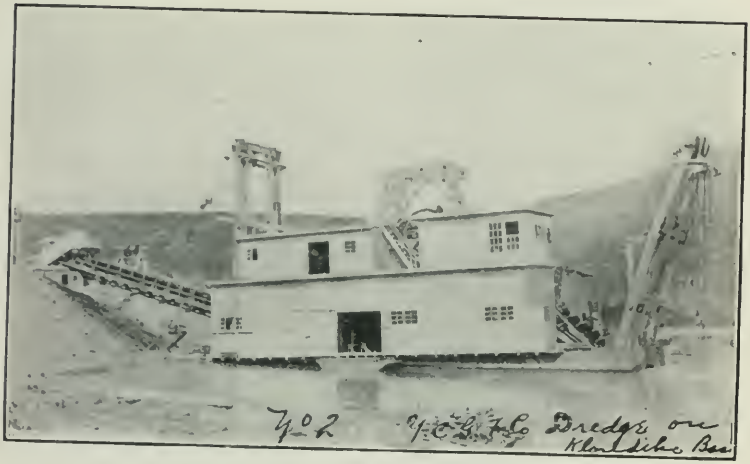
Shovelling into a wheelbarrow and wheeling to self-feeding hopper a distance of 50 ft., one man will do 3.5 cu. yds. in 10 hours.

Shovelling from a scaffold not over 6 ft. in height is the same as that of two men shovelling on to the scaffold, *i.e.*, 8 cu. yds. in 24 hours.

The duty of a man shovelling in a dump is 9 cu. yds. in 10 hours.

The author wishes to express his indebtedness to Mr. Beaudette, Government Consulting Engineer of the Dawson District, and to Mr. Geo. Armstrong, for their kindness in giving information and costs.

566.



Y. C. Goldfields Co's Dredge on Klondike Basin.

Retaining Wall and Cribbing on Cheechaco Hill, Bonanza.

THE CREIGHTON MINE OF THE CANADIAN COPPER CO., SUDBURY DISTRICT, ONTARIO.*

By L. Stewart, McGill University, Montreal, Que.

Introduction

The Sudbury nickel-copper district centres about the town of Sudbury, at the junction point of the Soo and main lines of the Canadian Pacific Railway, in Northern Ontario. Sudbury is 440 miles west of Montreal and 182 miles east of Sault Ste. Marie. The Algoma Central Railway runs out of Sudbury into the mining district for a distance of 13 miles, terminating at the Gertrude Mine of the Lake Superior Power Co., who own the railroad.

In the year 1907 this district mined 343,814 tons of ore, producing 10,530,000 lbs. copper and 21,490,000 lbs. nickel, making the Sudbury region the greatest nickel producer in the world. The only other competing region, New Caledonia, produced in 1907 about 20,000,000 lbs., exact figures not being available. It might also be remarked that for ore reserves and undeveloped prospects the Sudbury region also leads.

The entire output of 1907 was mined and smelted by two companies. The first and larger of these, the Canadian Copper Co., a subsidiary company of the International Nickel Co., N.Y., has its headquarters, roast yards and smelter at Copper Cliff, four miles west of Sudbury on the Soo line of the C.P.R. It owns many mines and prospects in the district, but in 1907 only three of these were worked; No. 2 mine at Copper Cliff worked for a few months, the Creighton mine, six miles west of Copper Cliff, and the Crean Hill mine, eighteen miles south-west of Copper Cliff.

*Paper entered for the "Student Competition, 1908," and awarded third prize by the judges.

The Canadian Copper Co. produces about four-fifths of the entire output of the district, and of this, 80% or about 60% of the output of the district, comes from the Creighton Mine.

The other company working in the district, the Mond Nickel Co., has its smelter and headquarters at Victoria Mines, twenty-two miles west of Sudbury on the Soo line of the C.P.R. Its mines are three miles north of the station.

The purpose of this paper is to describe the Creighton Mine, which boasts the distinction of being the largest and most valuable nickel deposit in the world.

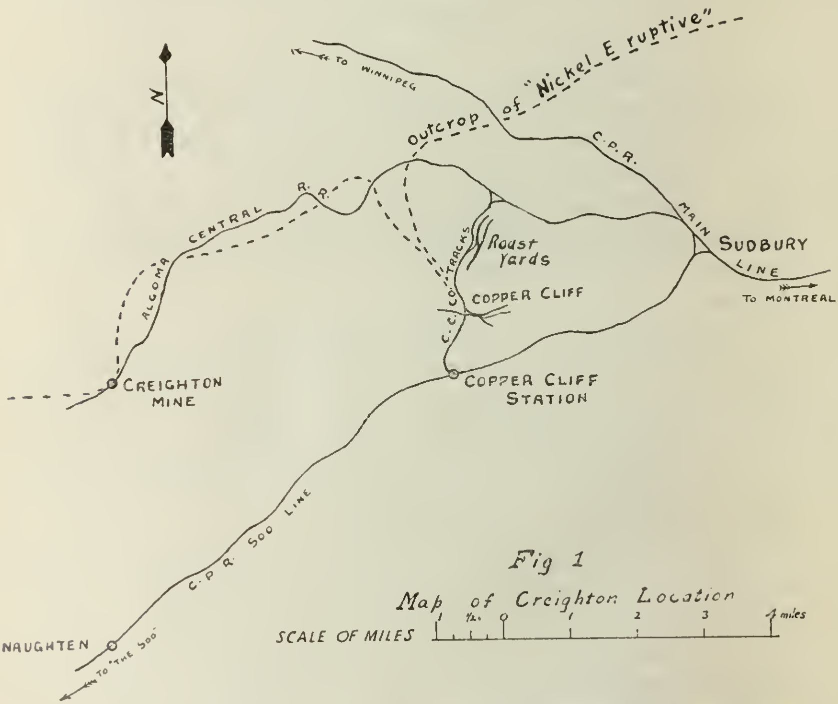


Fig. I. is a map of Sudbury and the vicinity, showing the Creighton and Crean Hill Mines.

GEOLOGY OF THE SUDBURY DISTRICT

The oldest rocks in the Sudbury region belong to the Laurentian and Huronian divisions and are classed together by the Ontario Bureau of Mines as Archean.

The Laurentian consists of a very coarse, flesh-coloured, granitoid gneiss and covers the greater part of the district to the north and west of Sudbury, also it appears beyond the Huronian eruptives in the south-west. It is, in fact, the most prominent formation in the region.

The Huronian (Lower) formation in the vicinity of Sudbury itself extends in a broad band about twenty miles wide to the north-east and south-west. It contains many varieties of eruptive basic rocks, such as diorite and gabbro, along with highly metamorphosed arkose, quartzites and gray wackes. Numerous diabase dikes cut all of these formations.

All of these older rocks are greatly faulted and broken up. The region in general is very rocky, with here and there a very sparse covering of glacial drift.

Resting on these older rocks, and having an eruptive contact with them, is a huge laccolithic sheet of what is known as the "nickel-eruptive," about a mile and a quarter thick, thirty-six miles long and sixteen miles wide. This sheet is in the form of a boat-shaped syncline with its pointed end to the north-east and its square end to the south-west. It is generally called the "nickel basin."

The rock in this sheet is norite (a variety of gabbro in which hypersthene has replaced hornblende) on the outer or under edge, and merges with gradual transition into a form of granite called micropegmetite on the inner or upper edge. Numerous dike-like offsets from the basic edge are found running into the surrounding country, some of them for a distance of eight miles.

Resting in the synclinal trough of the "nickel-eruptive" are more recent rocks of the Upper Huronian formation. These are of sedimentary origin and are conglomerates, tuffs, slates and sandstones.

A section along a north-easterly line across the middle of the "nickel basin" is shown in Fig. 2. This line if produced a few miles would intersect the town of Sudbury, which is south-east of the centre of the "basin."

ORE DEPOSITS

All the ore bodies so far discovered have been found around the basic margin of the "nickel-eruptive" or along the dike-like offsets from it. There has been considerable controversy over the origin of the ore bodies and their relation to the norite. One school of geologists claims that the ore has been deposited and concentrated by percolating waters. The best authorities, however, including Professor Kemp, Dr. Barlow and Dr. Adams, favor Vogt's theory of magmatic segregation, that is to say, that the ore and basic material of the molten magma by reason of their higher specific gravity accumulated at the outer or under edge of the eruptive mass while it was still molten, and that the ore, copper, nickel and iron sulphides, being the heavier, sank into the bays and hollows in the country rock, forming the ore bodies of to-day.

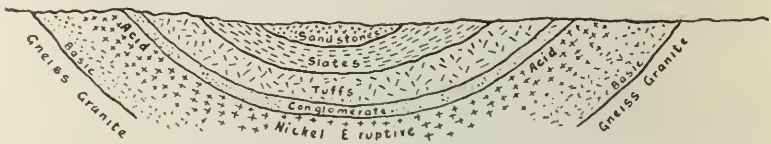


Fig 2

Geological Section across Nickel Basin

SCALE OF MILES 1 ½ 0 1 2 3 4 5 6 7 8 miles.

In favour of this view are the following facts:—

1. The ore is always found in the norite. No ore occurs without being associated with norite, and no norite along the lower or outer fringe of the nickel basin or in the offsets is entirely devoid of ore.

2. Norite and ore are mixed in every ratio from almost barren rock at the inner side to almost pure ore at the outside of the eruptive. This is the case at all of the ore deposits.

3. The adjoining gneiss, gray wacke, etc., has no ore spotted through it, although veinlets of ore penetrate it at places from deposits in the norite.

4. The freshest norite is found close to the ore deposits, while percolating waters would have altered the hypersthene in it.

5. Very few minerals accompanying water depositions are present in the ore deposits.

6. The ore deposits all over the district and in contact with different kinds of country rock are very similar.

7. The largest deposits are where bays or offsets of norite project into the country rock.

N.B.—The above account of the geology of the district is largely summarised from Report XIV. of the Ontario Bureau of Mines.

MINERALOGY

The ores of the Sudbury district are very uniform, three sulphides making up the whole of most of the ore bodies, and of these only two noticeable, pyrrhotite or magnetic iron pyrites and chalcopyrite or copper pyrites. The most important mineral, pentlandite or nickel pyrites, is scarcely ever seen free, it being usually enclosed in the pyrrhotite.

Pyrrhotite, the most abundant mineral, has a composition varying from Fe_5S_6 to $Fe_{16}S_{17}$. It has a pale bronze colour with bright metallic lustre but quickly tarnishes and weathers to the rusty gossan that is so conspicuous about all of the ore bodies.

The chalcopyrite, $Cu\ Fe\ S_2$, is bright yellow with metallic lustre. It readily weathers to azurite, malachite and peacock copper, but no deposits of these latter are found. The chalcopyrite and pyrrhotite are usually mixed in the ratio of 1:10 respectively.

Pentlandite is occasionally found free in small amounts in some of the richest mines in the region, notably the Creighton. It is not easily distinguished from the pyrrhotite. Its formula is (Fe Ni) S with varying proportions of nickel, usually about 35%. It is contained in the pyrrhotite in varying amounts but usually so that the pyrrhotite has an average value of 3.5% nickel.

THE CREIGHTON MINE

HISTORY

In the year 1855 great magnetic disturbances were noticed near the present Creighton Mine by Salter, an early land surveyor, and were put down to "the presence of an immense amount of magnetic trap." Samples of this trap were sent to Dr. Sterry Hunt for analysis, and he reported the presence of magnetic iron pyrites and magnetic iron ore generally disseminated through the rock; also the presence of titaniferous iron ore and a small quantity of nickel and copper. Nothing was done, however, towards prospecting the district, and it was not until the year 1884 that this large deposit of ore was discovered by the well known Sudbury prospector, Henry Ranger. In 1886 the Canadian Copper Co. secured the property and in 1900 they started to open it up. The first ore was shipped in 1901, and last summer, 1907, it was shipping over 1,000 tons of ore a day.

LOCATION

The location of the Creighton Mine is seen from the map, Fig. 1. The mine is situated six miles west of Copper Cliff on the line of the Algoma Central Railroad, and exactly on the line separating Snider and Creighton townships. The mine buildings and most of the workings are in Snider township. The Algoma Central R.R. and a good highway road give connections with Copper Cliff and Sudbury.

ORE DEPOSIT

The position of the mine with reference to the nickel eruptive is of interest, since it is thought that this accounts for the great size and richness of the deposit. The immense open pit shown in Fig. 3 is situated at the south-eastern corner of the largest and deepest bay of norite in the district, the width of the eruptive here being four and one-eighth miles. Here also is the greatest width of the whole nickel basin. It is thought that "the greatest amount of fluid ore accumulated beneath the greatest thickness of the overlying magma is at this point and was caught in the extreme end of the bay, which had no funnel-shaped outlet along a plane of faulting to allow the ore to push out as separate ore bodies along an offset."

Fig. 3 shows the location of the mine with reference to the norite on the north-west and the granitoid gneiss on the south-west. Fig. 4 shows a section across the great open pit.

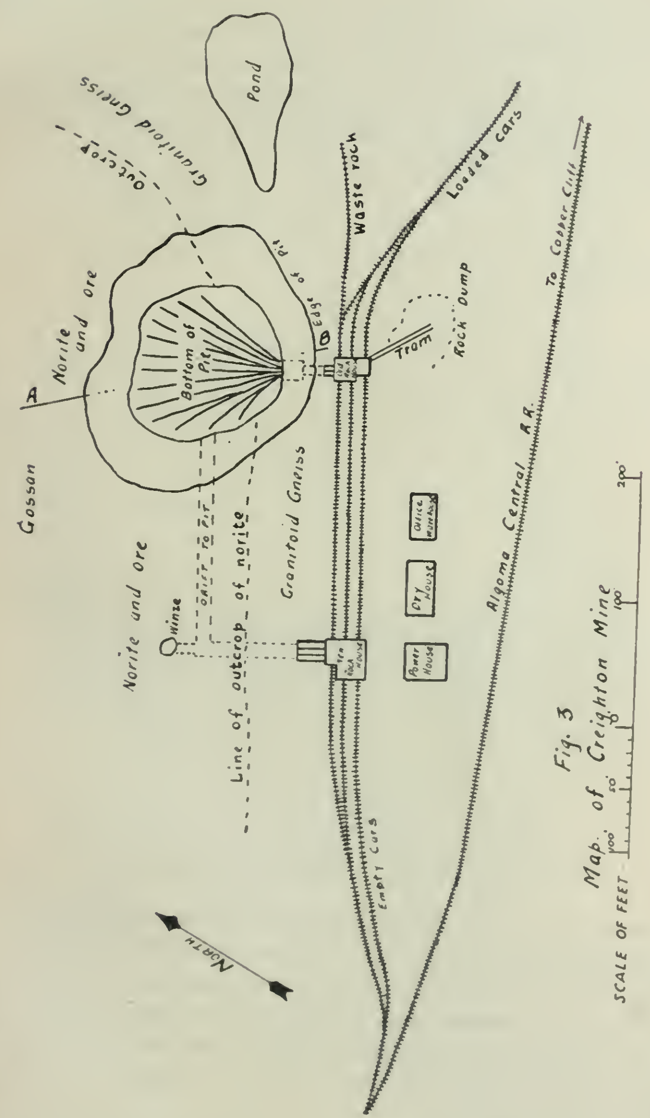


Fig. 3
Map of Creighton Mine

The granite dips about 50° to the north-west, but the dip varies considerably at different places and at different depths. It is coarse, flesh-coloured, granitoid gneiss, often porphyritic.

The norite on the north-west of the ore body is the usual coarse, dark gray variety, containing blebs of quartz and flakes of biotite. Much pitting of the surface is noticeable, due to the weathering of spots of ore.

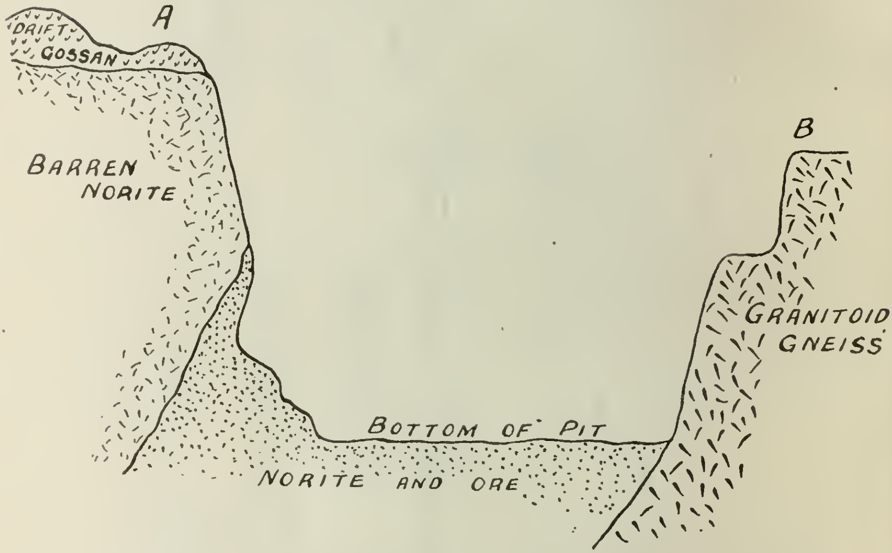


Fig. 4.

Section across pit on Line AB

There is no sharp dividing line between the norite and the ore. The one appears to merge into the other by gradual transition. The ore itself, as already mentioned, is the richest in the district and consists of almost pure chalcopyrite and pyrrhotite, containing an average of 5% nickel and 2% copper. An occasional horse of rock several feet in thickness is met with, but such occurrences are not usual.

The ore body extends to the south-west following approximately the outcrop of the norite, as shown in Fig. 3. A lot of careful diamond drilling has been done on it and the results indicate that the ore body is several hundred feet in length, with a width of about three hundred and depth of over five hundred feet. About 4,000,000 tons of ore was blocked out by the diamond drills before operations were suspended in this work.

To the west and south the ore body is covered with about eight feet of glacial drift and boulder clay, which is always stripped off before extending the edge of the pit. The ore runs right to the surface of deposit practically, as there is very little oxidized capping, the boulder clay having protected the minerals.

MINING OPERATIONS. (1) SHAFTS.

The first shaft at Creighton was sunk in the granite with a dip of 60° to the horizontal and in a north-westerly direction more or less at right angles to the outcrop of the norite. This shaft contains three compartments, two for 1¼ ton skips, and one for a ladderway and the different pipe lines and signal tubes. It is heavily timbered in pine, the sets being eight feet apart and connected by four lines of stringers 8 x 10″ deep on foot and 6 x 8 on hanging wall.

The skip tracks are made by laying a strip of ⅜″ thick and 3½″ wide along the top edges of the lower stringers. These tracks run from the bottom of the shaft right up to where the skip dump is placed at the top of the rock house, at the same inclination. The dump is merely a curve downwards of the end of the skip track, thus tipping the car forward as it is pulled up.

Levels were driven from this shaft at 60 and 160 feet vertical depth.

MINING OPERATIONS. (2) STOPING.

From the shaft on the 60 foot and 160 foot levels, cross-cuts were run into the ore body and raises run from 1st level to surface, and from 2nd. level to 1st. level. Stoping was then started in the walls of these raises and the ore broken down on to the level below and trammed to the shaft and hoisted. In time the 1st level was entirely opened to the surface and, somewhat later, the 2nd level likewise. As a result of these operations there is now a huge open pit about 350 feet in diameter and 160 feet deep as shown in Figs. 3 and 4.

The stoping operations of the present day are similar to those already mentioned. From the bottom of the pit the stopes rise in irregular steps to the surface. On these steps or ledges the miner sets his drill and drills vertical holes 10 feet deep into the ore body. The holes are spaced differently depending on the amount of rock in the ore.

The drills used are 3⅛″ Rand type working under 95 lbs. air pressure per sq. inch. With one of these a good machine man can drill and blast 30 to 40 feet per shift of 10 hours. Each machine man has an assistant or "helper."

The men go to work at 7 o'clock each shift, and drill until about 5.15. The holes are measured by the foreman and powder checker, and the men then go up to the powder house where the powder man gives them such powder as the foreman has estimated. They then go down and load up the holes and are ready to fire them at 6 o'clock after the men in the pit below have left off work. After blasting, the machine men and helpers go back to see that there are no misfires and also to scale down any loose particles that have not fallen down into the pit.

Blasting is done by 40% dynamite. It takes an average of 9 sticks of dynamite for each 10 foot hole. One of the sticks of dynamite in each hole has a detonating cap in it with fuse connected to it. The fuse burns at the rate of 2 feet per minute.

The sticks of dynamite are rammed into the hole, which has been blown clear of water, and fine muck, dirt, etc., is tamped down on top of them. The end of the fuse has been slit previously and a pinch of dynamite stuck into the slit to assist in lighting. A torch made of the wrappers of the dynamite sticks is used for lighting the fuses.

After lighting the fuses the men run to the nearest shelter, the buildings above ground or the tunnel on the pit level, for the blasting throws particles of rock and ore in every direction within a radius of 300 feet.

There is never any delay in the drilling in order to muck the stopes, for most of the material is thrown into the pit in blasting and what remains is scaled off by the machine men after the holes are fired, before the next shift comes on.

Mining Operations. (3) Sandblasting.

The ore from the stopes is blasted down on to the floor of the pit in irregular masses varying from ½ a foot to 4 or 5 feet in thickness. Anything larger than about 1 foot cube is broken on the pit floor before loading. Generally speaking about one-third of the ore from the stopes requires this treatment, which is locally called "sandblasting."

The operation of sandblasting consists in placing the necessary amount of dynamite on top of the chunk of ore, patting it into a small heap, sticking a 3 foot fuse capped at one end into it, and covering the dynamite with muck or sand from which is derived the name sandblasting. The end of the fuse is slit and has a small pinch of dynamite inserted therein to aid in lighting.

The sandblasting is done by "block holers" and their assistants. There is a "block holer" to each mine track in the pit and it is his duty to keep his track clear of large pieces of material. His assistant follows him around and covers the charge with muck as it is loaded on to the pieces of ore.

Sandblasting is done at 7 o'clock as each shift goes to work, the shots being fired as soon as they are all loaded, which takes about 25 minutes. Another sandblast takes place at 12 o'clock after the plant has shut down for noon hour. The object of the sandblasting is to break up such material as cannot easily be sledged. The "block holers" and their assistants sledge when they are not sandblasting, the ore being broken small enough to admit of its being shovelled into the tram cars by the trammers.

A partial separation of ore and rock is made down in the pit, the pieces of barren rock being piled together beside the different tracks to be sandblasted and hoisted, which is done once a week.

Mining Operations. (4) Tramming.

From the shaft on the pit level a cross-cut 20 feet wide, 8 feet high and 40 feet long, extends to the wall of the pit. From opposite the two skip tracks at the shaft, two main 19 inch gauge mine tracks extend along the tunnel and are connected by a double diamond crossover with the necessary switches. From these two tracks there branch at the edge of the pit thirteen tracks extending to all corners of the pit, as shown in Fig. 3. On these tracks run rectangular sheet iron 1½ ton tramcars with a gang of four to six men to load, and 2 or 3 men to push them. After shovelling their car full, the men push it towards the shaft, and as the tracks have a down grade of 8 inches per 100 feet the car is easily moved. At the shaft the back of the car is hoisted, sliding the muck towards the front, which is an iron plate hinged at the top. The lower end of this is released before up-ending, thus allowing the contents to slide out into the skip on the track below.

Nine or ten tramcars are usually in operation.

MINING OPERATIONS. (5) IN GENERAL.

The water from the pit and the shaft drains into a large sump in a short gallery back of the shaft. On a platform above the sump is a 3 cylinder pump geared to a 15 H.P. 3 phase 550 volt induction motor. This raises the water to the surface through a 4 inch iron pipe.

All signalling is done by electricity. A bell circuit runs up the shaft connecting with a bell in the power house above. The wires are taken down the shaft in a ¾ inch iron pipe. Signal boxes are placed at the bottom of the shaft and at the surface level.

The shaft and the tunnel at the bottom of it are lit by incandescent lamps set in water-tight sockets. The wires are taken down in iron pipes similar to the signal wires.

The big open pit is lit at night by acetylene lamps placed between the tracks. The machine men and most of the pit men carry small oil torches in their caps.

The mine is worked continuously day and night in ten hour shifts from 7 a.m. Monday until 11 p.m. Saturday. On Sunday the stopes are thoroughly scaled down and such repair work as is necessary executed.

ROCKHOUSE. NO. 1 BEFORE BEING REMODELLED IN 1907.

The stringers carrying the skip tracks are extended past the collar of the shaft to the top of the rockhouse, 60 feet vertical height. These skip tracks are supported on a trestle work of timbers.

There is a break in the skip tracks about half way from the collar of the shaft to the rockhouse, and the tracks are bent down to dump the skips into chutes leading to cars on a railway track below. This is used only in hoisting waste from the mine, and the breaks are closed by blocks making a continuous track when ore is to be hoisted up to the rockhouse.

The skip discharges its contents upon a grizzly placed below the dump at the top of the rockhouse. This grizzly consists of rails 15 feet long placed 2 inches apart in the clear and sloping down towards the crusher floor at an angle of 45°.

The finer material goes through the grizzly into a hopper below, while the larger stuff slides down the rails and drops on to the crusher floor which forms the top storey of the rockhouse. Here a separation of rock and ore takes place, any low grade material being set aside and trammed out along a trestle to the rock dumps. The material in these dumps averages .5% copper and .4% nickel.

The large pieces of ore are shovelled into two Blake crushers, one 30 x 18 inches and one 28 x 16 inches in size. A gang of eleven men does this work.

Below each crusher is a hopper leading to a revolving screen. There is a revolving screen under the hopper from the grizzly also.

These screens are about 18 inches diameter and 8 feet long. They slope away from the hopper at an angle of 25°. The holes in the screens are ¾ inches in diameter, and as it slowly revolves the fines drop through into ore bins placed below. The larger crushed ore is emptied on to a picking table at the lower end of the screen.

These picking tables are made of sheet iron 16 feet long by 3 feet wide, with an edge 2 inches turned up along the sides. They slope away from the screens at an angle of 8° and are given a forward bumping movement which jolts the ore along. Six pickers sit along the sides of each table and pick out any rock that appears and throw it down into bins beside them. The picked ore drops over the end of the tables into large ore bins.

Fig. 5 shows a plan of the operations in the rockhouse.

Under the bins in the lower part of the rockhouse run two railway tracks. Empty cars are run underneath and loaded by opening a gate on the bottom of the bins. About twenty cars per shift are loaded in this manner. Two trains of ore go to Copper Cliff each day via the Algoma Central.

All machinery in the rockhouse is driven by belting and shafting from a 50 H.P. 3 phase induction motor set on the ground floor of the building.

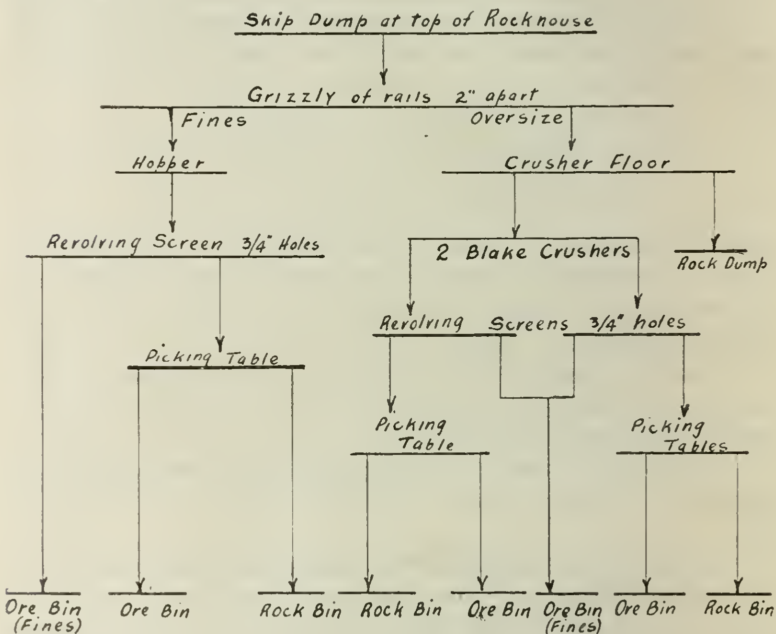


Fig. 5

Plan of operations of Rockhouse

The rockhouse is a wooden structure 42 x 46 feet and 72 feet high. It contains two floors, the crushing floor and the picking floor, the lower part of it being occupied by the ore and rock bins.

Power House and Hoisting

All machinery at Creighton, and for that matter in all departments of the Canadian Copper Co., is run by electricity.

Power at Creighton is received from the main sub-station at Copper Cliff at 35,000 volts, over a 3 phase transmission line.

Three 275 K.W. transformers reduce this voltage to 550 volts for use around the plant. Power is distributed from a large switchboard to the compressors and hoists in the power house, to the rockhouses, mine pumps, and to a pump at a lake one quarter of a mile away; also for lighting the works.

The hoisting equipment consists of two Denver Engineering Co. 3 drum hoisting sets. The drums are 48 inches in diameter and are connected by means of friction clutches to a main driving shaft, which is geared to a variable speed 150 H.P. 3 phase induction motor.

The hoisting sets are placed at right angles, there being one for the shaft already described and another for a new shaft to be described later. The skips are hoisted at the rate of six hundred feet per minute.

Each hoist is operated by five levers, one to control the motor, three for the friction clutches connecting the drums to the driving shaft, and the fifth to apply a brake for stoping. Three systems of rotating rings and a pointer are set in front of the operator, one geared to each drum, and he knows the position of each skip by the position of the pointer in reference to the rings.

In the shaft just described there are only two skips and a system of balanced hoisting is employed, two of the drums in the hoisting set being run simultaneously, the other not being used at all. In the second or new shaft, which was beginning to hoist at the close of the summer of 1907, three skips are working and are hoisted independently.

One compressor furnishes air for the whole plant and is situated beside the hoisting sets in the power house. It is a Rand engine and furnishes air at 100 lbs. pressure, at the rate of 1,635 cu. feet per minute, to a cylindrical reservoir outside of the power house. Air regulation is effected by automatic Corliss stop valves.

The compressor is driven from a shaft directly connected to a 300 H.P. 3 phase induction motor running at 500 R.P.M. Air is piped from the power house by 8 inch iron main pipe lines to the principal centres of distribution.

There is in the power house a 1,000 gallon 6 inch 3 stage turbine fire pump directly connected to a 150 H.P. 3 phase induction motor. This pump is fed from a steel stand pipe of 60,000 gallons capacity, situated just outside of the power house. The stand pipe is fed from another electrically driven turbine pump situated near a small lake one quarter of a mile away, which works continuously. The necessary water for use around the plant is piped from the stand pipe.

NEW WORK

NO. 2 SHAFT

The company at the close of the summer of 1907 had just completed and was starting to put into operation a new shaft and rockhouse at Creighton.

The new shaft is a four compartment one, containing three skipways and a ladderway. It is sunk at an angle of 47° to the horizontal in a parallel direction to the old shaft, which is 300 feet north-east of it, as shown in Fig. 3. It is fitted for 3 ton skip cars and has wider compartments than has the old shaft. The timbering is similar to that of the latter, except that the first 50 feet are finished in concrete

At the level of the big pit a cross-cut 40 feet long was driven in to the ore body. A raise was then started to the surface and a winze sunk to meet it. This connection has already been made. A drift was also started towards the pit, which work was not finished when the mine was last seen, August, 1907. The idea is to tram the greater part of the ore from the pit through this drift to the new shaft, and to work both of the shafts continuously.

Below the level of the pit the new shaft has been sunk another 100 feet and a cross-cut was being driven from it to the ore body.

NO. 2 ROCKHOUSE.

The 3-ton skips run up the new shaft and dump on to the large grizzly at the top of the new rockhouse. This grizzly is similar to the one in the old rockhouse and several feet wider, but instead of leading to the crusher floor it leads into two chutes running directly to the two Blake 30 x 18″ crushers. By this system the necessary labour is greatly cut down, only one man being needed to watch the chutes instead of the eleven men which are required to feed the crushers in the old rockhouse. The ore from the grizzly and from the crushers goes through the usual revolving screens, but the screens empty on to rubber belt conveyors instead of picking tables. The belts, 3 feet wide, move very slowly and the rock pickers remove the rock as the belt carries the material past them. The belt empties its load of ore into an ore bin, and if necessary it can empty into a chute dropping on to a second belt which feeds a second bin. In this way the new rockhouse is given double the capacity of the old.

The building and bins are of wood and rest upon heavy concrete arches spanning the two railway tracks that pass underneath it. The usual rock chutes with their track are placed below the skip tracks in front of the rockhouse.

There is a 50 H.P. 3 phase induction motor connected to each crusher and its dependent equipment, screens, belts, etc.

YARDS

The Algoma Central R.R. runs close to the workings, as is shown in Fig. 3. On it, about two hundred and fifty yards north of the new rockhouse, is situated the switch from which run the tracks to the mine. The tracks leave this switch on a sharp up grade for the first two hundred feet and run from this point on along easy down grade underneath both rockhouses, curving back to the main line of the railway at the lower end of the yard.

By this arrangement of tracks all moving of cars is done by gravity. The Algoma Central shunts the empty cars in over the hump at the upper end of the yard, and the car loaders, when they require empties, merely release the brakes and start them rolling down to the rockhouses. When loaded the cars are run on to the curve at the lower end of the yard, and are drawn out by the Algoma Central engine on its way out of Creighton. All cars are weighed on their way out at a scale house placed on a siding beside the main line of the Algoma Central.

BUILDINGS

At the mine there has just been finished a set of brick steel framed buildings. There is a 60 x 30 foot office and warehouse building; an 80 x 36 foot wash house or "Dry" for the men to change their clothes and wash up in, and in which are 205 lockers, several long enamelled wash troughs, shower baths, etc. The power house has already been mentioned.

The company also has a house for the mine superintendent, close to the mine, and owns all the houses and buildings in the village behind the mine.

The buildings at the mine are heated by a steam heating plant placed at the basement of the warehouse.

ORGANIZATION

Under the mine superintendent, or mine captain, come the foremen of the mine, the No. 2 shaft, the yard, and the No. 1 and No. 2 rockhouses. The mine foreman has charge of all operations in the big pit and under him is a "straw boss" in charge of the trammers. The rockhouse foremen are assisted by "straw bosses" in charge of the rock pickers. The yard foreman has charge of all surface labour, tracks, rolling stock, etc., and is only on duty during the day. The foremen take the time of the men working in their departments, which time is checked by an outside timekeeper, who takes the time of all the employees on each shift.

The rockhouse foremen make out reports for each shift, showing the amount of rock trammed out to the dumps and the amount of rock unloaded from the bins. The hoistmen send in reports giving the number of skips of rock or ore hoisted on each shift.

From these reports and the time books of the foremen the clerk in the office makes out each day what is termed the "Product and Labour" report. This report shows the number of men working in the different departments of the works, day shift and night shift, their rate of pay and total wages; also the tonnage of ore and rock hoisted on the different shifts including the waste rock sent to the dumps. Totals of cost and of production are brought down, and the cost per ton of labour for the day of twenty-four hours is tabulated.

In addition to this report, detailed reports on the blasting operations are filled out by the outside time and powder checkers. One of these reports deals with stoping and shows the number and depth of the holes drilled by each machine man, along with the dynamite fuse and caps allotted to each hole. The other report covers the sandblasting and gives the dynamite, fuse and caps used on each rock along with the total number of shots.

Special reports on construction and development, similar to the above, are also made out each morning.

All of these reports are phoned into Copper Cliff in detail and there are filed and entered up along with similar reports from all of the other workings. The reports are also filed at the mine office.

IN GENERAL

The Creighton Mine is entering upon a period of increased production. For the past year the company has been remodelling the plant with this end in view. The old steam power plant was replaced in March, 1907, by the electric plant already described. The new shaft and rockhouse were just being completed in August, 1907.

As the plant derives its power from a large hydro-electric installation on the Spanish River, owned by the Canadian Copper Co., this item of cost is greatly reduced.

When both shafts and rockhouses are working at their full capacity, the present output of about 1,000 tons per day ought to be increased to something like 2,400 tons, making the Creighton Mine one of the largest mines in the Dominion of Canada.

REFINING OF SILVER BULLION CONTAINING ARSENIC AND ANTIMONY.*

By B. Neilly, University of Toronto, Toronto.

The following work was suggested by a paper on *The Refining of Gold Bullion*, read by Dr. T. Kirk Rose in 1905, and found in Vol. XIV, Transactions of the Institution of Mining and Metallurgy.

In his experimental work, Dr. Rose did not confine himself wholly to gold bullion, but proceeded to show that even in the case of silver bullion, the base metals could be oxidized off by passing a stream of oxygen through the metal. In his early work he used only pure oxygen, but in subsequent experiments he used air and found the results obtained were quite as satisfactory. In the case of gold, he found that by this method it could be reduced to the pure state with very small losses.

The writer applied Dr. Rose's method to the refining of silver bullion containing arsenic and antimony, but found that it required very careful manipulation to prevent spitting. The pipe immersed in the molten metal gradually corroded away, the end broke off suddenly and the pressure being reduced, particles of silver were projected out of the crucible. In addition to this, the method was slow. After passing a current of air through the metal until the fumes apparently ceased to come off, it was cast and assayed only 92% silver. It was again melted down and air passed through. At the end of ten minutes no fumes were visible, but on withdrawing the pipe and allowing the air to play upon the surface, copious fumes began to rise at once. This method was continued and, from the results that follow, it would appear that blowing on the surface rather than through the metal is much more satisfactory.

The apparatus at our disposal consisted of a crucible furnace

*Paper entered for the "Student Member's Competition 1908" and awarded an "Honourable Mention" by the judges.

No. 6 and a cyclone crucible furnace with air blast as manufactured by Fletcher, Russel & Co. The bullion was fused in Battersea graphite crucibles and the air was conveyed by a rubber hose from a Roots No. 08 blower driven by ½ h.p. motor. To the end of the hose was attached a 22-inch fire-clay pipe, ¼-inch in diameter, to convey the air down to the surface of the metal. This was then suspended from above in such a way that it could be raised or lowered through a hole in the asbestos top to any required position.

In order to get rid of any nickel, copper or cobalt present, along with as much arsenic and antimony as possible, it was decided to form a speiss. The bullion was melted down in the cyclone furnace at a temperature of about 1140°C, and iron in the form of nails added until they were unattacked by the arsenic and antimony present.

The crucible was then removed and cooled suddenly. Under these conditions the speiss separated cleanly from the bullion.

This bullion was again melted down (temperature about 1098°C) with enough flux composed of sand and borax (2:1) to form a thin covering on the top of the molten metal. The air with sufficient pressure to cause a depression of say ¼ inch on the surface was then blown on the metal until the arsenic first and then antimony were all oxidized off and the bullion pure.

The end point is easily determined. Samples are dipped out and, after cooling, hammered. If they are inclined to be brittle to the least degree the metal still retains some impurities. Even a small fraction of one per cent. impurity will cause it to crack. Again on becoming pure the metal changes from a white to a clear sea green colour.

The bullion used in the first four experiments assayed as follows:—

Silver	80.9%
Arsenic	7.4%
Antimony	9.6%

Nickel, cobalt and copper not determined.

The charge used in each case was in the neighbourhood of 6 lbs.

EXPERIMENT No. 1.

General method used and time required for blowing, 3 hours and 40 minutes.

Loss sustained up to the end of speissing where it assayed 83.8% silver.....................0.11%
Loss due to volatilization, slag, etc.............0.66%

Total loss for all reasons..................0.77%

EXPERIMENT No. 2.

Used same method as before but tried to speiss with magnetite, without success, in the end having to remove it. Again used pure borax as flux. Time required for blowing was 3 hours 50 minutes.

Loss including everything.....................0.91%

NOTE.—The crucible in this case was badly corroded and no doubt some of the loss occurred in removing the magnetite.

EXPERIMENT No. 3.

In this case did not speiss, but began blowing at once. At the end of 1 hour 20 minutes it assayed 87.8%, and at the end of 4 hours it ran 96%. It still required 2 hours to bring it to the final stage.

Loss including everything..................... 0.9%

The time was long and it would appear that the speiss is useful if only for the removal of some of the antimony.

EXPERIMENT No. 4.

Followed general plan carefully assaying slag and speiss.
Time required for blowing was 3 hours 45 minutes.
Total loss allowing for everything was..........1.08%
Speiss assayed 0.46% and accounted for a loss of.0.08%
Slag assayed 0.79% and accounted for a loss of..0.13%
Loss due to volatilization, etc..................0.87%

NOTE.—In this case the crucible broke and in recovering the bullion there must have been some mechanical loss.

EXPERIMENT NO. 5.

The bullion used here assayed 88.7% silver and the impurity present was mostly arsenic with very little antimony. Time required to blow 3 hours.

After speissing it assayed	94.02% silver.
Total loss for everything	0.98%
Speiss assayed 0.46% and accounted for a loss of	0.13%
Loss due to slag volatilization, etc.	0.85%

EXPERIMENT NO. 6.

This was by all odds the most careful determination made. Starting with a bullion assaying 80.15% silver the impurities being arsenic and antimony. Time required for blowing 4 hours.

Total loss		0.79%
Speiss assayed 0.45% and accounted for a loss of	0.08%	
Slag assayed 4.8% and accounted for a loss of	0.12%	
		0.20%
Loss due to volatilization		0.59%

In the first four experiments the bullion after speissing assayed between 83.2% and 83.8%, and on remelting and adding more iron it was found impossible to raise the silver content. Apparently the affinity of iron and silver for arsenic and antimony at this stage is equal.

In the case of the bullion containing arsenic almost entirely as its impurity; it could be speissed up to 94% but no further.

Summarizing the results, it is found that the average total loss allowing for everything was 0.88%. Of this (say) the speiss contributed 0.1% and the slag 0.12%. Then the loss due to volatilization and mechanical means is placed at 0.66%.

No attempt was made to collect the flue dust, but on disconnecting the furnace and scraping out the flue, a sample of 200 grs.

was collected that assayed 2.2% silver. On volatilizing this in an open tube small particles of metallic silver were left behind, showing that some of the silver had been carried over mechanically.

In Plattner's *Rostprozesse*, losses due to the oxidization of silver at high temperatures are dealt with largely.

First he records that in passing hydrogen or carbon dioxide over silver at high temperatures there was no loss. In heating silver in the presence of oxygen and arsenic or antimony the losses were not so high as where sulphur, iron or copper were present. He reasoned that the silver on being heated first changes to the oxide. Now when arsenic and antimony are present they unite to form arsenates and antimonates and are themselves oxidized, thus protecting the silver. After the arsenic and antimony have been removed the loss becomes heavy. Dr. Rose found that on passing oxygen through 10 qrs. of molten silver for 40 minutes the loss was as high as 8%.

Plattner exposed a finely powdered smaltite ore carrying about 50 oz. to the ton in silver to a high temperature and collected the flue dust in a long pipe.

2	feet from	furnace	residue	assayed	10%	silver	value of ore.
12	"	"	"	"	4%	"	"
36	"	"	"	"	2½%	"	"
98	"	"	"	"	1/10%	"	"

In this dust he found a portion of the finely divided ore and on investigating concluded that the mechanical loss was proportional to the amount of finely divided material carried over. Later he mixed the finely divided silver with powdered quartz and his loss was over 10%.

After many experiments such as these, Plattner concluded that the loss due to volatilization and mechanical means was influenced by the amount of surface exposed.

Now in the method described in this paper only a thin covering of acid slag is used and the surface exposed is small, since it depends on the amount of slag displaced by the air blast.

About 70% of the total loss is charged to volatilization, and from Plattner's experiment with flue dust it would appear that this could be greatly reduced by the use of a dust chamber.

No difficulty was experienced in refining the bullion to 99.985%, and since the loss is exceedingly low and the cost of refining small, it looks as though it might be made use of commercially.

Section No. 1 assays:—

Original bullion	Ag...80.9%
	Sb... 9.6%
	As... 7.4%

Co and Ni not determined.

Section No. 2 assays:—

Bullion blown	Ag..88.33%
	As.. 2.13%
1 hr. 20 min.	Sb.. 9.54% by diff.

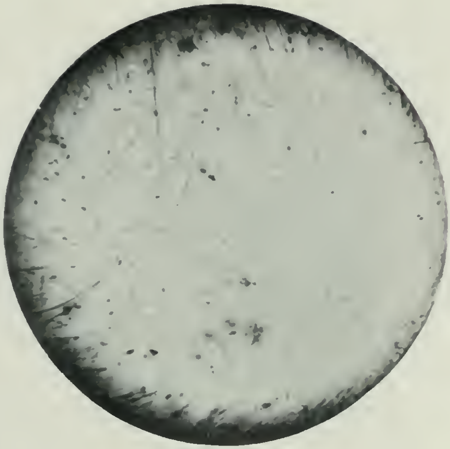
Section No. 3 assays:—

Refined bullion	Ag..99.985%
	As........
	Sb........

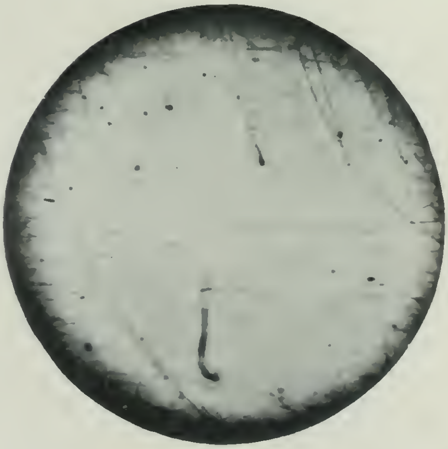
Section No. 4 assays:—

Bullion from As ore	Ag. .94.02%
after speissing ...	As.. 3.00%
	Sb.. 2.98% by diff.

Bar Broken at 96



Section No. 1



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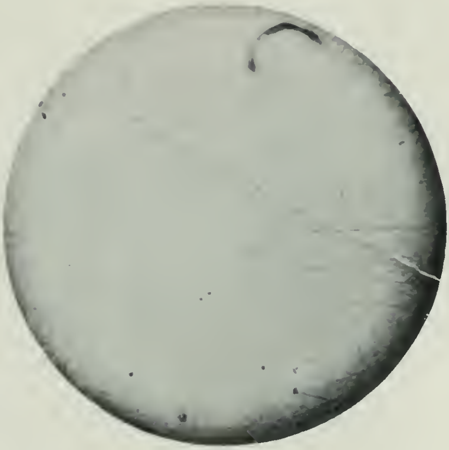

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COMPILED BY F. J. NICOLAS.

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