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CONTAINING THE

PAPERS AND PROCEEDINGS OF THE MEETINGS
OF THE INSTITUTE.

EDITED BY THE SECRETARY.

VOLUME V.

PUBLISHED BY AUTHORITY OF THE COUNCIL
AT THE SECRETARY'S OFFICE.

OTTAWA, AUGUST, 1902.

NOTICE.

The Institute as a body shall not be responsible for the statements or opinions advanced in the papers which may be read, or in the discussions which may take place at its meetings.

(*See By-Laws.*)

THE LATE J. RODERICK ROBERTSON

General Manager of the London & British Columbia Gold Fields, Nelson, B.C., accidentally killed in New York, 27th January, 1902.

NOTICES TO MEMBERS.

BRITISH COLUMBIA MEETINGS.

A meeting of the members of the Institute will be held at Nelson, British Columbia, on the evenings of Wednesday and Thursday, 10th and 11th September next. By special arrangement made with the Canadian Pacific Railway members will be carried from any point on this railway to the place of meeting and returned for a SINGLE FARE. In order to secure the benefit of this liberal concession members when purchasing their tickets must obtain the usual form of Standard Convention Certificate from their ticket agent and this will be signed by the Secretary at the meeting.

VISIT OF THE LAKE SUPERIOR MINING INSTITUTE.

Arrangements are proceeding for a joint meeting of the Canadian Mining Institute and the Lake Superior Mining Institute, to be held at Sault Ste. Marie, Ontario, August, 1903.

INSTITUTION OF MINING ENGINEERS.

The Council has made arrangements whereby members of The Canadian Mining Institute are permitted to purchase copies of the Transactions of the Institution of Mining Engineers of Great Britain at the special rates named below :—

Vols. 1, 2 and 3, 25 shillings each, post free.

Vol. 4 to date, 10 shillings each, post paid.

All applications and remittances for these copies should be addressed to the Secretary.

SUBSCRIPTIONS.

Members are reminded that subscriptions for the ensuing year were payable at the Annual Meeting, 1st March last, and arrears should be remitted without delay to the Treasurer, Mr. John Stevenson Brown, Temple Bdg., Montreal.

LIBRARY AND READING ROOM.

The Library and Reading Room (Room IV., Windsor Hotel, Montreal) is open daily for the use of members from 10 a.m. to 6 p.m.

CHANGE OF RESIDENCE.

The Secretary will be obliged if members will notify him promptly of any change in their address.

B. T. A. BELL, SECRETARY.

INDEX TO PAPERS.

STUDENTS' PAPERS.

The following of the above papers have been submitted in competition for the President's gold medal and the prizes annually awarded by the Institute:

GENERAL INDEX.

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22 Plates in ms. paged as follows —

18^{a} 56^{1-6}, 76^{a} 78^{1-4} 80^{a}

$214^{a\,b}$, 256^{a} 268^{a} 272^{a} 310^{a}

446^{a} 484^{a} 504^{a}

PAPERS.

Notes on some Work recently done in the Mining Laboratories of McGill University.*

By J. B PORTER, Ph.D., M. Inst. C.E.. Professor of Mining and Metallurgy.

The Canadian Mining Institute and its predecessor in this Province, the General Mining Association of the Province of Quebec, have for many years consistently pursued a policy of giving every encouragement in their power to young men engaged in the study of mining.

Bona fide students of Mining and Metallurgy are admitted to the Institute at a nominal fee as student members, and valuable prizes are annually offered for their competition. The policy is in fact even more liberal than this, for the ordinary meetings have for several years been open to our students regardless of membership, and it is not now necessary for even the competitors for prizes to join the Institute, although we of course wish them to do so.

The fruits of this policy are to be seen in our Transactions, in which there are a number of excellent papers written by students of one or another of our Mining Schools ; and any one who has attended the meetings of the last two days must have noticed the large number of young men who have been present. Today we have them with us in even greater force than before, and all of our members who are interested in educational work and in the future of our Institute, must be greatly encouraged by these evidences of their desire to listen to our papers and discussions, and to take part, so far as possible, in our proceedings.

In view of this I trust that I may be pardoned if I cast the few words I am about to say, more in the form of an exposition of my methods of teaching than is justified by the title of what our secretary has been pleased to call my "paper". As an additional reason for what I am about to do, I beg to call attention to the fact that the remainder of this session is to be devoted to the student papers submitted in competition for this year's prizes. Surely no professor could have a better excuse for talking "shop."

*This address was given as an introduction to the Students' Papers presented at the Annual Meetings in 1901.

McGill was the first of the Canadian Universities to institute a regular course in Mining Engineering. This was announced in 1871, and the first graduates were given diplomas in 1873. It is interesting to note that only three Americian Universites preceded us in this matter, Columbia School of Mines in 1867, Massachusetts Institute in 1868, and Lehigh in 1871.

At first Massachusetts Institute alone had laboratories, and the others—including of course McGill— made no attempt at any laboratory teaching except that of Chemistry and Assaying.

As time went on the others acquired more or less complete mining laboratories, but at McGill the growth was in other directions, and up to five years ago the only mining apparatus available was what my predecessors, Dr. Harrington, Mr. Carlyle, and Mr. Hardman, had got together with their own hands. It is the more to their credit that, in spite of such meagre facilities, these gentlemen turned out a lot of mining engineers, who have carried the name of McGill well to the front in both Mining and Metallurgy, not only here in Canada, but, as Mr. Bell said last night, in the United States, Mexico, and South America, and I may add in Australia and Africa as well.

In the meanwhile not only the Mining Schools in the States had secured equipment, but two strong Mining Schools in Canada (Kingston and Toronto) had developed courses and commenced to equip laboratories.

At last, just about five years ago, Sir William Macdonald turned his attention to our profession, and soon after announced his intention of giving McGill a mining equipment of the first rate.

I had the honor to be appointed the first Macdonald Professor of Mining and Metallurgy, and to me fell the task at once very interesting and extremely arduous of designing a laboratory, securing and installing the apparatus, and organizing the methods of instruction.

Laboratory teaching in Ore Dressing and Metallurgy may be of three kinds:

1st. Purely theoretical with small apparatus, requiring methods of work similar in scale to those of the chemical laboratory. Such work is extremely useful, especially in getting at fundamental principles, but if only this type of study is carried on, the student is likely to get a very incomplete conception of his subject.

2nd. Highly practical work on a scale of "almost 12 inches to the foot", as Professor Richards calls it. The best example of teaching of this sort is probably found at the Camborne School of Mines in Cornwall where the school owns a mine and a dressing works, and each student is required to do quite a good deal of real work as a set part of his course.

3rd. A combination method in which so far as possible the good features of the first and second are joined.

We have tried to lay out our laboratories on this third plan, and as we are at last really in working order I may be permitted a moment to explain what we do, or at least try to do, for our students.

I shall not describe the laboratories, for I trust that you will visit them and see for yourselves. Even the members who visited us last year, will find if they come again many additions, especially to the accessory apparatus that is so essential to the successful use of all laboratories, whether educational or merely experimental.

Nor shall I detail our course, which we fully set forth elsewhere, but I may say in this connection that we strive first to ground our men thoroughly in the essentials of all engineering, namely Physics, Mathematics, Surveying, Drawing, etc. We then give them elementary theoretical courses in Engineering, Mechanics, Chemistry, Geology, Mineralogy, Ore Dressing, and Metallurgy; each course of lectures being demonstrated and confirmed by laboratory work.

After these have been mastered, we have a field school in surveying and a six weeks' summer school of practical mining, which we hold in some one of the large mining districts.

Finally, after all of this preparatory work, we give our men one final year of advanced work in the especial subjects of their profession.

In this year they do their most serious mining laboratory work. First, they witness and to a certain extent help in a stated number of standard operations, a stamp mill-run, coarse concentration on jigs, slime concentration on tables and vanners, and a day at each of the roasting furnaces, and several days at the water jacket smelter.

These large tests are paralleled and checked by a number of little runs made by the individual students, who put through complete tests on 50 and 100 lb. lots, using simple apparatus, such as the miner's pan and hand jigs so far as possible, but when necessary making use of working models of the larger machines.

As soon as these tests are completed, each man is required to take up some one comparatively large problem in ore-dressing or metallurgy and the remainder of the year is devoted to working this out to a successful conclusion.

As an illustration of this final work I may name the following as some of the subjects of the current year:

1. The comparison of different methods of crushing, as affecting the proportion of fines.
2. The losses of value in the different classes of slimes resulting from crushing of various gold and silver ores.
3. The effect of different degrees of crushing and grinding and of other variations in treatment, on the recovery of values in gold and silver amalgamations.
4. The comparison of Wilfley and Frue concentrators on ores of different sizes and kinds.
5. The magnetic treatment of various Canadian ores with a view to their concentration, or the elimination of impurity.
6. The effect of washing on several kinds and sizes of Canadian Coals.
7. The leaching of concentrates and tailings from certain Canadian gold mills.
8. The electrolytic refining of certain metals.

I might extend this list, but enough is given to show the wide choice offered the men and the practical bearing of their work.

In each case, the theoretical side must be worked up, and small scale experiments made, leading to and culminating in one or more fairly large tests; and it is very satisfactory to note that our equipment is sufficient, thanks to Sir William Macdonald's munificence, to enable all of these operations and more to be conducted at once without serious interference.

Most of this work results in nothing very startling, for our chief duty is to teach young men the elements of their profession, and there is little time left for advanced research ; but even in this matter of fact work, valuable data are constantly accumulated and occasionally new results and new combinations are obtained. Furthermore, as we get our educational work more and more in hand, we are beginning to find time to do a little experimenting ourselves. This second function of an experimental laboratory is scarcely less important than the first, but must come after it. As time goes on, I trust that we shall be able to make the McGill laboratories of very great value to Science, to the Mineral Industry, and perhaps even to the individual mining engineer. As a mere taste of what may be done, I shall now give some details of a few of the more advanced researches that have been carried out, or are being carried out under my charge.

1. In conjunction with one of the officers of the department of Physics, Mr H. M. Tory, we have experimented on the melting points of gold, silver, copper, etc. and thanks chiefly to Mr Tory and my late Assistant Mr Yuile, extremely interesting results have been attained, especially in the exact determination of high temperatures. Degrees of heat as high as 1100 or 1200 centigrade have been measured and re-measured with an accuracy and ease probably never heretofore attained.

2. The concentration of Molybdenite, which so far as I know has never heretofore been attempted, has been quite successfully accomplished, and a high grade concentrate obtained from very low grade rock by a somewhat unusual series of crushing, jigging, and sizing operations. The process is probably not commercially applicable to the particular ores on which we experimented, but might well be used on similar ores occurring in larger quantity or in more favourable situations.

3. The concentration of Chromite. This mineral is valued for its Cr_2O_3 and its price in the markets of the world enhances very much as the tenor of chromic oxide increases, the critical point being 50% in most cases. The concentration of chromite on jigs is an old story, but there are in this Province many chromites which jigging fails to raise above 45-48%. We find that a judicious combination of magnetic separation with jigging or other gravity separation, raises the Cr_2O_3

several percent above the result obtained from either alone, and in the cases of ores which fall below 50% without this treatment, but rise above 50 by means of it, the extra cost will no doubt be more than met by increased values.

In this connection I may say that the late Director of the Geological Survey was very hopeful of valuable commercial results in this matter, and a few weeks ago he secured from me a report, which he proposed to print in the forthcoming volume of the Survey. We had planned an extended investigation of chromite ores from various districts, and while I have no doubt that the new head of the Survey will carry out his predecessor's share of the proposed work, yet I shall be greatly obliged if any members of the Institute will help me by sending in lots of chromite rock. Samples for this purpose should not be less than 100 lbs in weight, and should be delivered free of expense and accompanied by full information as to locality, etc. Under these circumstances I shall be pleased to work upon them at my first convenience, and to include the result of my experiments in the series.

4. The magnetic separation of blende and galena. One of the serious problems in ore-dressing, in certain districts, is the separation of the above minerals. which often occur together. It is possible to dress the mixed ore so as to produce a fairly clean galena and often also a fairly clean blende, but there is usually a large middle product carrying enough of both to make the stuff worthless as a source of either. Sometimes the precious metal contained is sufficient to justify the saving of this material in spite of the zinc penalty, but often it is not, and the product is thrown away.

We find that in some cases this middle product can be separated into commercially clean blende and equally clean galena. In other cases, it can be divided into two portions, one high in lead and low in blende, and the other just the opposite. The magnetic permeability of these two minerals is unfortunately variable in different cases, and it would be too much to say that all blendes and galenas can be separated or even bettered by magnetic treatment, but, unquestionably, there are many cases where very good results can be obtained at a small cost.

5. The magnetic separator in which these last named experiments

are made is a special experimental machine of unusual magnetic power and of great range of adjustment, recently built for us by the Wetherill Company. With it a great many very interesting operations are possible that are far beyond the power of ordinary machines. I will merely name a few.

(a) We have secured some very interesting results in the separation of titaniferous iron sands into portions, one of which is far lower in titanium than the other.

(b) We have separated rare and, in certain cases, valuable minerals contained in a great bulk of other and worthless rock. In this way Monazite has been secured and several other separations have been accomplished. In this work I have again to refer to the late Director of the Survey, who in this and the next named tests gave us great assistance, securing samples for our work and aiding us greatly by his advice, and still more by his broad and stimulating sympathy.

(c) Finally for this paper, but not I hope for our laboratories we have recently obtained some very striking results from the treatment of hydraulic black sands and others non amalgamable residues. It is not practicable to give details at the moment, but on some samples, obtained for us by the Geological Survey, concentrations to one fiftieth or even less have easily been affected and yet nearly every particle of the gold has been saved. Some figures are, I believe, to be published in this connection in the forthcoming volume of the Geological Survey.

In closing, I thank you for your attention to these very random notes. I should like also to say that the Mining Department at McGill is always more than ready to receive suggestions as to new problems to attack or old ones that may be attacked in a new way. We are also always very grateful for lots of ore on which we can work.

I cannot of course promise to work on everything that is sent in, and often even the most interesting things will have to wait for time and the man, but something can be done each year and, as we more fully master the routine portion of our work, the number and value of our investigations should be largely increased.

The Dry Ores of the Slocan, B.C.

By R. C. Campbell-Johnston, M.I.M.M., Nelson, B.C.

In submitting a paper on this subject to the members of the Canadian Mining Institute, the author is aware of the very large scope of area in which these ores occur in Slocan, and also of the many professed and actual commercial successes in treating this character of ore used locally, in Australia for Broken Hill ores, in the United States, Mexico and South America. The object of the paper is to draw the members' attention to this existing area, to recite the experiences of those engaged in mining these ores, to relate the present attempts to treat the ore and so pay dividends to the shareholders, to suggest other treatments that may be applicable, and to gather the members' experience and ideas on the subject, so that this rich area may become another gem in Canada's diadem, and thus make us all even more proud of the country we live in.

As far as the author can ascertain there is no fixed division between the terms "dry" and "wet" ores, to limit the hard line where one ends and the other commences. For the purpose of describing the ores of this district a return of 10 per cent. and less of metallic lead to the ton is spoken of as a dry ore, and over 10 per cent. as a wet ore.

All these ores are rich in silver values, some also containing gold, and some not; in fact the ores are phenomenally rich.

The area included, especially in this district under discussion, is bounded on the north by the divide between the Lardeau and Slocan, stretching from Kootenay Lake to Arrowhead Lake; bounded on the east by Kootenay Lake, on the south by Kootenay River, and on the west by the Arrowhead Lakes and the Columbia River. This division contains an area fifty (50) miles wide from east to west, and forty (40) miles long from north to south. There are other parts in the Lardeau, East Kootenay and elsewhere containing dry ores, but the scope of this paper must be limited, and so mention must be left to another time.

This Slocan area is composed of granite rocks, certainly a broad description, but sufficient till those with more leisure than the mine managers can make slices of the country rocks and classify them from a microscopic examination. The granite surrounds patches of slate as exhibited from Silverton to Whitewater, and south from Carpenter Creek to the village of Cody. There is a strip of other varieties of igneous rocks carrying copper, gold and silver along the north bank of the Kootenay River; and a strip of metamorphic rocks at Ainsworth. Outside of these isolated exceptions we may say broadly the country rock is granite. In the slate, as typified by the Rambler-Cariboo mine, they have followed their vein through the slate into the granite with even enhanced values occurring. The author would especially draw the members' attention to the ores on Springer, Lemon, Ten Mile, the head of Four Mile including Fennell, Cody, Kokanee and other Creeks. Among the many mines containing these ores are the Arlington, Hewett, Enterprise, Bondholder, Fisher Maiden, Republic, V. & M., Erin, Evening Star No. 8, Exchange and others.

Let us first look at the characteristics of the veins carrying these ores. So far as known there are at least four series of veins. First from Twelve Mile Creek going south across Springer to Lemon Creek are six (6) parallel veins within a zone three thousand (3,000) feet wide, known by development to traverse the country for five miles. Their strike is N 20° W, S 20° E, with an easterly dip of steep pitch, and they are strong veins varying from six to thirty (6 to 30) feet wide of vein matter between walls. They generally have a pay streak of extra rich ore on both hanging and foot wall, from a few inches to two feet wide, each one; then often one or more pay streaks lie in the vein matter between the outer streaks with some values distributed throughout, so that by stoping out the whole vein from wall to wall, twelve dollars ($12.00) and more per ton in gold and silver alone can be averaged from the mass. These mines of this series have a future of large tonnage, and that must be treated economically to pay dividends. Typical mines of this class are the Republic, Erin, Peerless, Combination and other groups.

Then intersecting these first veins are others with strike E 5° N and W 5° S (all points of the compass are described magnetically), dipping south with wide vein-matter carrying mostly silver values, most often in streaks. Typical of this series are the Rainbow, Wavertree, Evening Star No. 9, Golden West, and others. The Howard Fraction is reported to have the same strike with a northerly dip.

Another type the author has not examined is represented to the east of Republic Mountain by the Myrtle Group, where a vein occurs traversing also the Rainbow, I. X. L. and Morning Star on Springer Creek. The strike is reported N 10° E and S 10° W with dip west, and the ore is high grade in silver values. Farther east we come to the type of small high-grade veins represented by the Enterprise, Bondholder, Mabou, Missing Link, Premier and Evening Star No. 8. These veins traverse the country for six miles with average strike N 28° E and S 28° W, and dip east, carrying high silver values, but no gold to speak of.

This Enterprise series intersects the Republic series apparently on the Premier and Evening Star No. 8 groups, near Dayton Creek.

Intersecting the Enterprise series again is another series, viz.: the Arlington one. Here we have large veins striking N 10° E and S 10° W with dip east contrary to the Myrtle type.

This series is represented by the Arlington, Speculator, Mabou, Neepawa, Enterprise, Bondholder and others with parallel veins. These have streaks of pay ore like the Republic series, carry gold and silver values, represent large tonnage, and require economical treatment.

There is much more yet to be found out about the characteristics of the dry ore series in question. Though some development has been accomplished, a large amount more is still desirable, executed by skilled engineers who realise what they are learning, and who form their judgment from facts before them, sifting out fact from theory. This curt account of the series, however, is given in the hope of obtaining others' ideas.

Next has to be considered the mode of occurrence and constituents of the pay ore. Where gold occurs, as a rule it is not free, but alloyed or mechanically mixed with iron pyrites, a long disputed difference. The silver is sometimes alloyed with galena, zinc-blende, copper sulphide, or antimony sulphide, not in masses but dispersed through quartz gangue. At other times the silver is native, or as argentite (sulphide of silver), and in a few cases apparently chloride (horn silver). In all cases there are base metallic values with the precious metals in the gangue of the veins.

Now comes the crux of the whole matter. Nature has put the minerals in the veins with lavish hand to be extracted by the ingenuity of man.

The ores having been wrought, how are they to be treated on a commercial scale to secure an extraction of at least ninety per cent. of the values, and also bring the profits to the shareholders?

At present profits are given away to such vampires as railways and custom smelters, who suck the life-blood out of the mining industry, by exorbitant overcharges, though bonused by the country, just when expenditure of working capital promises success. If possible, any transportation expenses from the mine to the railway, and so to the smelters, must be saved on an average grade of ore; therefore, what is wanted is a process to treat the ore at the mine.

The present general teaming charges are $3 per ton. Freight and treatment on railway and at smelter are charged from $8 to $12 on dry ores (cheap compared with the wet ore charges), the two vampires do not make separate contracts for each division of labor, but combine against the hapless mines. Put mining charges on to the above cost, then masses of $12.00 ore are useless to the mine owners. Under present circumstances hand sorting is resorted to, or in other words, the eyes of the mine are picked out, leaving a lower second grade class of ore than if the mass was shipped. The owners fondly hope that in some dim future the vampires will lower their charges to allow this second grade ore to be shipped, but will they?

Another kind of sorting is introdued, viz.: Wet concentration by roll crushing and jigs with settling tanks for the silver slimes.

This reckless method, as proved in all mining districts where this class of ore occurs, may save seventy (70) per cent. of the values, hopelessly losing for all time the balance.

This is only picking out the eyes of the mine in another way, for the silver as argentite, antimonial, etc., will not settle effectually enough to permit its recovery. These facts all show that the mine to pay as its values warrant must have its ore treated in bulk by some smelting or chemical process.

Transportation charges of coke and coal and the necessary fluxes up to the mine to counteract the zinc contents, or want of sufficient lead, in most cases prohibit a smelting process.

We can only then begin where Broken Hill has left off in their costly experiments lasting over many years, having in our favour over them cheaper power from our creeks to generate electricity, abundant timber for all purposes, cheaper fuel in coal and coke, and possible fluxes in the district.

Their hope is in the Phoenix process of bessemerizing with chlorine gas, and using a cycling chemical reaction also making marketable zinc. Rumours are rife of other processes there. Magnetic separation of blende from galena will not help us where the silver is unalloyed with lead and zinc. Would this system of treatment aid us, viz. : Dry crushing, dry concentration with sizers and Clarkson-Stanfield's centrifugal machines, or with pneumatic blowers ; then treating the product, briquetted or sintered if necessary, by the Phoenix process ?

We have to put our heads together to think out, and spend money in trying to solve successful extraction, that will add millions to the world's wealth, and many dividends to the lucky shareholders interested in these Slocan mines. Let us remember that the big tonnage of average grade ore, when effectually treated, make larger and more permanent mines than shipments only of rich picked material.

Notes to Accompany One Plan and Three Vertical Sections of the Athabasca Mine, on Toad Mountain, near Nelson, British Columbia.

By E. Nelson Fell, A.R.S.M., Nelson, B.C.

The vein cuts across a well defined contact between a schistose eruptive rock and a more recent granite. This area of schistose rocks and its northern contact with the granitoid area is shown in the reconnaissance map, published in Part B, Annual Report, Vol. IV, of the Geological Survey of Canada (Dr. Dawson's Report, 1889).

It is a narrow vein about one foot in width; the gangue is quartz, heavily charged with sulphides of iron, zinc and lead, containing high values in gold and about the same number of ounces of silver as ounces of gold.

The chief characteristics of the vein are: that it is remarkably well defined; that it is very continuous; that it is broken by innumerable faults, some of which have occasioned considerable displacement of the vein; that it passes from the schist into the granite without any interruption or disturbance; that the values encountered in the granite are good, but not so good as those in the schist, with a tendency, perhaps, to be a little pockety.

In the maps herewith, the granite is indicated by crosses, the schist is in blank.

The discovery of the vein was made and work was commenced on a prominent exposure in the granite. A tunnel was run in at the point marked on the plan "Main tunnel entrance," and a shaft was sunk on the vein near the portal and the vein stoped out down to a fault; to recover the vein on the other side of this fault, crosscuts were put in, both on the hanging and the foot-wall side, but without result.

The "Main tunnel" was then carried on into the schist, and, shortly afterwards, encountered what was then supposed to be a second vein. This vein was very flat, and disturbed by a most remarkable series of faults, running in every possible direction. The faults were, practically always, normal; and, in following the vein up to the surface, there was a general tendency to a downward throw at each fault running east and west (section through C.D.) and an upward throw at each fault running north and south (section through E F.).

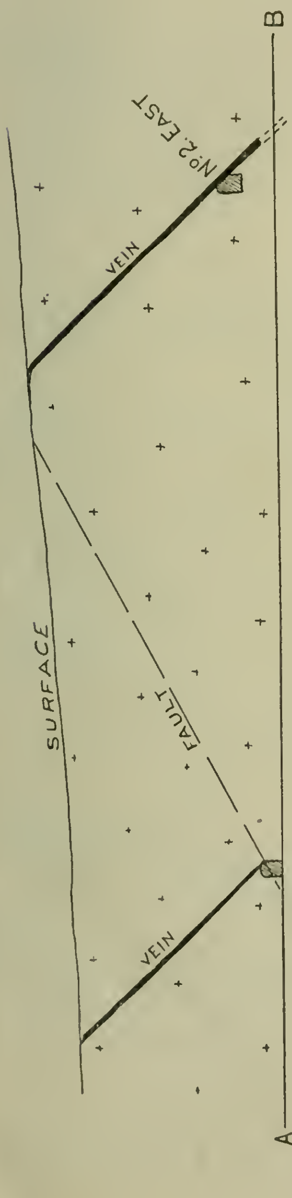
Associated with the vein (in the schist especially) are numerous aplite (acidic) dykes of earlier origin than the vein, and minette (basic) dykes of later origin than the vein. One of the latter follows a prominent fault plane thoughout the mine and is shown in section through C.D. Not only is the vein faulted, but it is subject to remarkable rolls, in the course of which it sometimes assumes a horizontal position and sometimes a sharp "dip upwards," if I may use the expression. This is especially noticeable along the contact of the granite and the schist. As a result of these displacements, drifts are frequently seen at the same horizon, although 150 feet apart on the dip of the vein.

It is hardly necessary to say that to meet these extraordinary conditions, an extraordinary system of mining was necessary, which was inconvenient and expensive and could not have been carried out at all, unless the gold contents had remained persistently high.

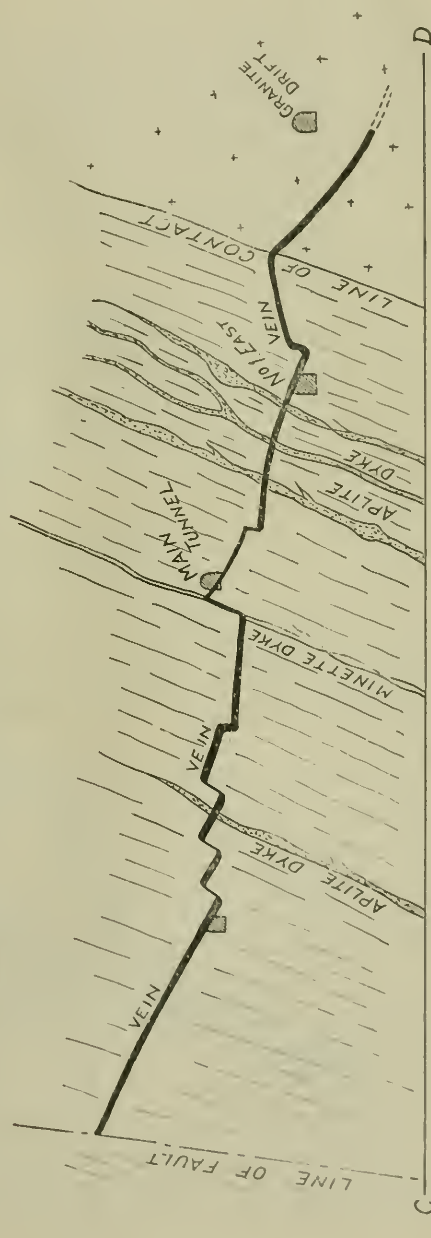
At the end of the main tunnel, the ground became unusually disturbed; stoping had to be abandoned here and a small shaft was put down from the point marked "Hoist Station," which ultimately passed into the granite. Along the contact, both in the schist and to a lesser extent in the granite, a remarkable concentration of values occurred which yielded very fine results in the mill; but below the contact in the shaft, and in the drifts to the west of the shaft, the vein was found in patches only, cut off by faults every few feet and thrown by each fault from 50 to 100 feet.

Eastward from the shaft, No. 2 East was carried about 500 feet, meeting the vein in fine condition about 200 feet east of the shaft, and carrying it to the present face, without faults, well defined, with a regular dip of about 45°.

As this work proceeded, it became more and more evident, until there was finally no room for doubt, that this vein was the same as that on which Shaft No. 1 had been sunk, and that we had now come round, on the other side of the fault, to a point on the vein which lay about



SECTION ACROSS STRIKE OF VEIN IN GRANITE



SECTION ACROSS STRIKE OF SCHIST AND CONTACT

220 feet from the point where it faulted. The throw of the vein along the dip of the fault was about 175 feet. The outcrop on the surface was then sought for and uncovered under the wash. This is illustrated in the section through A.B. It is an interesting matter for speculation as to what the results might have been, had the work originally been done at this outcrop, instead of at the bolder and richer outcrop below. It is not impossible that the history of the mine would have been materially changed.

A few general points may be summed up as noteworthy.

Firstly: that the vein occurs cutting both granite and schist.

Secondly: that there is a remarkable concentration of values along the contact, especially on the schist side.

Thirdly: that the values in the granite do not average as well as in the schist; the vein being inclined to be more uneven, both in size and contents.

Fourthly: that the vein in the granite is found in a more normal condition and is better adapted for mining.

Fifthly: that in the schist the vein is flat and very much disturbed by faults and folds, and finally enters upon an area of ground which is so shattered that all traces of the vein are lost. It is probable that it will be recovered here at some deeper point, approach being made from the granite.

Sixthly: that extreme caution must be exercised in undertaking the opening up of a vein in shattered ground of this kind. Theories of parallel ore bodies and numerous veins may be rudely dispelled by events, and the plan of work must be held continually subject to modification. Only the most shadowy estimates can at any time be made of ore in sight, and the plan of operations can only be outlined in a vague way. To open up a mine of this description is an entirely different proposition to that of opening up a regular ore body. It would appear, however, that the vein, where it is now being worked in the granite, has at last reached a condition of permanency, and it is likely that it will retain this character, as further depth is attained.

I have attempted to outline the doubts and difficulties connected with opening up an ore body of this character. This is a class of min-

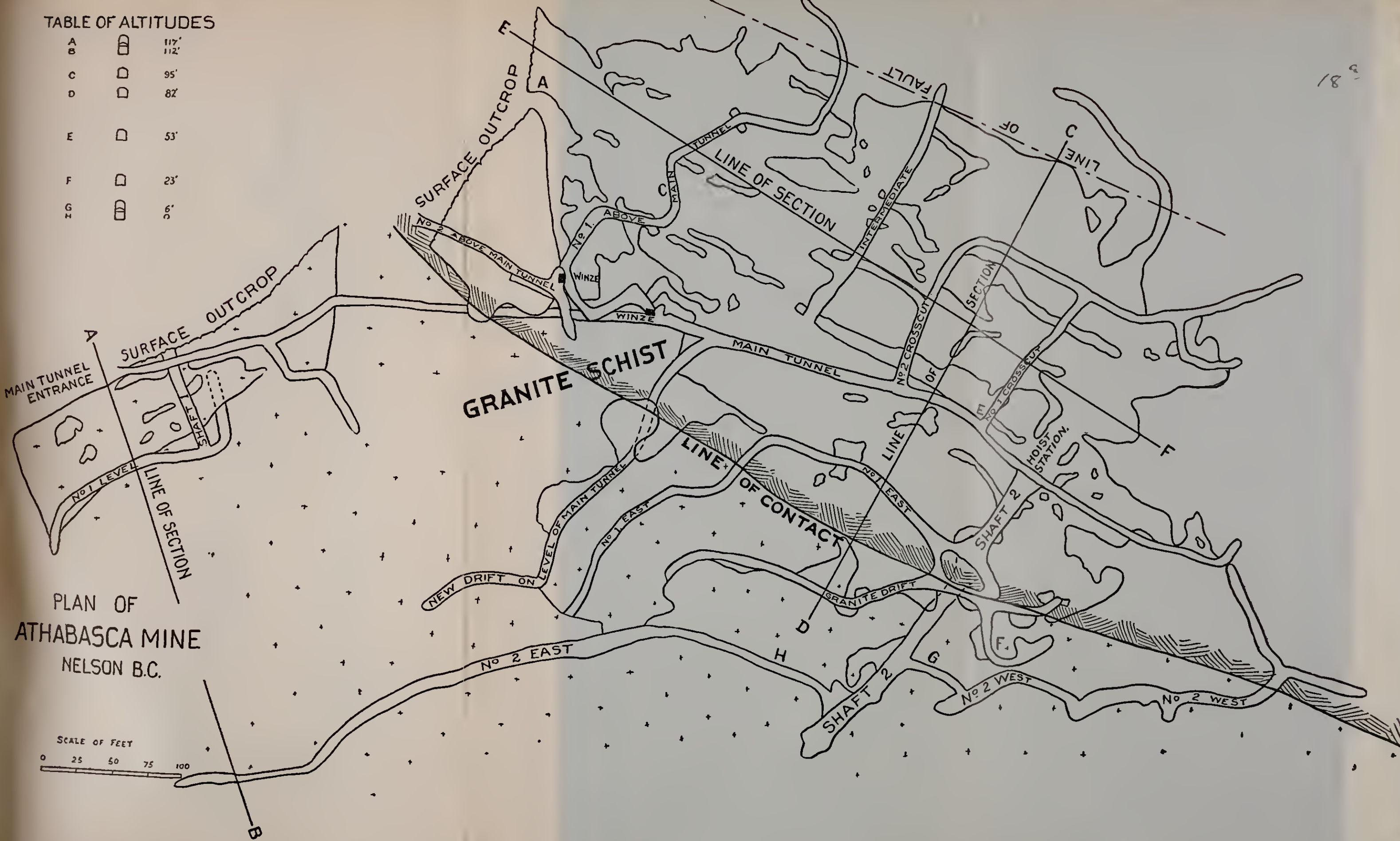
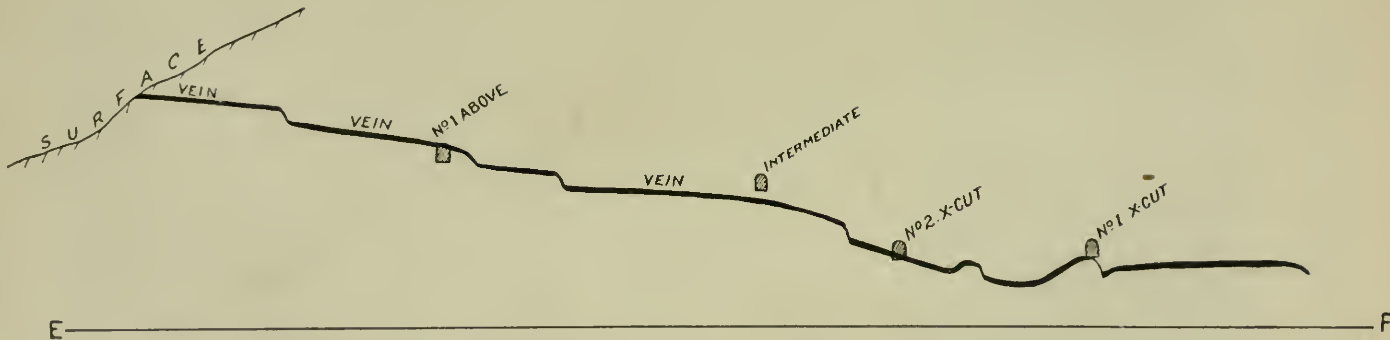


Plate I.—Illustrating paper by Mr. E. Nelson Fell, A.R.S.M., "Notes on the Athabasca Mine, Toad Mountain, B.C."



SECTION APPRCXIMATELY PARALLEL TO STRIKE OF SCHIST ing, however, which opens up attractive possibilities and cannot be neglected. This vein yielded in thirty months $350,000 from 11,500 tons of ore. It is an open question whether the system of limited liability company organization is adapted to a mining proposition of this kind. For conducting large operations on lines which can be definitely and permanently foreseen and laid out, the present system is no doubt to be preferred. But I believe that a system of assessable stock would be found to be more economical and, speaking generally, more suitable for working a property of the kind under discussion.

The maps above referred to were prepared by Mr. H. W. Mussen, superintendent of the mine.

Characteristics of the Atlin Gold Field.

By J. C. GWILLIM, B.Sc., M.E., Nelson, B.C.

The mountains about the eastern shore of Atlin lake are not rugged. They have rather a worn down appearance. If one passes eastwards behind them no great deep valleys are found on the other side but great tracts of evenly sloping ground above and at the timber line; the streams do not appear to have cut deeply into this great mountain mass, which lies immediately about and behind the gold bearing streams.

In considering the two principal placer bearing streams, Pine and Spruce creeks, the valleys in which these streams run appear much too wide and flat bottomed to be the result of the cutting out action of such streams as the present Pine and Spruce creeks.

Both of these streams flow in sharply cut gutters through the general level of the broad valley bottoms, Spruce Creek in places having cut a deep trench two to four hundred feet below the general valley surface.

Leaving out as much of the theoretical origin of these valleys as is advisable, the observed facts appear to point to the conclusion that the present streams did not wear out or form these great valleys.

Above the junction of Pine and Spruce creeks the main valley is over 2 miles wide and at 6 miles east of the lake is 600 feet above it. With such a fall and an uninterrupted period of time to operate in the present streams should have cut out a V shaped valley.

Spruce valley trending off to the south-east rises gradually by its broad valley to the level of the upland slopes or moors previously mentioned, a height of about 1,700 feet above Atlin lake.

Pine valley goes eastwards to Surprise lake, eleven miles from Atlin lake and 825 feet above it.

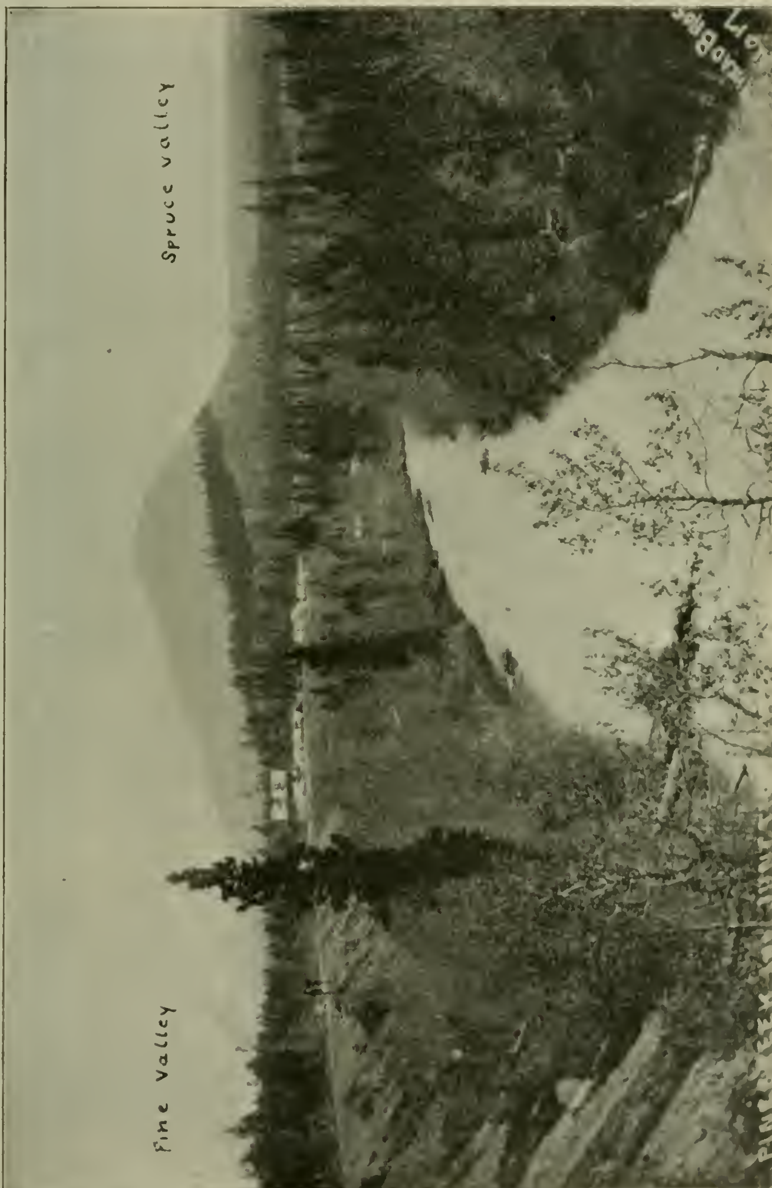
These broad raised valleys are floored with serpentine, magnesite, diorite and diabase. The mountains about them are composed of the same material together with some patches and bands of a very granular friable limestone, and a cherty quartzite capable of breaking up into small fragments very easily, and actinolite slates. These rocks with the possible exception of the diabase and diorite appear to belong to the lower Cache Creek series, a formation recognized at various places in a like relation east of the granite Coast ranges for many hundred miles on a south-easterly trend. The Cache Creek series of rocks has been found to be placer-bearing elsewhere. In the Atlin district it is amongst the more basic and magnesian portions of the series that paying placer has been found. Such as the rocks of Pine and Spruce and McKee valleys.

The rock surface or bed-rock underlying the valley of Pine and Spruce Creeks appears to be uneven in a minor degree, there are a few low out-crops of diorite, diabase and serpentinized rock. These inequalities are hidden to a great extent by terrace deposits up to a height of about 600 feet above the lake. Farther up the valleys, at higher levels, there are irregular ridges of drift material and little lumpy hills of clay, gravel and boulders and, on Spruce Creek, these finally give place to the smooth easy slopes of the upland moors above timber line. The occurrence of deep ditch-like canyons made by the present streams appears to indicate that these streams have been rapidly cutting new channels in the old valley for a limited period since the lake receded to its present level.

These streams have cut down through superficial deposits of clay, boulders, gravel and sand. All of which are largely composed of the local rock material. At places this material is false bedded gravel and sand; at other places it is a stiff grey boulder clay containing striated boulders.

On Spruce Creek the present stream has cut through this grey and blue drift material to a depth of two or three hundred feet. It has also cut through bands of diabasic rock forming canyons

Beneath the drift and at about the level of the present stream bed, the action of the stream and the workings of the miners have shown large deposits of yellow gravel, so far traced for about two miles on Spruce Creek, from a point a little above Discovery Claim to about No. 100 below Discovery.


Spruce valley
Pine Valley

This yellow gravel represents a stream bed formed prior to the drift deposits which now overlie it. It contains gold values sufficient to cause it to be worked on 94 below by wheeling out of a tunnel into the sluice boxes. Near 100 below it is said to have returned six dollars to the yard. At Discovery, two miles above, the bench formed the old yellow gravel bed rock and this has been worked out.

On Pine Creek a somewhat similar deposit is found, but is not here overlain by drift material. A superficial area of this yellow gravel near Willow Creek adjoining Pine, of 100 feet square is said to have cleaned up over three thousand dollars. There is no doubt that these yellow gravels represent pre-glacial stream beds having much the same drainage and depth as the present Pine and Spruce creeks.

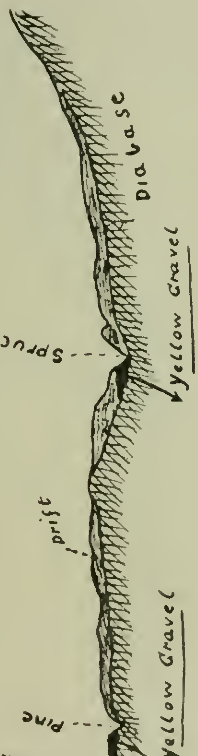
These gravels are in an advanced state of decomposition. Outwardly they appear to be composed of rather large shining yellow pebbles in a paste of yellowish mud. They are not usually cemented.

The paste containing the pebbles is apparently nothing more than the completely rotted or decayed gravel of smaller size. The large pebbles easily break with a yellow oxidized fracture, and are of the same rock as the very tough greenish boulders so prevalent in the present stream bed

The thickness and width of these yellow gravels is perhaps somewhat greater than the corresponding deposits of the present stream beds. They were not observed at any point lower down in the valley than about the level of the present surface terraces five to six hundred feet above Atlin lake.

The gold contents of these pre-glacial streams are concentrations from the wearing out of the pre-glacial valley, and appear therefore to have been locally derived. The change of conditions which brought about the filling in of the pre-glacial stream beds with the drift gave these valleys their present superficial flooring. The post-glacial streams had therefore to cut out new channels for themselves through this drift, and there is evidence to show that several minor channels were formed before the present ones fixed the drainage.

Any such temporary stream bed would concentrate more or less placer gold from the drift which it disposed of, and this accounts for



Hor scale 2 in = 1 Mile   Vert Scale 1 in = 1000 ft

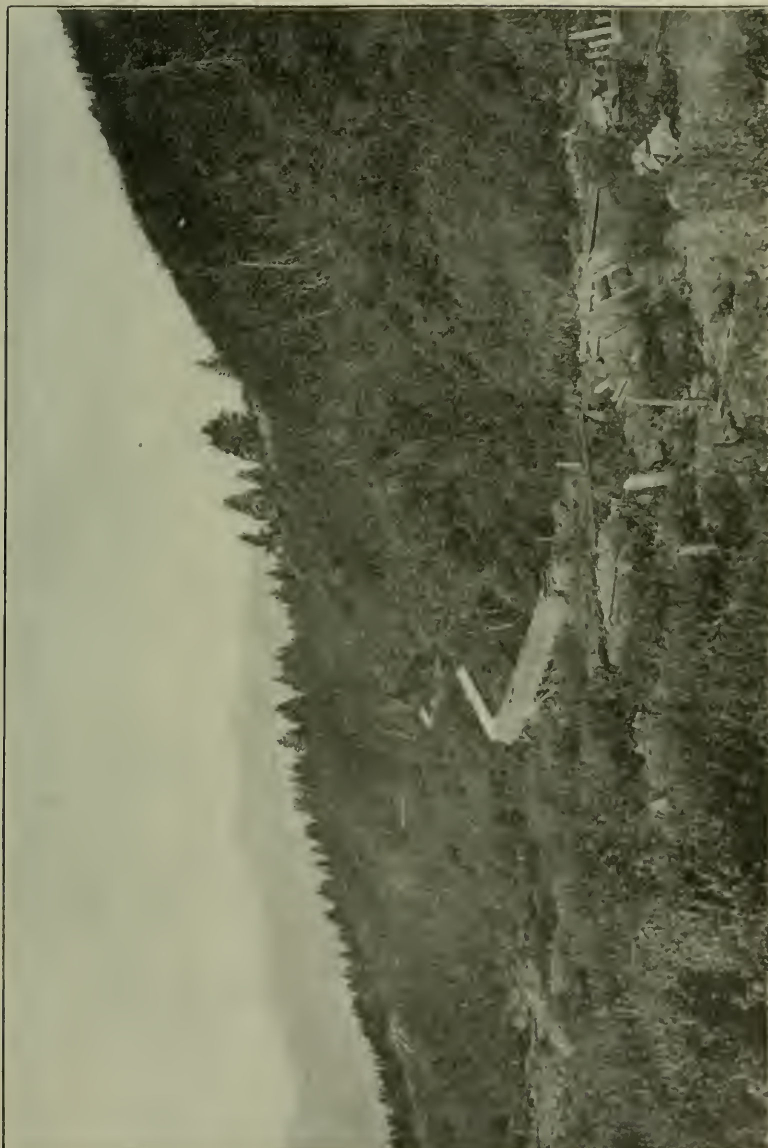
Cross-section of Pine-Spruce valley from Willow Creek to No 94 below on Spruce the gold in some of the dry or nearly dry runs, found in these broad valleys.

It is not likely that any of these minor superficial depressions indicate the position of the older pre-glacial stream, excepting where the contour of the rock floor beneath might force the new stream to cut down the drift in its former depressions.

Gold Run, Willow Creek and Trand Gulch may or may not have been the courses of pre-glacial streams—evidence goes to show they were not—but in any case these channels were formed *since* the covering of drift and being in drift still, show no evidence of the pre-glacial drainage. Gold Run is said to have yellow gravel about 30 feet below the superficial channel. Willow Creek is a former channel, on bed-rock, of the present Pine Creek. Trand Gulch has shown no yellow gravel from its pits and shafts, but is a well defined shallow depression now almost dry. The placer gold of the runs and creeks in the valleys of Pine and Spruce seems to have been derived entirely since the period of glacial drift from concentrations of this drift and re-washing of the pre-glacial stream bed by present or past glacial streams. There appears to be, or to have been, no considerable amount of gold added by reason of the denudation or wearing down of the surrounding mountains since the deposition of the drift.

In this they differ from the placer concentration of the minor V shaped creeks tributary to Pine Creek, such as Birch, Boulder, Ruby and Wright. These last named creeks are typical, lateral V shaped streams heading in mountain basins and still cutting down the trough through bed-rock. They carry no apparent evidence of glacial action, the stream beds are filled in with boulders in most places. Bed-rock is usually more in evidence about the middle portions of these streams. This seems to be due to the fact that the upper basins keep filling in with talus while the lower portions are filling up with gravels.

The bed-rock is often actinolite slate, and on Wright Creek is an argillite or soft black shaly slate. Boulder Creek shows an instance of gold on granite bed-rock on its upper portion, not elsewhere found in the district. The bed-rock is granite and the basin at the head of the stream is granite, but the great mass of rock which formerly filled



Atlin Mining Company's Flume on McKee Creek.

this valley was of the gold-bearing slate variety, and its gold has been concentrated as the stream cut down to the underlying granite.

Ruby Creek has so far been unproductive; originally this creek had cut down more deeply than the other lateral streams through the rocks favorable to placer gold. At a later time it appears to have been partially filled in by a basaltic flow from an extinct volcano on its western side. The stream has not yet cut down through this basaltic covering to the gravels beneath. The glacial drift which lies as an overburden of from a few feet to over three hundred feet in depth in the Pine-Spruce Valley carries gold prospects in most unlikely places, apparently, such are found amongst the little lumpy hills far up on Spruce Creek. Prospects have been found in the gravel on the exposed summits of these moraine-like deposits; such may be due to a weather concentration by which the lighter materials have been removed leaving a little gold and the gravel behind.

Such a flooring of more or less assorted drift material will naturally contain considerable gold in a more or less concentrated condition; for this drift represents great masses of the gold bearing country rock and vein material of these valleys, and their pre-glacial wash or surface. It is possible that there may be some fairly rich concentrations of gold within the drift itself wherever contemporary streams had their courses during the deposition of this material and it follows that any later stream cutting out and re-washing this drift does little more than concentrate an equal volume of country rock, excepting where it may cut into some such concentration of values. There appears to be some evidence that Pine Creek has cut some earlier concentrations other than its own bench or former stream gravels, and the yellow gravels.

On the south bank of Pine near Discovery there are pay gravels which, from the present contour of the surface, do not appear to underlie any stream bed more recent than the deposition of the drift, and these are not yellow gravels.

It will be seen that in these wide flat valleys the streams are not now actively concentrating gold from the mountains about them, and that wherever the present small troughs of these streams traverse the

Working on Atlin Company's Flume Line, McKee Creek, Atlin, B.C.

unassorted drift they are not likely to have gathered much gold. Hence their richness depends upon their cutting some earlier concentrations which may be in the drift material itself but is more often the pre-glacial yellow gravel. This deposit as already stated exists at about the level of the present stream beds.

The portions of Pine and Spruce creeks now being productively worked coincide with portions of these yellow gravels which have been at these places more or less cut into and re-sorted. That is from Discovery to 140 below on Spruce; and from Gold Run to Stephendyke on Pine. If the gold is derived in this manner it follows that the bench gravels or former courses of Pine and Spruce will not be found to be rich, excepting in such cases as Willow Creek and Stephendyke where the earlier courses are themselves below the bedrock of the yellow gravels and have received enrichment from them. At horizons *above* the older deposit, the earlier stream beds or benches contain only what has been concentrated from a very limited amount of drift material, more or less gold bearing according to the amount of concentration it has undergone.

Concerning the origin of the placer gold there are, as is common, reports of mother-lodes. Certainly there are many well defined quartz veins in the district but these as a rule are not rich in free gold. Some large bodies of country rock such as magnesite, and the shaly slates of Wright Creek carry mineral sulphides and more or less gold. There is also some rich gold bearing rock crossing Pine Creek near Willow. This has been credited with mother-lode properties but it does not account for the gold on Birch, Boulder, and Wright and Otter which lie above and eastwards of it.

It is not likely that any great vein or system of veins originally contained this gold, but rather that the different varieties of country rock which limit the field productively are gold bearing either in themselves or in the various forms of dykes, veins, and stringers or segregations of secondary material. At no place has gold been found at all comparable in coarseness with that of the placers, and its fineness varies on different creeks These characteristics of coarseness and variety may or may not have belonged to the original gold *in*

Flume of Atlin Mining Company, McKee Creek.

situ. The useful results of observation appear to be as shown in this paper that the placer gold is of local origin and that it is found associated with certain distinct rocks not necessarily gold bearing elsewhere, but shown to be so in this district, and that there are certain recognized factors in the enrichment of the gravels.

The Atlin district was first opened up in 1898.

In 1899 about three quarters of a million dollars was taken out.

In 1900 and 1901 the Atlin "Claim" gives the following outputs for the different creeks in ounces :—

	1900	1901
Pine and Willow	4918	5330
Spruce	1699	2308
Boulder	1916	2640
McKee	1733	1013
Wright	1068	283
Graham	19	103
Otter	122	143
Birch	15	271
Gold Run	——	31
Totals	11490 ozs.	12122 ozs.

A total of about two hundred thousand dollars for each of these years. This being only the official record and less than the real production.

The falling off is due to the transition from placer to hydraulic mining in a large degree. There is much ground fit for hydraulic working if a sufficient amount of water is obtainable.

McKee Creek appears to combine some of the characteristics of drift deposits and a V shaped valley. No yellow gravel is known to occur but its presence is possible.

The photos and cross-section sketch will illustrate the character of the Pine-Spruce Valley at its principal placer bearing horizon.

On Wire Ropes.

By W. D. L. HARDIE, M.E., Lethbridge, Alta.

That wire rope as a mechanical means of cheaply conveying coal is being superceded by electricity and compressed air is not admitted by many mining engineers.

After many years of careful study of the three systems and closely watching the actual application of them all, we are fully convinced that wire rope haulage will live on after some of the new fangled systems have settled down to their proper sphere. That compressed air and electricity have many advantages in some respects, it is not our purpose to controvert, but that wire rope haulage actuated by steam, electricity or compressed air has a wider field than either the compressed air or electrical locomotive is our contention. If this be admitted as correct and, whether or no, it certainly is the duty of all mining engineers and colliery managers to have as complete a knowledge about wire ropes as is possible in one having so many diversified duties to perform, so that he will not be entirely at the mercy of the rope manufacturer who has his little "trick of trades" in common with most other manufacturers.

It is the writer's intention in this short paper to give some practical and theoretical notes on wire ropes, not claiming any originality, in the hope that they may be beneficial to the younger members of the profession.

Wire ropes for mine use are generally composed of :—

(1). Six wire strands composed of seven wires each, twisted on a hemp centre. The centre wire of the strand sometimes being soft.

(2). Six wire strands, composed of twelve wires each, twisted on a hemp centre.

(3). Six wire strands, composed of nineteen wires each, twisted on a hemp centre.

This construction is sometimes varied so that there are 13 larger wires and 6 smaller wires in each strand, but the general construction of the rope is the same.

The ratios of the diameter of the individual wires to the diameter of the rope in these three cases, not including the rope with two sized wires as in No. 3, are as follows: (1) $\frac{1}{9}$, (2) $\frac{1}{12}$, (3) $\frac{1}{15}$. From this, the gauge of wire required to constitute a rope can readily be got to a close approximation.

No. 1 is only used where large wheel drums and easy curves can be employed. Such a condition does not very often present itself in coal mines. The No. 2 rope is a more pliable one and can be used on smaller drums, wheels, and curves, but when we remember that the size of the individual wires govern the size of wheel it will be seen that with this rope, with a heavy load, such as is usual in mine haulage, the wheels would be relatively large. A wire should not be bent over a wheel less than 1,000 times its diameter for good results in length of life and tons hauled.

Excepting in ropes of large diameter No. 3 is not used for mine haulage but is largely employed for hoisting ropes.

To meet the conditions of severe bending usual in the underground working of collieries the British manufacturers construct a compound rope which we will designate as (4):

(4). Six wire strands, each composed of 9 large wires twisted around 7 smaller wires (the centre or seventh wire being soft), twisted round a hemp centre. The gauges of wire used and number of wires used in the construction of a compound rope are varied to suit the circumstances. These ropes are very servicable and meet the mine manager's wants with a wonderful degree of satisfaction.

I am not aware that any American rope makers are constructing ropes of this style.

In computing the strength of any twisted wire rope it is well to remember that the strength of each individual wire is reduced from 4 per cent. to 10 per cent. by twisting. The makers claim the strength is reduced 4 per cent. while disinterested experimenters claim the strength is reduced 10 per cent. Perhaps a fair allowable reduction of strength for twisting in manufacturing, would be the average of the two, viz: 7 per cent.

Iron wire ropes are not suitable for mining purposes and are not considered in this paper.

There is a very wide range in the grades of steel ropes and as the breaking strength per square inch of section of the material of which they are constructed is fundamental, we herewith give a short table which will make the point clear.

NAME.	Homogeneous Steel.	Patent Improved or Crucible Steel.						Plough Steel.			
Quality	Tons. 40-45	Tons 60	Tons. 75	Tons. 80	Tons. 85	Tons. 90	Tons. 95	Tons. 100	Tons. 105	Tons. 110	Tons. 120

The quality here is in tons of 2,240 lbs. per square inch of section.

The composition that enters into these grades is partly a secret of the manufacturer, however, a vast amount of information has been published but the articles are too numerous and conflicting to be brought within the limits of this paper.

For the purpose of making the above tables clear let us take an example: Suppose we are going to use a crucible steel rope 15-16 nch diameter, or 3 inches circumference, composed of six strands, each strand having 9 wires .080 inch diameter, twisted over 7 wires .054 inch diameter, of 201,600 lbs. breaking strain per square inch, what is the breaking strain of the rope ?—

.082 in. x .7,854 x 201,600 lbs. = 1008″ x 9 wires. 9,072 lbs.
.0542 in. x .7,854 x 201,600 lbs. = 461.7″ x 6* wires. 2,770 lbs.

Strength of one strand........ .... 11,842 lbs.
6

11,842 lbs. x 6 strands............ .... 71,052 lbs.
Less 7 per cent. allowed for twisting.. .... 7,105 lbs.

Breaking strain of rope .... 63,947 lbs.

† The safe working load in underground haulage may be from 1-7 to 1-5 say 1-6.................. 10,658 lbs.

* Six of the seven small wires only enter into this calculation as the seventh wire is the core of the strand and is soft having little t nsile strength.

† A rope running at a low speed and no lives depending upon it, is not subject to the sudden strains of a high speed rope and may have a very low factor of safety. In slow endless rope haulage 1-2 miles per hour, we think, 5 is a safe factor. But with fast running tail-ropes 7 is not too large. For hoisting ropes the safe factor should be 10.

The following we regard is a good sample of a specification for wire rope :—

Quality of Wire.—1. All steel used in the manufacture of the cable shall be of the "best selected patent improved crucible steel" drawn to a uniform diameter throughout, and capable of withstanding the tests mentioned in the table given below.

Length, size and form of Wire.—2. The cable shall be feet long and shall have a circumference of 3⅝ inches (three and five-eighths) when finished. It shall consist of six outside strands laid up in the formation known as the "Lang lay," with the lay in the rope in the same direction as the lay in the strands.

Strands.—3. Each strand shall be composed of seven wires .115 inch in diameter, laid round a core consisting of five wires .061 inch in diameter round one wire .049 inch diameter.

Spinning.—4. Each strand shall be spun in feet lengths and evenly wound direct from the machine on to a reel. When it is necessary to join either the outside or inside wires they shall be properly scarfed and brazed.

Closing.—5. The six strands shall be closed under uniform tension round a heart consisting of the best white manilla rope, having three strands, hard laid, and well soaked in oil.

Lay.—6. The lay of the wires in the strands shall be 3¾ inches (three and three-quarters) and the lay of the strands in the cable 9½ inches (nine and one half).

TABLES OF TESTS—7.

TENSILE TEST.

Diameter of wire.	Length of test, piece between gauge marks.	Tensile test. Stress per square inch.	Stress per wire.
.115 inch.	8 inches.	90 tons	2,094 lbs.
.061 "	8 "	85 "	556 "
.049 "	8 "	85 "	359 "

Here the core wire of the strand is not soft as in the case we made the calculation for.

DUCTILE TEST.

Length of test, piece between gauge marks.	Number of twists.	Bends to 180° over one-quarter inch radius.
8 inches.	25 number.	3 number.
8 "	45 "	6 "
8 "	58 "	10 "

Each Hank to be subjected to test.—8. Before proceeding with the manufacture of the cable, the contractor shall submit every hank of wire to the engineer, who will make tensile and ductile tests from each end of the hank before it is worked into the cable.

Variation from specified tests.—9. Every hank which shall be found to vary more than 2½ per cent. in either direction from the tensile tests specified above, or more than 8 per cent. below the specified number of twists in 8 inches will be rejected.

Test of Cable.—10. The contractor shall make the cable sufficiently long to allow for cutting off a suitable portion which shall be tested for tensile strength in the presence of the engineer, or his representative, and must withstand a load of 43 tons (ton here is 2,240 lbs.) without breaking.

Cost of making tests.—11. The cost of all tests, whether made at the contractor's works or elsewhere, shall be borne by the contractor.

Chemical tests.—12. In addition to the above, chemical tests may be made at the discretion of the engineer.

	Outer wire. .115 in. diam.	Inner wire. .061 in. diam.	Core wire. .049 in. diam.
Carbon............	.50 %	.50 %	.50 %
Silicon............	.06 "	.06 "	.06 "
Manganese........	.50 "	.50 "	.50 "
Phosphorus.......	.045 "	.045 "	.045 "
Sulphur...........	.040 "	.040 "	.040 "

"Manganese imparts toughness and neutralises "shortness," it further acts in favor of the presence and functions of the carbon." Silicon can only be tolerated in very limited quantities, whilst phosphorus and sulphur are the greatest enemies encountered in the manufacture of steel. Any excess of silicon produces brittleness, which is more marked as the percentage of carbon is raised. Small quantities of sulphur present in steel will produce unsoundness and "red shortness" whilst phosphorus is detrimental on account of causing "cold shortness" besides being an enemy to any form of tempering and conductivity."—*Smith.*

In the ordinary construction of wire ropes the wires forming the strands are twisted to the left hand but the strands are twisted to the right hand, or opposite direction. In the "Lang lay" the wires forming the strands and the strands comprising the rope are all laid in the same direction. Ropes may be laid up "right" or "left" hand and this is no small consideration in the life of a rope if one coil chafes on another. If, when standing behind the drum facing the pit head pulleys, the rope travels on drum from left to right, the rope should be laid "right handed," or vice versa. The tendency to mount and side friction are minimised.

The "lays" adopted in wire rope making are principally dependent upon the gauge of the wires employed, the size of the rope to be made, and the purposes they are intended for. Approximately it may be said that the "lays" in strand, vary about three to four times the diameter of the rope and the "lays" in the rope vary from seven to ten times the diameter of the rope.

The average elongation of ordinary constructed rope is about 3 per cent. and with "Lang lay" 1½ per cent. to 2 per cent. which must not be lost sight of in hoisting ropes and endless ropes. A suitable tightening arrangement will take up the elongation in endless ropes but in hoisting ropes it is a case of pulling the rope up in the fastenings in the drum.

With hoisting ropes the life can be greatly increased by ordering sufficient length to enable 6-10 feet to be cut off the end periodically and thus change the point of lift or stress.

It is of the first importance that ropes be greased frequently and carefully with a good, pure, grease which is absolutelv free from acids. A grease with acids in it is worse than no grease.

It is obvious where ropes have to bend round wheels, drums, or curves, that the outer fibres of *each wire*, as they accommodate themselves to the curvature, are in tension, and the inner wires in compression, while the center or neutral axis is unchanged. As a consequence it may be assumed that the more flexible a rope, *i. e.* offers less resistance in compression and tension in each wire, where it is subjected to much binding in work, the better will be the results, provided that such flexibility be not obtained by the use of such fine wires that the wearing capacity of the rope is affected.

We said in the early part of this paper that a rope should not bend over a wheel less than 1,000 times the diameter of the largest individual wire in the rope. This is built up on assuming $S = 30{,}000$ from which we have $D = \frac{30{,}000{,}000}{30{,}000} d = 1{,}000\ d$. This only implies, after all, that if D is greater than 1,000 d the life of the rope will be greater and *vice versa*.

A prominent rope-maker in England answers a letter of enquiry from us asking his rule by which to calculate the size of wheel for a given size of rope as follows :—

" In haulage it is advisable to use the largest pulleys you can possibly get in ; this however is governed a great deal by the conditions under which you have to work, and when we know the size of the pulleys you are using we can generally suggest to you the class of rope most suitable. There is no rule for this, but it is purely a matter of experience and how ropes have worked under similar conditions in other places."

However we know we have two stresses "tensile" and "bending" which we can fairly well approximate by which we "get out of the woods."

The "tensile strain" we will take to mean the dead load and the "bending stress" to mean the extra load due to bending which must be added to the "tensile stress" for the total load.

The generally accepted formula for bending stress is $S = E \frac{d}{D}$ in which

$E =$ Modulus of elasticity which is variable. For steel we will call it 30,000,000. pounds per square inch.

$d =$ Diameter of a single wire of the rope in inches.

$D =$ Diameter of pulley in inches.

$S =$ Stress per square inch of section exerted upon the outermost wire of the rope in pounds.

Reverting to example given above; the diameter of the outer wire is .08 inch and, using a pulley 1,000 times diameter of wire (here use only for convenience) we have $d = .08$ inch and $D = 80$ inches.

$$S = \frac{d}{D} = 30{,}000{,}000 \ \frac{.08 \text{ inch}}{80 \text{ inches.}} = 30{,}000 \text{ lbs.}$$

The cross sectional area of the two sizes of wire in that example is:—

		Sq. in. area.		wires.		Sq. in. area.
$.08^2$ inch × .7854	=	.005026560	×	54	=	.27143424
$.054^2$ inch × .7854	=	.002290223	×	36	=	.08244803
						.35388227

.35388227 x 30,000 lbs. = 10616.5 lbs. stress due to bending.

The stress produced on the tension side by bending, must be considered in connection with the stress produced by the load in order to arrive at the total stress. In order to avoid a permanent set, it is necessary that the sum of these two stresses should not exceed the elastic limit.

In our example by using a safe factor of 6 we allowed a load 10,658 lbs. but when we add the bending stress we get 10,658 + 10616.5 = 21274.5 lbs. The breaking strain was 63,947 lbs.;

$$\frac{63{,}947 \text{ lbs.}}{21274.5} \quad 3+ \text{ safe factor.}$$

The following certificates of ropes actually purchased and in use show results which agree very closely with theoretical calculations. The specifications required these ropes to be made of a quality of 90 long tons per square inch of section :—

WIRE ROPE WORKS . . . . . . ENGLAND,
December 27th, 190—.

Best Patent Improved Crucible Steel Wire—

Order No. ——. The Alberta Railway and Coal, Ltd.

We certify the following to be the tests of the wire used in these ropes :

HAULAGE ROPES.				WINDING ROPES.	
.080 Breaking Strain in lbs.	Torsion 8″	.052 Breaking Strain in lbs.	Torsion 8″	.085 Breaking Strain in lbs.	.085 Torsion 8″
				1120	38
1040	40			1100	36
1030	40			1120	36
1070	38	470	53	1110	38
1010	39	460	58	1130	35
1040	38	435	58	1150	35
1010	42	440	53	1120	38
1040	39			1110	38
1010	41			1030	37
1070	40			1050	36
1040	38			1140	36
1010	37			1110	36
1020	39			1130	36
1010	36			1100	35
1060	39			1120	36
1070	36			1100	39
1060	36			1160	35
1040	39			1140	36
1040	41			1110	36
1030	37			1140	39
1030	36			1160	36
1050	39			1130	38
1010	36			1110	36
1050	36			1170	36
1030	37			1140	36
1060	39			1110	38
				1150	35
25930		1805		1140	35
				31400	
Average 1037		451		Average 1121	

Signed —————————.

THE SHEFFIELD TESTING WORKS,
Blank Street, Sheffield, England.

———— ——, 190—.

Report No. ———.

The following are results of tensile tests of two specimens of { 4″ cir. steel wire rope / 3″ " " " " } received —— ————, 190—, from Messrs ———— :—

Test No.	Mark on Specimen.	Circumference in inches	Weight per fathom in lbs.	STRANDS. No. of Strands.	STRANDS. No. of Wires	STRANDS. Diam. of Wires in inches	Total No of Wires	Hemp Core	Strength of Rope Tensile.	STRESS IN LONG TONS, EXTENSION IN INCHES. 1	5	10	15	20	30	40	50	Maximum Stress. Lbs	Maximum Stress. Long Tons	Total Elongation. Inches	No. of Twists in 8″	REMARKS.
M 12177	None	4″	14.53	6	12 outer 7 inner	.85 .085	114	Main	100″	0	0	.20	.32	.50	.85	1.34	2.58		52.24	3.70	{ 36 37 }	3 strands broke clear of the fastenings.
M 12178	None	3″	8.36	6	9 outer 7 inner	.81 .052	96	Main	100″	0	.25	.48	.70	1.02	3.10				30 40	4.08	{ 40 55 }	5 strands broke clear of the fastenings.

Messrs. ————,

————, England.

In the example the factor 6 was allowed to overcome bending stress, sudden jerks, etc. By finding the bending stress we see that factor a of 3 is ample to pnt up for the other possible stresses. A threefold security is considered sufficient.

Whatever may be the relation of these two stresses, pulling and bending, the total stress on the rope will be that due to the combination of these two stresses.

If $\frac{D}{d}$ is made so small that the two stresses, pull and bending, are greater than the elastic limit the rope will receive a permanent set which, however, is not always dangerous.

In this connection we might call attention to the baneful effect attending the use of wire ropes where reverse bends are made. Careful record and experiment have shown that the life of the winding rope which goes over the pit-head pulley and under the drum is only from one-half to three quarters as great as the rope which goes over the pit-head pulley on to the top of the drum.

The importance of greasing ropes is also accentuated by Mr. Biggart's tests. Two lengths of the same size and manufacture of rope were used; the unoiled length made only 16,000 whereas the oiled length made 38,700 bends over the same pulley before breaking. Other similar pieces of rope unoiled would run over a 24 inch pulley 74,000 times, and the oiled length 386,000 times.

This paper has assumed proportions we had not intended when undertaking its compilation, and indeed it has been compiled on lines that we had not intended when commencing it. Such a paper as this cannot be considered complete without considering many other important points in wire rope construction, and its use, such as the neutral axis, the proper diameter of sheaves, curves, etc. At some future time we may send in another paper covering these important points.

The Analysis of Insolubles.

By DOUGLAS LAY, A.R.S.M., Nelson, B.C.

No attempt is made in the following to repeat the mass of detailed information, which is already furnished by the numerous text books on the subject of technical analysis. What is offered is merely a collection of notes, the evolution of practical experience, which aim at a statement of general principles, coupled with an elaboration in one or two instances, where more than ordinary difficulties seem likely to occur

As is well known, bodies which are completely insoluble, require a preliminary fusion with some kind of flux, before being subjected to treatment with acids, with a view to analysis. This procedure is sometimes also advantageously resorted to in the case of those bodies which, while not wholly insoluble, yet only yield completely to the action of acids after prolonged treatment. More frequently, however, the partially soluble body is first treated with acids, and a fusion of the insoluble residue subsequently made. In any case the object of fusion is to form compounds, which shall be readily soluble either in acids or water.

Bodies, partially or wholly insoluble, may be divided into classes, in accordance with their behaviour, when subjected to fusion, towards the fluxes employed. We thus have :—

1. Those which are *acidic* in character, and which therefore require to be fused with a *basic* flux. This latter may be pure sodium carbonate, or a mixture in molecular proportions of sodium and potassium carbonates (fusion mixture), or a mixture of carbonate of soda and nitre.

The action of sodium carbonate and nitre upon a few of the more common insolubles may be illustrated thus :—

$Fe_2O_3 + 2 Na_2CO_3 + 3 KNO_3 = 2 Na_2FeO_4 + 3 KNO_2 + 2 CO_2$.

$Cr_2O_3 + 2 Na_2CO_3 + 3 KNO_3 = 2 Na_2CrO_4 + 3 KNO_2 + 2 CO_2$.

$Al_2 O_3 + 3 Na_2 CO_3 \; {}_2 \; Na_6 Al_2 O_6 + 3 CO_2$.

$Ba SO_4 + Na_2 CO_3 = Ba CO_3 + Na_2 SO_4$.

Upon extraction of the melt with boiling *water*, the chromium, aluminium and silica pass into solution, while the iron is left as hydrated ferric oxide together with barium carbonate.

2. Those which are *basic* in character, and hence necessitate fusion with an acid flux. Potassium hydrogen sulphate (occasionally sodium hydrogen sulphate) being employed for the purpose. By fusion with this reagent metallic oxides are converted into sulphates or double sulphates, in main readily soluble. It is well to bear in mind that silica is not rendered soluble in this case.

3. Those which are *neutral* in character, and the opening up of which obviously presents the greatest difficulty. A typical example is chrome iron ore.

For purposes of fusion a platinum vessel is employed in the majority of cases, but it must be noted that the following substances injure platinum, and if they are present obviously the use of a platinum vessel is attended by specific risk, though in one or two instances the adoption of special precautions renders its employment permissible. The substances are :—

1. Compounds of any easily reducible metal (lead for example) which would alloy with platinum.
2. Sulphur, arsenic, and antimony.
3. Caustic soda or potash.
4. Sodium peroxide.
5. Nitre heated to decomposition.
6. Any substance yielding silicon, which alloys with platinum.
7. Solutions yielding free chlorine.
8. Contact with carbon at high temperatures renders platinum brittle.

It is well now to proceed to the consideraiion of a few cases, where special difficulties may be encountered :—

1. *The determination of silica in ores containing barium sulphate.* Two methods of precedure are open in this case :—(*a*) Fusion of the

residue insoluble in acids with fusion mixture and extraction of the melt with *water*, the water extract containing all the silica. (*b*) Treatment of the insoluble residue, after weighing, with $H_2 SO_4$ and hydrofluoric acid, or ammonium fluoride, whereby upon evaporation to dryness and subsequent ignition, the silica is volatilized, and upon again weighing may be determined by difference. The residue will contain the barium sulphate.

(*c*) By fusion with "fusion mixture" the silica is converted into alkaline silicates and the barium sulphate into barium carbonate, thus:

$$Si O_2 + Na_2 CO_3 = Na_2 Si O_3 + CO_2.$$
$$Ba SO_4 + Na_2 CO_3 = Ba CO_3 + Na_2 SO_4.$$

Upon thorough extraction of the quenched melt with boiling water and filtration, the silica may be entirely separated from the barium, and may be determined in the filtrate in the ordinary way. Upon treatment of the residue with dilute hydrochloric acid, the barium passes into solution as chloride and may be readily obtained and determined by addition of dilute sulphuric acid.

A common mistake in this case is to extract the melt with dilute H Cl with the result that the barium carbonate is converted into chloride to be immediately precipitated as $Ba SO_4$ by the alkaline sulphates present, leaving matters in much the same state as before fusion, thus:—

$$Ba CO_3 + 2 H Cl = Ba Cl_2 + H_2 O + CO_2.$$
$$Ba Cl_2 + Na_2 SO_4 = Ba SO_4 + 2 Na Cl.$$

2. *Titaniferous Iron Ores.* (*a*) Determination of silica.—In this case, the entire sample taken for assay—say 0.5 gram. is fused in a platinum dish with acid potassium sulphate. The cooled melt is thoroughly extracted with hot water. The insoluble matter after thorough washing is dried, ignited, weighed and treated with $H_2 SO_4$ and H F, evaporated to dryness and again ignited, the silica being determined by the difference between the weighings, before and after treatment. Fusion with $K H SO_4$ converts the titanium into a double sulphate of titanium and potassium readily decomposed on boiling with precipitation of titanic oxide. Silica is not converted into a

soluble form. This tendency of titanium compounds obviously renders inadmissible the determination of silica in the ordinary way, viz : by fusion with fusion mixtures, inasmuch as $Ti\ O_2$ would simulate $Si\ O_2$.

(*b*) Determination of Iron.—Fusion is made in precisely the same way as in the silica determination, and then the cooled melt is extracted with hot dilute H Cl. All the iron and alumina are now in solution. The titanium partly is dissolved and partly is precipitated as titanic oxide, which latter is seen as a white precipitate. The iron is best determined volumetrically, but reduction of the solution by means of zinc is not permissible in this case, owing to the fact that salts of $Ti\ O_2$ are also thereby reduced to salts of $Ti_2\ O_3$, which latter would be again oxidized upon subsequent titration with bichromate or permanganate of potassium, simulating iron. Hence one of the other modes of reduction must be employed, when no further difficulty is presented.

3. *Determination of Iron and Chromium in Chromite.* The opening up of chromite presents considerable difficulty by reason of the fact that fusion with the usual fusion reagents has to be very prolonged in order to get all of the iron and chromium into a soluble form. Of the many fluxes, sodium peroxide will be found to yield highly satisfactory results. The method is as follows:—Fuse 0·5 gram. of the ore with 3 grams of sodium peroxide in a nickel crucible for ten minutes, keeping the crucible in motion, then add 1 gram more of sodium peroxide and fuse five minutes longer. (The temperature of fusion should not exceed that required to furnish a good melt.) Quench the melt, and thoroughly extract with boiling water, filter and well wash the residue. The filtrate contains all the chromium as sodium chromate, while the iron is all present in the residue as ferric oxide. The latter may be determined by any of the ordinary methods. Dilute the filtrate to 150 c.c., thoroughly boil, acidify with $H_2\ SO_4$ and add a known amount of $Fe\ SO_4$. This latter is in part converted into ferric sulphate by the chromic acid present, accordingly determine the excess of $Fe\ SO_4$ by titration, whence the amount of chromium present may be calculated, the equation expressing the reaction being

$6\ Fe\ SO_4 + 2\ Cr\ O_3 + 6\ H_2\ SO_4 = 3\ Fe_2\ (SO_4)_3 + 2\ Cr_2 \cdot (SO_4)_3 + 6\ H_2\ O.$

Fusion of chromite ($Fe\ O.\ Cr_2\ O_3$) with sodium peroxide converts the iron and chromium into sodium ferrate and chromate respectively, thus:—

$$2\ Na_2\ O_2 + Fe\ O = Na_2\ O + Na_2\ Fe\ O_4.$$

$$3\ Na_2\ O_2 + Cr_2\ O_3 = 2\ Na_2\ Cr\ O_4 + Na_2\ O.$$

Upon addition of water the sodium chromate passes into solution as such, but the sodium ferrate is decomposed, with precipitation of ferric oxide (hydrated).

Notes on the Limestone of the Philipsburg Railway and Coal Company.

By J. T. Donald, M.A., Montreal.

In a recent article on Michigan Limestones,* A. C. Lane writes:— " There is a very great demand for anything like pure Carbonate of Lime, and as soon as it gets near 98 per cent. it can be used in the manufacture of Calcium Bromide and of Calcium Acetate in connection with charcoal kilns, the clarification of beet sugar syrup; the generation of carbon dioxide for soda water, or for making soda carbonate out of chloride."

Not all of these industries are as yet found in Canada. But there is no doubt that Canadian manufacturing is destined to grow rapidly, and it is doubtless only a question of time before all of these industries and others as yet undeveloped will be represented in Canada.

With the hope that placing on record in the Transactions of the Institute the location and composition of a high grade limestone may in some measure, however slight, tend to the extension of Canadian manufacturing, these notes are submitted.

The Philipsburg Railway and Quarry Co's property covers some 315 acres on the outskirts of the village of Philipsburg, Que., and on the easterly shore of Missisquoi Bay, an arm of Lake Champlain.

The whole property is a series of beds of limestone, some of which have been converted into what is practically marble.

This high grade, highly altered limestone or marble exists in very large quantity. The main quarry has been opened up for a length of some 750 feet, and displays a magnificent mass, of undetermined extent, of stone of a high degree of purity.

In September last the writer visited this deposit and carefully sampled the same, and submitted to analysis a fair average of the whole deposit as exposed in the development work carried on up to the date mentioned.

*" Michigan Limestones and their uses."—Engineering and Mining Journal. May 25, 1901

The analysis gave the following results:—

Analysis of Limestone:—

Insoluble in HCl	1.43	per cent.
Ferric Oxide	.24	"
*Lime	54.40	"
†Magnesia	.30	"
Carbonic Acid, &c. (by diff.)	43.63	"
	100.00	per cent.
*Equivalent Carbonate of Lime	97.14	per cent.
† " " Magnesia	.63	"

An average sample of the whole exposure was then "burned," the resulting lime was analysed along the lines required by advanced manufacturers of Calcium Carbide.

Analysis of Lime:—

Calcium Oxide or Lime	95.79	per cent.
Magnesium Oxide or Magnesia	.53	"
Sulphur	103	"
Phosphorus	.007	"
Insoluble, Iron Oxide, Alumina, &c.	3.57	"

The Philipsburg limestone and lime are growing in favor as their purity becomes known.

The above analyses represent as stated the average composition of the whole face of the quarry as exposed in September last.

It is not improbable that a careful selection would enable shipments to be made guaranteed to contain not less than 98 per cent. carbonate of lime.

This Philipsburg stone makes an excellent lime for use in the manufacture of Calcium Carbide where a high tenor in lime and little or no magnesia, sulphur and phosphorus are required.

This limestone is also well adapted for building purposes, giving a very effective appearance. It has been used in the construction of the fronts of some houses on the west side of Park Avenue, just above Prince Arthur Street, Montreal.

The Iron Ore Deposits of Western Ontario and their Genesis.

By F. HILLE, M.E., Port Arthur, Ont.

If we consider that the world used in the neighborhood of 100,000,000 tons of iron last year, and the United States alone nearly 30,000,000 and if we picture to ourselves the space which these ores have occupied, and remember that these figures represent—especially on this Continent—only the higher grades, then it is not astonishing that everyone interested in the manufacture of iron is developing a feverish activity in the search for new resources of this raw material. We, here in this country, have been very active this season, from near and far came representatives of larger and smaller iron works, with a sprinkling of speculators mixed in. Those who did not know our iron deposits, and the rocks in which they occur, but have been here and have diligently studied them, should now have become better acquainted with them, and should know—at least to a certain extent—what we have here ; how it occurs and how it originated. I confess, however, that it is difficult for the occasional observer to become readily and intimately acquainted with both our stratigraphical and economical geology, because, our rocks represent the oldest members of the earth's crust, with not too many later sedimentary rock depositions to help us to read them like turning the leaves of a book, to enable us to grasp the subject at a glance. Our rocks are principally eruptive, and to recognize which is the older, and which the younger, and which the mineral producer, needs a long while of close study, the possession of a keen sense of observation, and also a certain enthusiasm in these researches, to overcome the drawbacks and fatigues which such a new, uncultivated, and extensive country as ours offers. My long years experience in, and acquaintance with this country, gives me perhaps a certain justification to approach the subject of this paper, which so far has found no exponent, and which seems to me to be rather timely. But before doing so, however, I have to make the reader first somewhat acquainted with the geology. He will understand more readily that which I shall say later about the genetic relation of the ores with the rocks in or nearby they are found. Let me commence at the lowest series of our rocks and continue in an ascending order.

ARCHÆN.

A. Laurentian
Gneiss and granite.

B. Huronian
(*a*) Coutchiching (lower) mica schists and quartz—porphyries.
(*b*) Keewatin (upper) chlorite, talc, hornblende and sericite—schists.

CAMBRIAN.

(*a*) Animikie (lower)
Chert and jasper argilites.

(*b*) Keweenawan or Nepigon (upper)
Jasper and quartz conglomerates.
Sandstones, marls and dolomites.

LATER ROCKS

1. Diorites, 2. Gabbros, 3. Serpentine, 4. Syenite, 5. Granite, 6. Conglomerates, and 7. Traps.

This classification of our rock formation is the one adopted by the Canadian geologists; our neighbors to the South, classify it somewhat differently, as for instance, they bring the Animikie among the "Huronian" and this because they hold too strictly to the name which was given to the rocks occurring around Lake Huron. These rocks are for the greater part, doubtless younger than the Keewatin and Coutchiching rocks, some even Post Cambrian, but the Archæn rocks also are not lacking in that region and as it is in our vast country with its still primitive communication, nearly impossible to map down each different rock occurrence and especially where the field appearances of even many of these younger eruptive rocks is so similar to those of the north shore of Lake Superior and the coming of a new name is not desirable, the word "Huronian" therefore was adopted by us exclusively for those oldest rocks of our earth's crust which are so well developed in Canada, and so little noticeable in other parts of this continent. The United States Geological Survey has placed these oldest rocks in one group together with the much younger sedimentary rocks and has called this group "Algonkian." This would signify that they consider the Keewatin and Coutchiching to be also sedimentary rocks. This is doubtless erroneous, because most of them, if not all in our country were without question, originally eruptive rocks, changed *in situ* through heat, dynamic action and chemical agencies to what they are now.

How these steeply tilted crystalline rocks, can be placed with those much younger, mostly flat lying amorphous slates, sandstones, marls, etc., which are resting uncomformable on the former, is not readily understood. In the course of this paper, I shall therefore, always use the name " Huronian " in the same sense as our Canadian geologists.

I now come to the subject of this paper, that is, the iron ore occcurrences in these western districts, and I shall place and describe them as they appear and are found in the different geological horizons.

1. Huronian : Magnetites and limonites from carbonates.
2. Post Huronian : Magnetites.*
3. Cambrian : Magnetites and carbonates, etc.

They are found in the following localities :—

Class 1. (A) The Kaministiquia. (B) The Matawin. (C) Green Water Lake.
(D) Hunter's Island deposit.
(E) Atikokan.

Class 2. (F) Green Water Lake.
(G) Head Lake.

Class 3. (H) Magnetites at the northern margin of the formation.

A, B, C and D deposits are all of the same nature, and originated through the infiltration of hot iron and silica solutions into the fissures of a sheared chlorite schist. These fissures were still further widening through the replacement of the latter by the first. If we look at the accompanying maps 1, 2, 3, we find that these deposits form an almost continuous belt, representing a flat lying crescent whose eastern horn commences south of Kaministiquia Station, continues north for miles, turns then in a sharp curve to the Matawin River, follows this river and travels onward past Green Water Lake and Moss Township and turns then in a long sweeping curve into Hunter's Island. Along the Kaministiquia, Green Water Lake, and Hunter's Island the ore is banded, iron and jasper alternating, while along the Matawin River the iron deposits are more massive, some of extraordinary width and comparatively free of jasper. I have tried to show this on map sheet No. 2. The quality of the iron is low grade averaging from 35 to 40 per cent., the

* This class belongs doubtless to the Post Cambrian but as they form dykes in the Keewatin rocks, I have placed them close to the Huronian.

largest portion consists of an intimate mixture, and the other of a chemical combination of magnetite and silicate acid, very fine and close grained, from blueish black to reddish black in color. At the eastern and western ends the iron bands when separated from the Jasper, show a somewhat higher percentage of iron, but these bands are usually not wide enough for any economical separation of both those minerals. Now it might be that there are places in these deposits where the iron is more concentrated, and the jasper replaced by iron, but only the diamond drill can disclose this. On some localities these jasper and iron bands, are most wonderfully contorted, the general trend is with the foliation of the rock formation, but often we see long pieces turned and bent out of line, and pointing to all directions of the compass. I mentioned above that the iron deposits on the Matawin River especially so, near the "upper falls" of that stream, are of considerable width. On hill 7 three parallel running deposits form together a width of over 700 feet (*vide* map 2). A part of this iron which was formerly all magnetite, is more highly oxydized, particularly so at the north and south side, and changed into a martite, or in less technical language in an ore of hematitic nature. Considerable prospecting work has been done on these deposits, in stripping, crosscutting and diamond drilling, of the latter work several holes are down 1,000 feet in an angle of 45 degrees, and where the drill was kept with the strike of the deposit, ore was encountered all the way down and exactly of the same quality as the surface, showing 35 to 40 per cent. with phosphorous, a little over the Bessemer limit. Except somebody wants a silicious ore for a mixture with pure soft iron ore, this ore will come into use after all the higher grades are exhausted, but then we could supply the world for centuries with it. For twenty miles we find this same ore in wider and narrower deposits, striking with the formation in a nearly east and west direction. These deposits when nearing the volcanic centre of Greenwater Lake become more banded with blueish black, white, and red jasper and show here often, as I mentioned above, a remarkable contortion, the bands turned and twisted in every conceivable form and shape. This is doubtless produced by the later coming diorite, which can be seen cutting both the rock and the iron, which exerted pressure from different sides and ends. These iron deposits are found usually resting upon the anticlinal of a chlorite schist, and are the results of the ulterior action of an eruptive granite or gneiss whose fumerolic activity must have been not only very intense, but also of considerable duration. Then the exhalated minerals coming in contact with underground water furnished not only the contents of these iron deposits directly, but leached also a large portion of iron out of the schist and deposited it into the fissures. In confirmation of this we find that the latter rock down to a considerable depth contains only a small amount of iron, the less the nearer to the deposit, but the farther from it the more it retained its original iron contents. Diamond drill cores of rock not far from the iron gave only 2½ per cent. ferrous oxide, farther away nearly 5 per cent., and increasing in percentage the more we leave the deposits. In the same progression, the silica increases in the rock the nearer we come to the iron, which is at last 70-79 per cent. Through this leaching and replacing process the field appearance of the schist near the iron is therefore more that of a creamy white dolomite. Also some minerals of secondary origin are found in the rock as well as in the iron, among several calcite is the predominating, filling out the little fissures caused by later crushing, and showing often to the amout of 6 per cent. Their existence is due to an intrusive diorite which shows in numerous dykes cutting both the schists and iron deposits, as I already mentioned, and formed along both a very interesting breccia-conglomerate. I can now leave these magnetites which are perhaps the most massive deposits of iron which the world knows and it will take centuries to exhaust.

I used above the word "Groundwater" in speaking of the genetic occurrence of this iron, now I do not apply it here in the sense of some writers who claim "that there exists in considerable depth in the earth's crust a moving body of water flowing and percolating through the rocks, leaching out therefrom the minerals, and after acquiring the higher temperature of the lower rock strata, ascending again into the cooler upper regions, owing to their isogeothermal difference, and redepositing their contents into the fissures and cracks of the rocks." Water doubtless percolates through permeable, slaty, or fissured rocks to a certain depth, but which can be in volcanic localities not very great, surely not in our country. It would therefore be erroneous to speak of a flowing groundwater in this sense, the less so, as we find most of the deeper mines nearly dry. When I nevertheless used this expression, I pictured out before me the earlier state of the earth's crust which at that time was still comparatively thin. I mean at the time when the Huronian rocks had already solidified and had at their base the still viscid present Laurentian gneisses and granites. The volcanic and plutonic activity must have been immense at that period, and especially at the commencement of the contraction and shrinkage of the gneissic magma whereby certain areas became also eruptive, so much so that this magma not only remelted the largest portion of the Huronian rocks but also became intrusive into the fissures of same, and overreached and overlapped the remaining rocks on both sides, so that the Huronian not only had to follow the contracting movements of the gneisses but had also to suffer immense lateral pressure, by which they were tilted, folded, sheared and fissured, and in the latter form principally so, at the axis of the anticlinals. This is easily recognizable in our country because we find most of the ore deposits and later dykes of other rocks at these weak points of the Huronian. These terrific pressures have been also the cause of the foliation of the older rocks In earlier times it was believed, and many writers to this day still cling to the belief, that the Huronian rocks were produced through sedimentation and later on tilted. But if we examine their cleavage plans a little closely, we find still in a great number of them layers of finely crushed material of the same substance as the ones of which the rock consists Of course, in many these foliations later infiltered mineral solutions obliterated, or changed the former crushed products to something else. Now this action by which hard, acid or basic rocks are foliated by pressure, can easily be seen at many places, especially at their contact with other harder rocks, for instance—quartz veins. The walls of the rocks show nearly always, when they have been unstable laterally, a slated, foliated or gneissoitic structure and this is the same phenomenon which produced the foliation of the Huronian rocks. It is easily comprehended that the latter at that period must have been considerably shattered and open, which not only permitted the gases and fumes of the eruptive magmas to find vent through them, but also allowed the condensed water-vapors of the surface to percolate through these openings, which, meeting with those gases, were taken up by them, and deposited upwards, sidewards, or wherever they found a sufficiently large opening. There, where the rock was permeable, or rendered so by crushing, these mineral solutions would also penetrate into the wall rocks, leaching out certain minerals and leaving, perhaps, others in the former's place ; but in my opinion they did not depend on these rock minerals for their vein fillings. Now these solutions I called "Groundwater," rightly perhaps so, when we keep in view the time in which these processes must have been going on ; but wrongly, perhaps, when we consider exclusively the intense heat which prevailed at the beginning. At that time the meteoric waters could not penetrate into the rocks beyond a certain depth, for they would have been expelled as steam, and very likely have been so, and this steam condensed in the upper cooler strata and deposited there the minerals first, until the lower part of the fissures cooled more and more, when gradually those waters would reach the lower region, depositing the minerals in their last. At the present time, conditions are changed, and it is very questionable if we can speak of a "general groundwater," as to-day most of the channels and fissures are closed and most of the existing rocks are impermeable with the exception of some of the newer sedimentary ones, which, however, play no great role in metal mining.

I thought it necessary to make such a long deviation from my principal subject to define the meaning of "groundwater" as I applied it in its action as a mineral distributor and depositor. There is still such a great diversity of opinion about the *role* water is playing in the formation of ore deposits, that it is necessary for everyone who attempts to speak about it to define his theory and position so as not to be misunderstood.

Among the Huronian rocks occurs, as I indicated above, also a limonite. Prospectors have found years ago large and smaller boulders as "floats" of this ore, especially near Steep Rock Lake ; only lately they have observed several localities where exactly the same kind of ore is in place. Unfortunately, it was too late in the season to go and make an examination of these deposits, but the samples brought into my laboratory allow the inference that they are derived from a siderite containing a certain amount of manganese and a very small percentage of phosphorous. Pseudomorphs of this ore gave up to 68 per cent. metallic iron and 0.001–0.004 per cent. phosphorus, 0.02 per cent. sulphur, and from a trace to 2½ per cent. manganese. In those samples free of manganese, the latter mineral and iron have separated, while the oxydation process of the original ore was going on, and deposited and formed small stringers of pure manganese in the crevices of the rock. The ore is found in a greenstone, but in what relation ore and rock stand to each other I do not yet know. I could also not state if there is a sufficient quantity for economical mining, but as soon as our country takes off its wintry white gown again I shall examine the deposit closely, and may find then, later, another opportunity of speaking more about it.

I come now to iron deposit of class 2, E, F and G. I mentioned already in a foot note that these iron occurrences belong by right after class 3, because the gabbro and peridotite rocks with which they are idiogenetic are Post Cambrian, but they form in our western district dykes in the Keewatin, the upper Huronian rocks, and are so closely associated with them that I consider it more correct to place them as I have done in following the formation step by step.

The iron deposits of class 2 originated through a "magmatic differentiation process," that is, the various constituents of the magma separated to a large extent in special groups; for instance, the Atikokan dykes contained in their magma sulphide of iron, (2) magnetic iron, (3) silicate of magnesium and calcium, (4) silicate of aluminum and sodium, then No. 1 formed pyrrhotite, No. 2 magnetite, No. 3 hornblende, No. 4 albite. Again Nos. 3 and 4 formed together to a rock as Gabbro, Nos. 1 and 2 separated into special minerals, or mixed mechanically with the rock; now we see that this class is of volcanic origin, that its constituents form pockets, and lenses of all sizes, either mixed together or partly separated, in the manner represented in map No. 3. These dykes are of similar nature to the rocks in which pyrrhotite is mined in the Sudbury country, with the only difference that the latter must have cooled

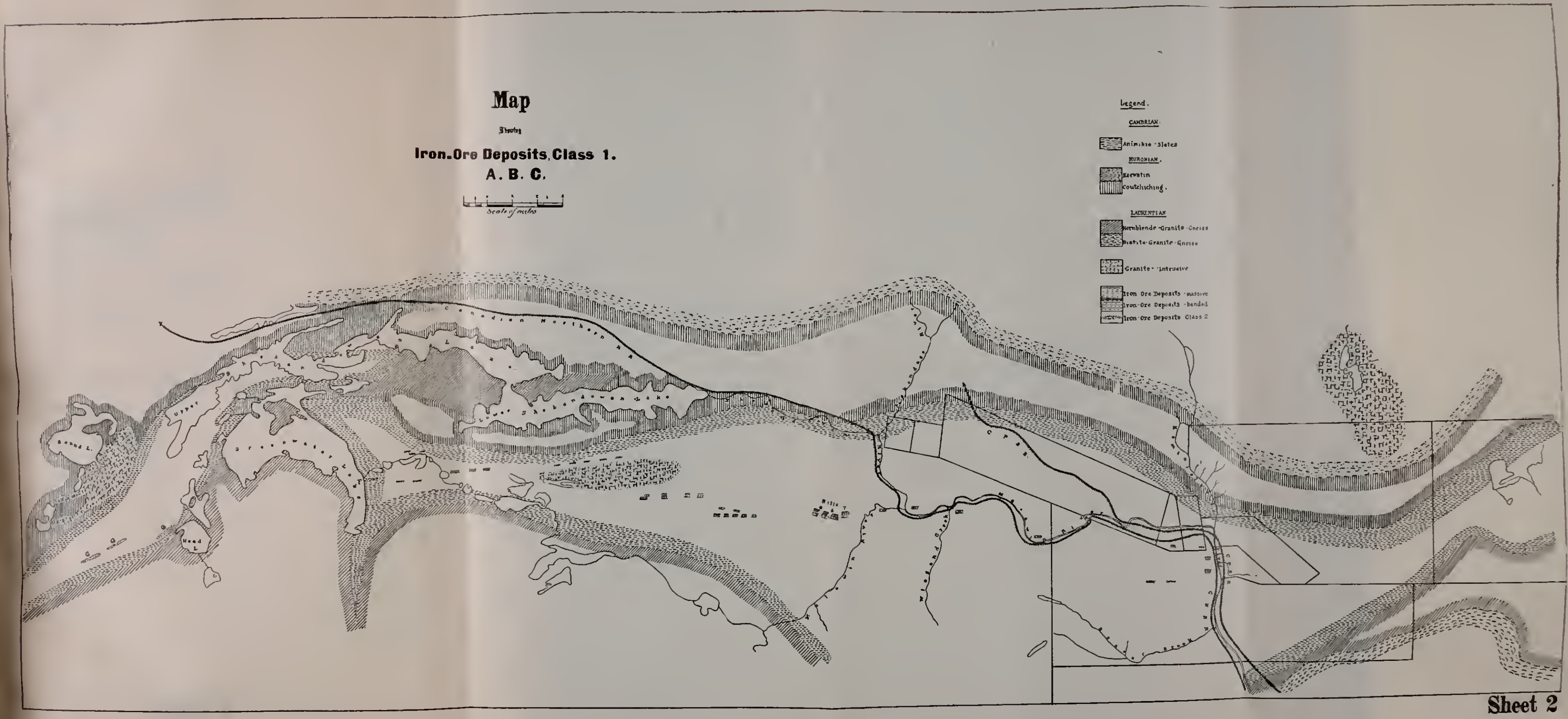
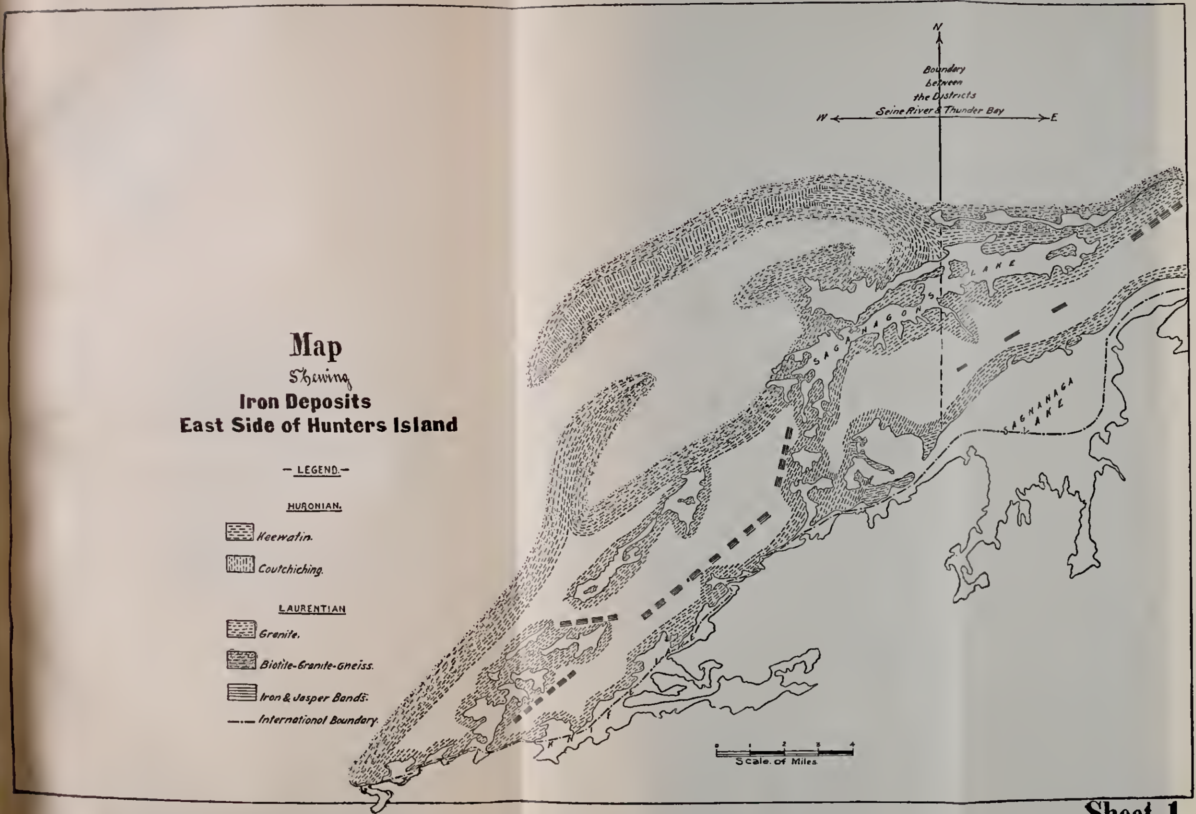


PLATE I.—Illustrating paper by Mr. F. Hille, M.E., "On the Iron Ores of Western Ontario."



Sheet 1

PLATE II.—Illustrating paper by Mr. F. Hille, M.E., "On the Iron Ores of Western Ontario."

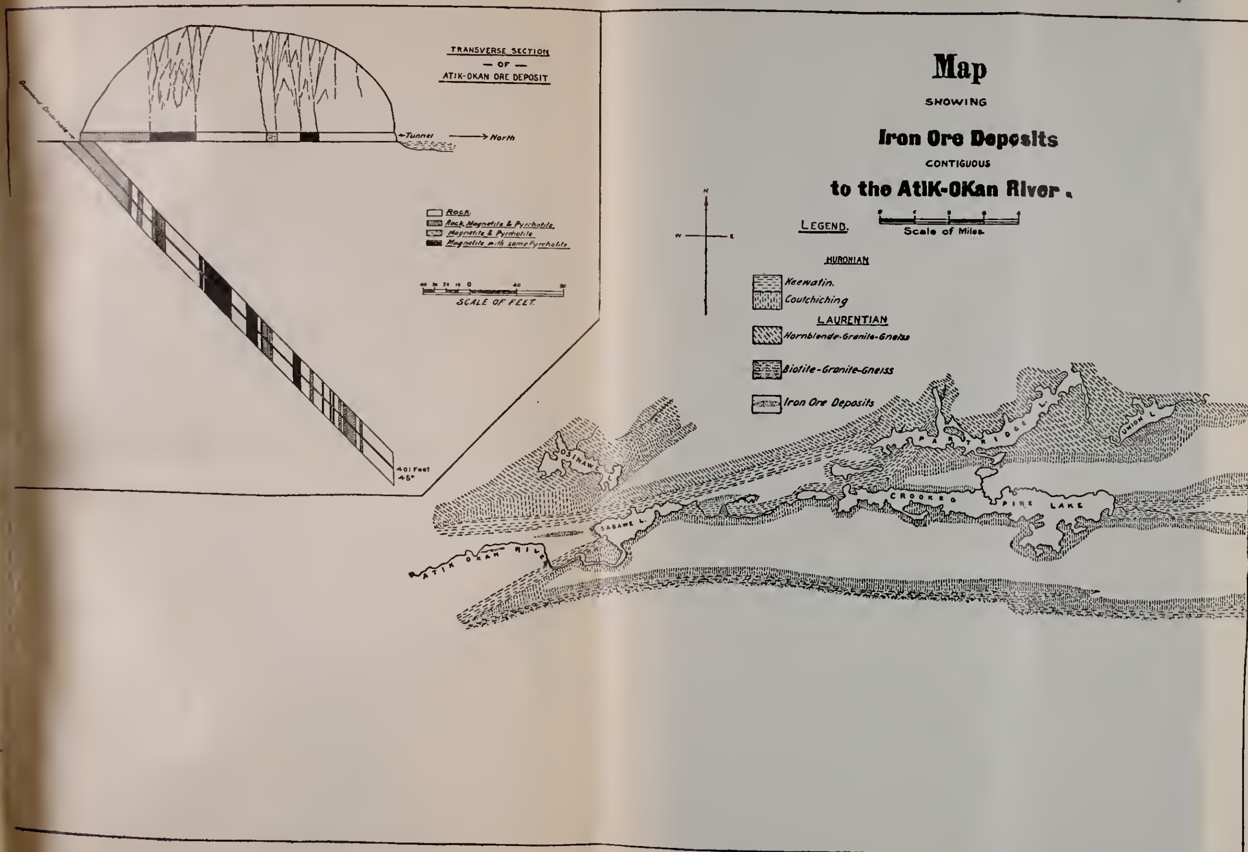
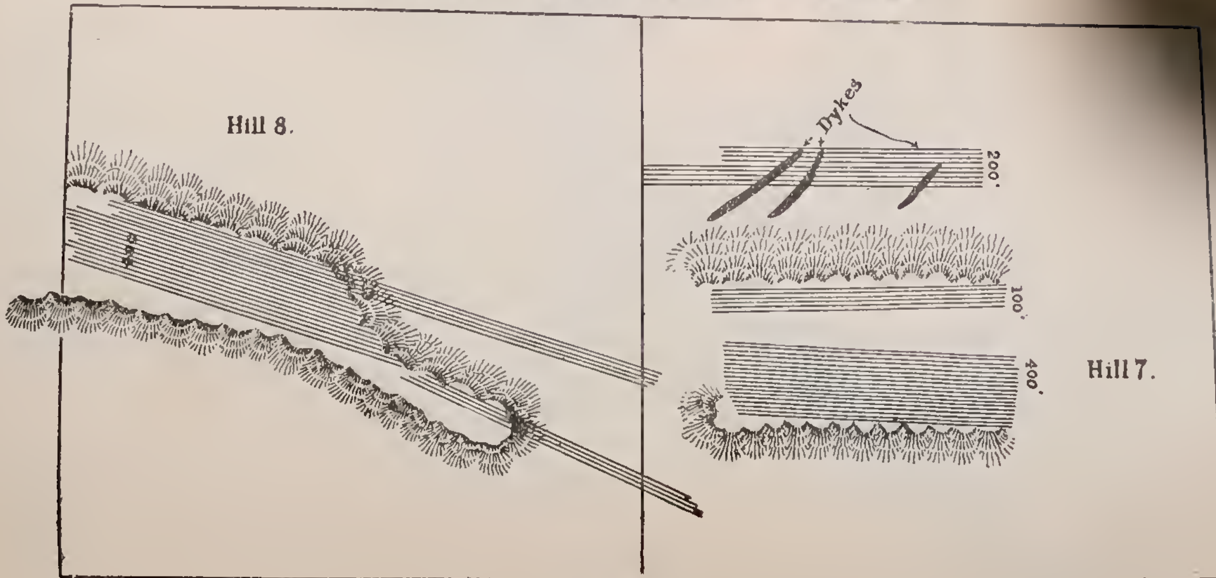


PLATE III.—Illustrating paper by Mr. F. Hille, M.E., "On the Iron Ores of Western Ontario."

Sheet 3.

Iron-Ore Deposits, Class 1.



B.

Plate IV.—Illustrating paper by Mr. F. Hille, M.E., "On the Iron Ores of Western Ontario."

Iron-Ore Deposits Class 2

G. F.

PLATE V.—Illustrating paper by Mr. F. Hille, M. E., "On the Iron Ores of Western Ontario."

5-6 c

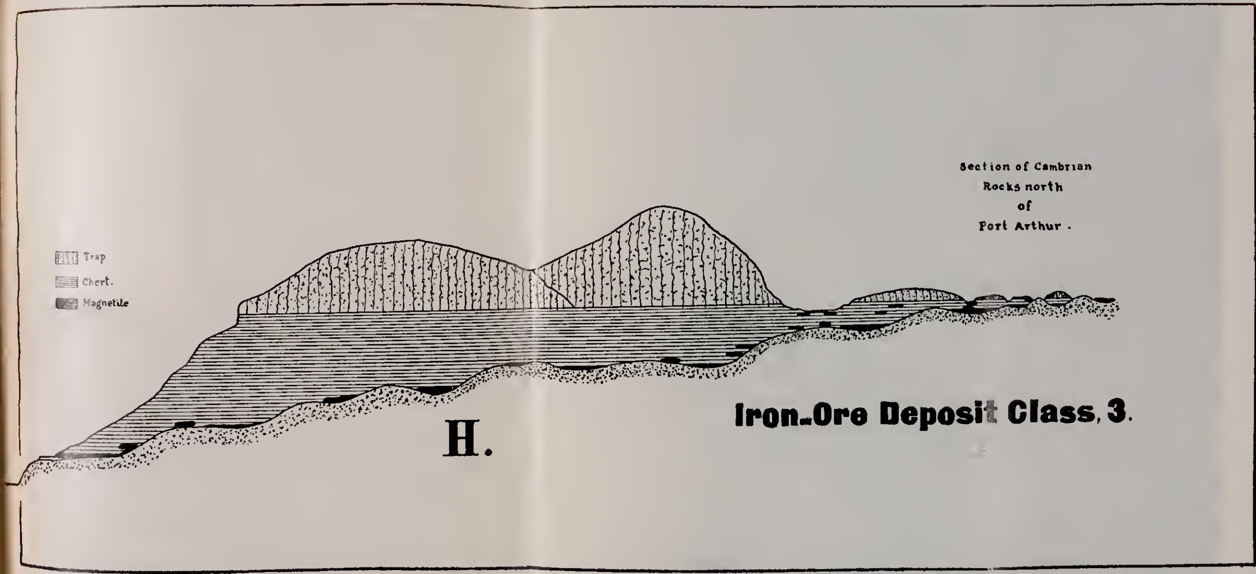


PLATE VI.—Illustrating paper by Mr. F. Hille, M.E., "On the Iron Ores of Western Ontario."

slower; the various constituents here, pyrrhotite and rock minerals, had time to separate more or less perfectly, while in the Atikokan dykes, sulphur, iron and rock are more mixed perhaps owing to a somewhat faster cooling of the magma. In a transverse section of the deposit as shown in the map, we notice how irregularly the minerals are distributed, and how small the lenses, and how short the continuity of each of these is downward. They are somewhat elongated in consequence of a considerable lateral pressure which they had been subjected to, very likely by the continued folding movements of the chlorite schists and through whose anticlinal axis they are now seen protruding, a large portion of the schists on both sides of the dykes is eroded, being softer than the dyke minerals, which withstood better the oxydiation process of the times and the ploughing action of the icebergs. The structure of the different minerals is decidedly crystalline, the rock minerals appear often in large phenocrysts, while magnetite and pyrrhotite consist of smaller grained crystals in close compact masses, tough to drill, although not difficult to crush or to powder. The pure magnetite contains from 64 to 68 per cent. iron, from 0.03 to 0.01 per cent. phosphorous and from 0.5 to several per cents in sulphur, while the pyrrhotite might contain at a greater depth nickel, at the surface it is only a trace, as this is a usual occurrence in pyrrhotite deposits

The rock under the microscope shows to be a gabbro; the greater portion of it is changing into a serpentine.

The width of these dykes is sometimes considerable, the most easterly—that is the one situated east of Sabawe Lake—is, at its greatest width, about 300 feet, running out at both ends to a thickness of a few inches. The dykes west of the lake are smaller, but have the same elongated form which follows the strike of the schist foliation. On account of the peculiar nature of the ore very little pure ore could be mined and shipped directly from the mine to the works; the ore has to be prepared first, that is the rock has to be removed and the pyrites roasted.

It might be perhaps of interest to relate some experiments which I made with the Atikokan ores last year, in trying to make a commercial product out of them. I think I succeeded very well. I proceeded as follows:—(1) I ground the ore, (2) separated by magnetic separation that part of the ore containing a certain amount of rock matter. If the ore was free of the latter, I commenced directly with (3) dead roasting and followed with (4) briquetting. The latter manipulation and (3) are done in one furnace, and I received a product which is nearly self-fluxing, and, what is of special importance, it is so solid that no danger exists of the ore crumbling to dust in the furnace through its own weight and choking it up. The analysis gave 68 per cent. metallic iron, 0.02 phosphorus, 0.5 per cent. silica, 0.08 sulphur, and the rest carbon. These briquettes should be suitable for making steel by a direct process.

I return now to our former subject. As I enumerated above, we have three localities in which we can furnish sufficient proof that the iron ore originated through volcanic action, and separated from the other constituents by a magmatic differentiation process. I think I have said enough of the Atikokan iron deposit to be plainly understood. I might also mention that a tunnel was driven into the widest place of one dyke, some cross-cutting done and a number of diamond drill holes bored into the deposit, east as well as west of Sabawe Lake.

I now come to F., the deposit at Greenwater Lake. We have here something similar as described under E., with the only difference, that there is no pyrrhotite mixed with the iron and rock, and both constituents better separated from one another. We find the iron more on one side, the rock on the other, and clean iron shows sometimes with a width of 20 feet. This separation of the minerals seems to continue downwards: the rock is in general more coarsely crystallized than in the Atikokan dykes, showing that we have here a deposit which has cooled more slowly. The rock shows under the microscope to be a gabbro with large hornblende phenocrysts cemented together by plagioclase, and changing into a serpentine. The ore averages about 54 per cent. iron, 0.12 per cent. phosphorus and a varying percentage of sulphur which is from surface samples not quite exactly determinable—because some particles of iron pyrites occur in the little cracks and interstices of the ore, as a secondary mineral, but usually the amount is not high enough to injure the quality of the iron. The ore underwent considerable lateral pressure; we find it therefore somewhat slatey, finer grained and intermixed with some chlorite, often in glauconitic form. This deposit is situated on the east side of Greenwater Lake on location R 526, and forms a dyke in the Huronian schists. Map No. 2 will show the situation and also a transverse section of it.

G. At the west side of Greenwater Lake half a mile west of Head Lake some similar deposits appear striking with the foliation of the Keewatin rocks nearly southwest-northeast, and are traceable for over two miles. The rock is here a peridotite partly changed into serpentine and well separated from the iron; this is principally observed at the northwest side of the hills. We have here therefore the same condition as at the east side of Greenwater Lake, that is, the cooling of the rock was comparatively slow. A large portion of the iron deposit has been cut away by icebergs, but at the foot of the hills we can easily observe how it rests against the rock, with a widening angle towards depth. The structure of this iron is crystalline, similar to that of the Atikokan; averages over 50 per cent. metallic iron and 0.15 per cent. phosphorus and carries a small percentage of sulphur.

The serpentine particles containing magnesia which are disseminated through the iron should have a purifying effect on the iron in the smelter in regard to its phosphorus, similar to the basic process. It would be interesting to find out the correctness of this hypothesis. Map 2 shows a transverse section of one of the hills. There have been no other iron ore deposits of this class discovered in this district so far, if we except the large titaniferous iron, or ilmenite deposits which exist here, but they have been and are still such terrible "scarecrows" to the iron smelter that I shall not say anything about them.

Further, there are quite a number of massive nickeliferous pyrrhotite deposits in this country "free of copper" which could be used for iron smelting. Nine years ago I made a proposition to eliminate the sulphur from these ores, use the resultant ferric and nickel oxides for making ferro-nickel, and save the sulphurous acid for any other commercial purpose; with correctly constructed roast-ovens this should be a success.

I leave now these very interesting deposits of Class 2 and pass over to "H" of Class 3.

At the northern margin of the Animikie rocks, especially in their lowest member, the chert and jasper, are found scattered over a considerable area thin horizontal layers of a very pure high-grade magnetite. These finds are remnants of ores which were once interstratified between the lowest bands of the chert, and escaped erosion and glacial action. They are seldom of great extent horizontally, or thickness vertically, resting either on the granites, gneisses or a rock of the Huronian series. On Map 2, I give an example how they occur. Now let us try to find out how this iron got into or between these chert and jasper beds, and what caused them to become magnetic. The deposition of the chert and jasper was produced by hot mineral springs, doubtless of considerable volume and of widespread extent, carrying silicate acid and some carbonate of iron in solution. These two substances were precipitated and later solidified together, that is, they not only mixed mechanically together, but also the iron seems to have partly separated from the silica and formed little "pools" of its own.

Now, it might be said that this iron had been an oxydation product of the chert, that is, that oxygen changed the carbonate of iron of the chert into ferric oxide and the latter replaced the silica, and formed these iron layers. I doubt this as far as all these latter are concerned. If that theory would be correct in every instance, we should be able to trace this replacement from one object to another, from chert to iron, but I was unable to detect this at such places where it would have been best observable, where later oxydation and cementation processes were highly unfavorable, as for instance at the "Wigwams," three isolated cones standing high and dry overlooking the country for miles. We see here, on the precipitous rock exposures, the cherts resting on the granite to a thickness of 20 feet and more and interstratified with the magnetite; both are overlayed by a varying thickness of trap, sometimes up to over 100 feet. But the teeth of time are gnawing also on this hard material and we see iron and chert falling out of their resting-places and covering sparingly the foot of the hills. Each of them, sharply separated from the other, they do not show a trace of partial pseudomorphism, from which we could conclude whether it originated from chert or not. I will not say that there are not a few places where the magnetite seems to be derived through the alternation of the chert, that is, that ferric-oxide was produced before the trap overflow occurred and that this oxide was then also converted into magnetite; but what I am claiming with the above is that the carbonate of iron did not only exist as a mixture with the chert, but that also pure carbonate of iron deposits of a small extent were formed at the same time with the formation of the chert and jasper. We have now to answer the question, how was the carbonate of iron changed into a magnetite? Simply through the heat of the trap lava which flowed over the chert in considerable thickness, and also through its hot floor, the granite; in other words, through the heating of the iron with the exclusion of air, the carbonate was converted into a ferro ferric oxide.

We find these conditions, as I mentioned above, only at the northern margin of the chert, that is, where the slates have been thin, while towards the thicker portion of these rocks the iron retained its original state as a carbonate, that is, of course, as far as the just described phenomenon has influenced the conversion of the siderite into a magnetite. Other conditions have prevailed, but I shall speak of these another time. I have also postponed mentioning to you the occurrence of hematite ores, which doubtless exist in considerable quantities in this country, but, strange to say, nobody seems to have observed "the signs on the walls."

If this paper had not already reached too great a volume, and our hustling secretary had not been too anxious to have the manuscript for printing in his possession as early as possible, I should have dealt with the description of all the different iron occurrences in our western districts.

Those which I have had to leave for the next meeting are the most interesting and are likely to prove for the future iron industry of Canada of the greatest importance.

Occurrence of Diamonds in South Africa, with the Method of their Extraction as adopted at the DeBeers Diamond Mines.

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By L. J. Abrahams, F.G.S., Bruce Mines, Ont.

Diamonds occur at Kimberley, Cape Colony, South Africa, on the banks of the Vaal River, the DeBeers Diamond mine, the Kimberley mine, the Wesselton or Premier mine, New Bultfontein mine and DuToits Pan mine; also at Jagersfontein, 80 miles to the south of Kimberley, in the New Orange River Colony; and at the Lace mine, 20 miles to the east of Kroonstad, also in Orange River Colony; the Schuler mine, near Pretoria, in the Transvaal.

The diamonds found in the different localities have their various characteristics, which are sufficient to enable an expert to identify the locality from whence they come.

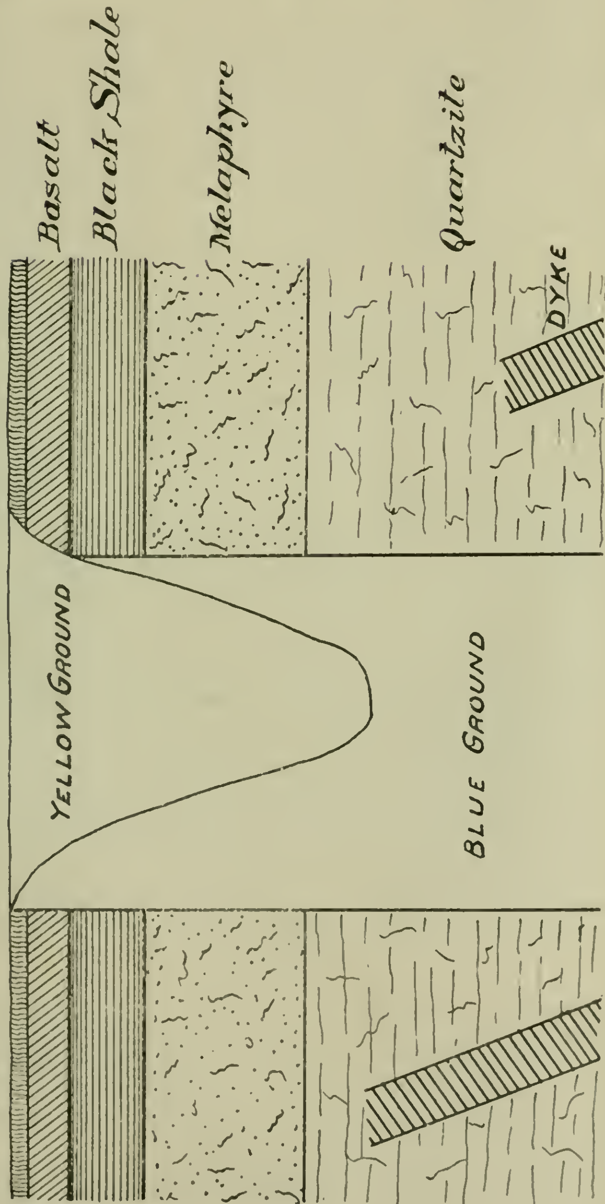
From Kimberley the best stones are found in the river diggings, next in value are those from the DeBeers and Kimberley mines, next the Wesselton and New Bultfontein stones, whose average size is smaller than that of those found in the former two mines. The DuToits Pan mine has not been worked for a number of years, hence it is difficult to make a comparison. This mine is being held in reserve by the DeBeers Co. The diamonds from Jagersfontein are the best that are mined; they having a blueish white color. The Lace stones at the time of the writer's visit were somewhat similar to those found at Wesselton, but were of inferior quality. The product from the Schuler mine consists of small stones, and are mostly cracked.

OCCURRENCE.

Diamonds at the river diggings are found from the surface down to a depth of 10 feet in the river gravel. The gravel consists of quartz, chert and jasper pebbles, together with agates.

In the mines, without exception, they occur in pipes of volcanic origin. The matrix, or blue ground as it is termed, consists of a breccia containing basalt, diorite, sandstone cemented with decomposed olivine, magnetite, bronzite, garnets, etc.

Section: Kimberly Mine



From the surface down to about 150 feet the ground is oxidised and is yellow. In the early working of the mine, when there were numerous claim holders, this caused no little consternation, and many sold out.

In the Orange River Colony the writer had the opportunity, whilst professionally engaged, to investigate a vein of blue ground. This had been found with the diamond drill, and was 48 feet down from the surface; strangely enough it contained all the necessary constituents of blue ground with the exception of the necessary diamonds. The vein averaged about 3½ feet wide, and was 2 feet thick. The country rock was quartzite. A shaft had been sunk and drifts extended. The western drift pinched out, and the eastern drift had been continued for 190 feet when the vein broke up into a number of stringers, and work was suspended. All the blue ground had been carefully washed without finding one single diamond.

In sinking the main shaft at the New Bultfontein mine some distance in the country rock a flat narrow sheet of blue ground was encountered, this, no doubt, being a crack or fissure filled in from the main deposit.

The Lace mine had a capping of limestone 20 feet in thickness, which was sunk through before the blue ground was discovered.

The mines around Kimberley occur in quartzite with layers of melaphire, black shale and basalt. (See section.) Igneous dykes occur in the quartzite.

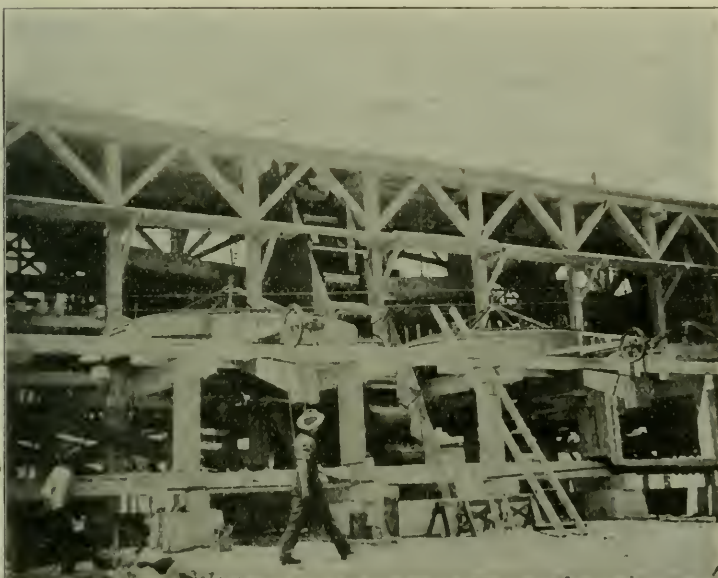
The Schuler mine in the Transvaal has no oxidised area, there being no yellow ground. The blue ground outcrops and does not weather. This weathering is an important feature in the treatment, and is hereafter explained.

TREATMENT.

The gravel from the river is washed in wooden rockers, similar to those used in gold washing, with the exception that at the feed end there is a screen of punched iron with holes of 1-16 in. diam. The gravel is thrown on to this, and water is fed over it. The mud runs to waste, and the oversize is hand sorted.

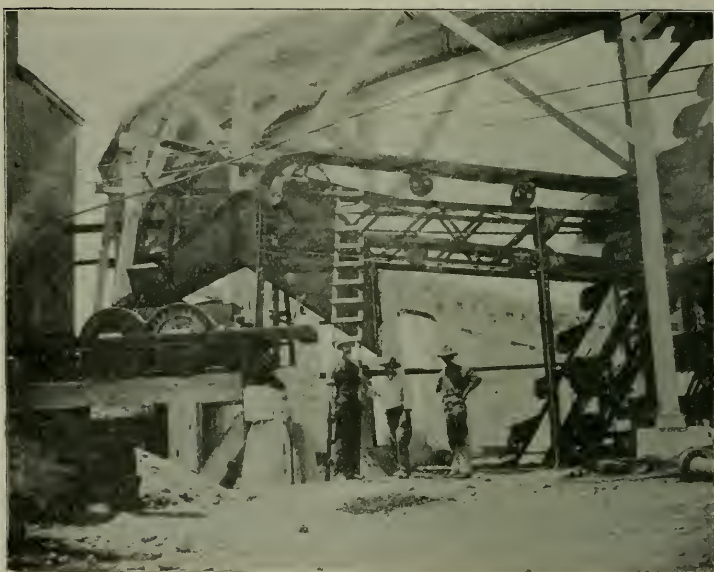
The blue ground, after it comes from the mine, is trammed to the

PLATE II.



Wesselton Washing Plant showing Washing Pans, Trommels and Elevators with part of Trestle.

PLATE III.



Wesselton Washing Plant, showing Trestle, Belt Conveyor, Toothed Rolls and Elevator for crushed material.

PLATE IV.

View in Wesselton Mine, looking East.

PLATE VI.

View in Wesselton Mine, looking West.

PLATE VII.

View in Wesselton Mine, looking South.

PLATE VIII.

Exterior of Mill at De Beers Mine—For treating the Hard Blue.

PLATE IX.

Head Frame De Beers Main Shaft.

depositing floors by means of a mechanical haulage, the endless rope system being used with a double track. Forty-five pound steel is used for the loaded cars and twenty-five for the empties. The return trip of some of these haulages is not less than 4½ miles. The depositing floors are made by clearing off the grass and levelling the ground. These floors are of considerable area; the blue ground is kept to an average height of 11 inches. Some of these floors have 11 million loads on them. These are not fenced off, as there is no fear that any one walking over them would find any diamonds; it is worse than looking for the proverbial needle in the hay-stack. An enterprising mathematician figured the chances to be somewhat over a billion to one against a person finding a stone in walking over the floors.

This is exposed to the atmosphere for periods varying from 6 to 9 and 18 months. This exposure weathers the ground and disintegrates the greater part of it. The disintegration leaves it in a pulverized condition. Part of it, however, does not weather, and has to be treated separately. The weathering is hastened by ploughing and watering. The ploughing is done by traction engines, one each side of the field with a rope stretched across; the plough is attached to the rope and drawn backwards and forwards by the engine. The disintegrated ground is taken to the washing machines. These consist essentially of pans about 8 ft. in diam. x 12 in., with revolving rakes. There are two discharges for the water and one for the resulting concentrates. The discharges for the water are placed at different heights in the pan. The higher one takes the cleaner water, and it is returned through the system, it being necessary to have muddy water for the better separation of the material; the lower one takes off the thick mud which goes to waste. The discharge for the concentrates is a sliding door in the bottom of the pan, and is worked by a worm and ratchet, the worm being worked by hand by means of a pulley and chain. (This is shown in photo No. 1.)

THE WESSELTON WASHING PLANT.

The blue ground is hauled from the depositing floors by mechanical haulage, in ore cars of 16 c. ft. capacity, up a low trestle to the top of the plant. These are discharged into receiving bins which empty on

PLATE X.

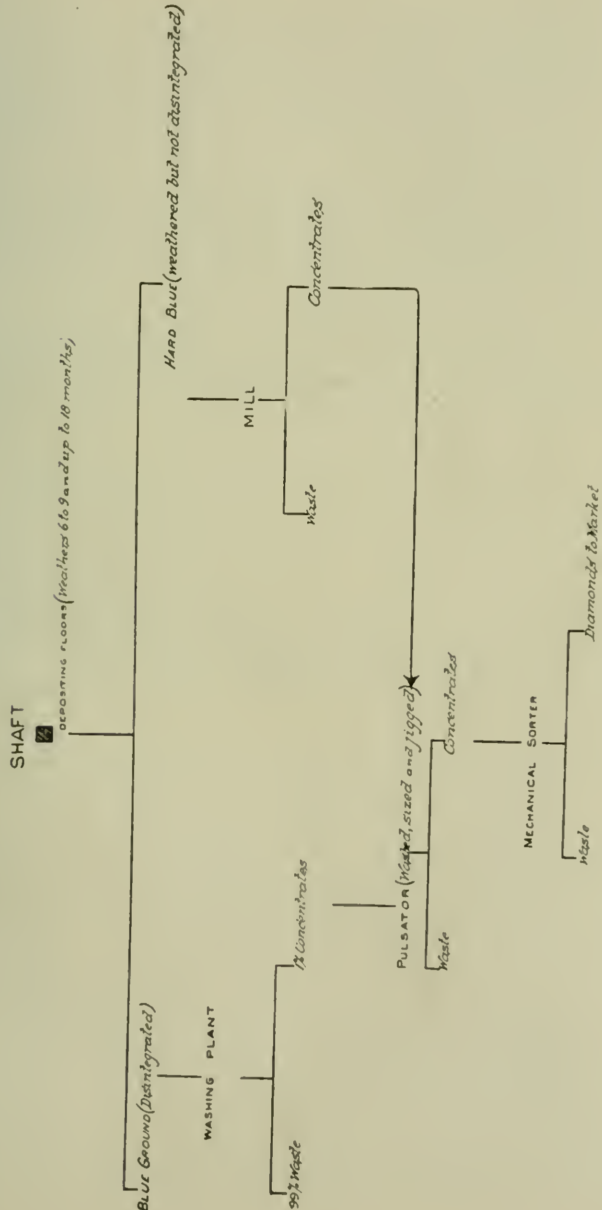


Diagram showing treatment of Blue Ground.

to a revolving table, which serves as a mechanical feeder, and discharges from two sides into trommels with holes 1¼ in. diam. The oversize from these fall on to a travelling belt, which conveys the material to toothed rolls which crush to 1¼ in., these discharge into an elevator which discharges again into the trommels. (This is shown in photo No. 2.)

The undersize from the trommels drops on to another elevator which feeds the washing pans above described. In this plant there are 12 pans, each treating 285 loads per day, and concentrates down to 3 loads, thus nearly 1 per cent.

These concentrates are sent by a light railway in locked ore cars to the pulsator, which is a system of jigs; they contain fragments of basalt, diorite, sandstone, bronzite, magnetite, garnets and the diamonds. The system of jigging consists only of the trommels for sizing with the necessary jigs for treating the sized materials. The beds for the jigs consist of leaden or iron balls, the iron balls being used for the smaller material. The concentrates from these jigs consist of materials of nearly the same, also of higher, specific gravity, than the diamonds, viz., bronzite, magnetite, olivine, garnets and the diamonds. This, up to a few years ago, was hand sorted. A machine is now in use for the sorting of this heavy deposit as these concentrates are termed.

This machine consists of 5 steps, each step being a plate of iron 4 ft. x 1 ft. 6 in., and each step is about 4 in. below the other. There are low, thin riffles on each plate. These plates are covered with grease, the riffles holding the grease on the plates when it is poured on. The material is fed on to the topmost plate with water from a V shaped box extending over the length of the plate, and has a ribbed roller in the bottom of it, which is revolved. All the steps are bolted on to one framework which is given a side shake. The whole of the material fed is washed off the plates with the exception of the diamonds. The waste travels down from step to step, and is thus treated 5 times when there are 5 steps; most of the diamonds are caught on the top plate, they sticking to the grease. When a clean-up is made, the plates, or steps, are removed and heated, the grease allowed to run off, and the diamonds collected, the grease being used over again. There appears to be more cohesive power between the surface of the diamond and the grease than with the surface of the minerals. The kind of grease used is kept secret.

The ground that does not weather is termed "hard blue." This is treated separately in the mill, where it is crushed with Comet crushers, sized, the over size being recrushed in toothed rolls, sized again, and then treated in the jigs. The concentrates from here go to the pulsator, the same set of jigs where the concentrates from the washing pans are treated. The mill in this manner takes the place of the washing gear, and treats the material that will not weather.

The treatment may be summed up in the accompanying diagram.

-16

The Iron Ore Deposits Near Kitchener, B.C.

By W. BLAKEMORE, M.E., Montreal.

These deposits consist of a series of parallel veins of hematite iron ore running continuously for a distance of ten miles, the full length of a solitary mountain known as the Iron Ridge, and situate, at its nearest point, a distance of three miles west of Kitchener Station on the Crows Nest Pass Railway. A reference to a map of British Columbia (Fig. 1) will show that Kitchener is 20 miles east of Kootenay Lake, 70 miles east of Nelson, which is the centre of the smelting industry of West Kootenay, and 120 miles west of the extensive coal fields of the Crows Nest Pass Coal Company at Fernie. The mountain is peculiar in formation, being entirely separate from the other ranges in the district, and representing the appearance of an inverted boat. It starts from the level of the railway and Goat River 2,400 feet above sea level, rises gradually to an altitude of nearly 6,000 feet in a distance of two miles, continues with slight variations at this level for six miles, and then dips down again at the extreme north end at about the same angle as at the south. The main direction of the mountain is 20 degrees W. of N., and upon the east side Goat River flows parallel to it. At its base on the west side is a large creek known as Arrow Creek, and around the north end is a pass connecting the two. The original survey for the Crows Nest line was around this pass, and it was only abandoned because it involved a detour of 20 miles. In view of the development of the property under consideration, this point is worth remembering, as the possibility of constructing a railway of easy grade all around the mountain was demonstrated by the survey referred to. (Fig. 2) Shows the elevation of the mountain from Goat River to its extreme northern limit. The character of the ore is chiefly hematite, and upon a few claims this has been found to be slightly magnetic, but over the bulk of the property it is pure hematite. The occurrence is in a large body of quartzite approximately 500 feet in width running longitudinally with the mountain, and along the eastern side co-extensive with the quartzite is a green stone dyke of gabbro-diorite. The

PLATE I.—Illustrating Mr. William Blakemore's pape
on "The Kitchener (B.C.) Iron Ore Deposits."

property consists at the present time of fifty claims, each 1500 fr. sq., upon which the ore has been located, an area which embraces practically the whole of the summit of the mountain. The property has been held for some years as a copper proposition, and probably from $10,000 to $12,000 expended in prospecting for that mineral. In the spring of 1901, however, the iron ore seems to have attracted attention, and for the first time the holders began to realize that it might possess an economic value. It came under my control last May, and from then until the 30th November I expended about $30,000 in prospecting and proving the property, the result being that the capitalists whom I represented have purchased twenty claims, and hold an option on the remainder. Our season's work has proved that the ore is of the highest quality, that there is sufficient to constitute an important property, and that the surrounding conditions are favorable to development. There still remains to prove the actual extent of the ore as development work would not justify a calculation of tonnage at present, but as I shall show, everything points to an enormous deposit. Owing to the large area to be prospected, much of the work consists of mere surface examinations and prospecting, it being important in the first instance to establish the area over which the iron extended. We soon discovered a 6 ft. vein upon the Keepsake claim near the north end of the property, and on putting the diamond drill to work found the iron continuous and good at a depth of 60 ft. On cross-cutting this vein we found that, in addition to the 6 ft. of solid iron, there was an admixture of iron and quartzite running in alternate bands for a distance of nearly 100 ft. In some cases the quartzite and the ore were mixed, in others there were clean bands of ore. Meanwhile another vein 6 ft. wide had been located upon the Maple Leaf claim, a little distance north; upon this claim a shaft was sunk 50 ft., and the iron at the bottom of the shaft continued of the same thickness and yielded the same assay as upon the surface, viz., 67.2 per cent. of metallic iron. About this time a vein was located upon the "American Flag" claim still farther north, and as it showed up nearly 20 ft. in thickness, it was decided to put a trial shaft upon this. The shaft went down 30 ft. and was then stopped in consequence of water, but the thickness and quality remain the same. Meanwhile the same vein was traced south to the O-Ray claim, upon which a shaft was sunk 50 ft. Here the vein was 18 ft. thick and of uniform quality. In none of these veins was there the slightest admixture of quartzite or other impurity, the whole of the material taken out being put on to the dump for shipment. An average assay of the ore on the American Flag gave : metallic iron, 67.4; silica, 1.7 ; sulphur, .16 ; phosphorous, .03 ; and upon the O-Ray, metallic iron, 64.7. In addition to these veins, one vein 15 ft. wide was located at the end of the season 500 feet east of the American Flag claim and traced for several hundred feet north and south : also another claim upon the Golden Cap to the west, the latter being 8 ft. thick, but upon neither of these veins was any work done beyond uncovering. It will thus be seen that in all there are five veins located up to date, aggregating 63 ft. in thickness, and that actual exploration has proved these to a depth of 50 ft. *in situ*. (Fig. 3) Is a plan showing vertical cross-section of the mountain with the relative position of the veins, and their dip which may be taken as 75 per cent. (Fig. 4) Is a surface plan showing the relative position of the claims. Beyond the actual exploratory work done, there are other evidences upon which the extent of the iron may be fairly considered. In the gulches which are found upon the mountain side the same veins have been uncovered at a difference in elevation of 1,200 ft., and they maintain their uniformity at those points. The diorite dyke referred to is continuous throughout the whole length of the mountain, and can be traced across the level ground and through a railway cutting on the Crows Nest line. Having regard therefore to the character of the deposit, to the persistency of the green stone dyke alongside which the iron occurs, to the formation of the mountain, and to the fact that the measures are found regular at the base as well as at the summit, there is no reason why the iron deposits should not also continue to that depth, but whether this be so or not, sufficient has already been done to show that there is an enormous deposit of iron of the highest quality quite sufficient to justify great expectations for the future of the property. I need hardly say that work will be continued during the coming season until a thorough proof is made.

With reference to the quality, this is so surprising that I have some diffidence in placing the figures before you, but still they speak

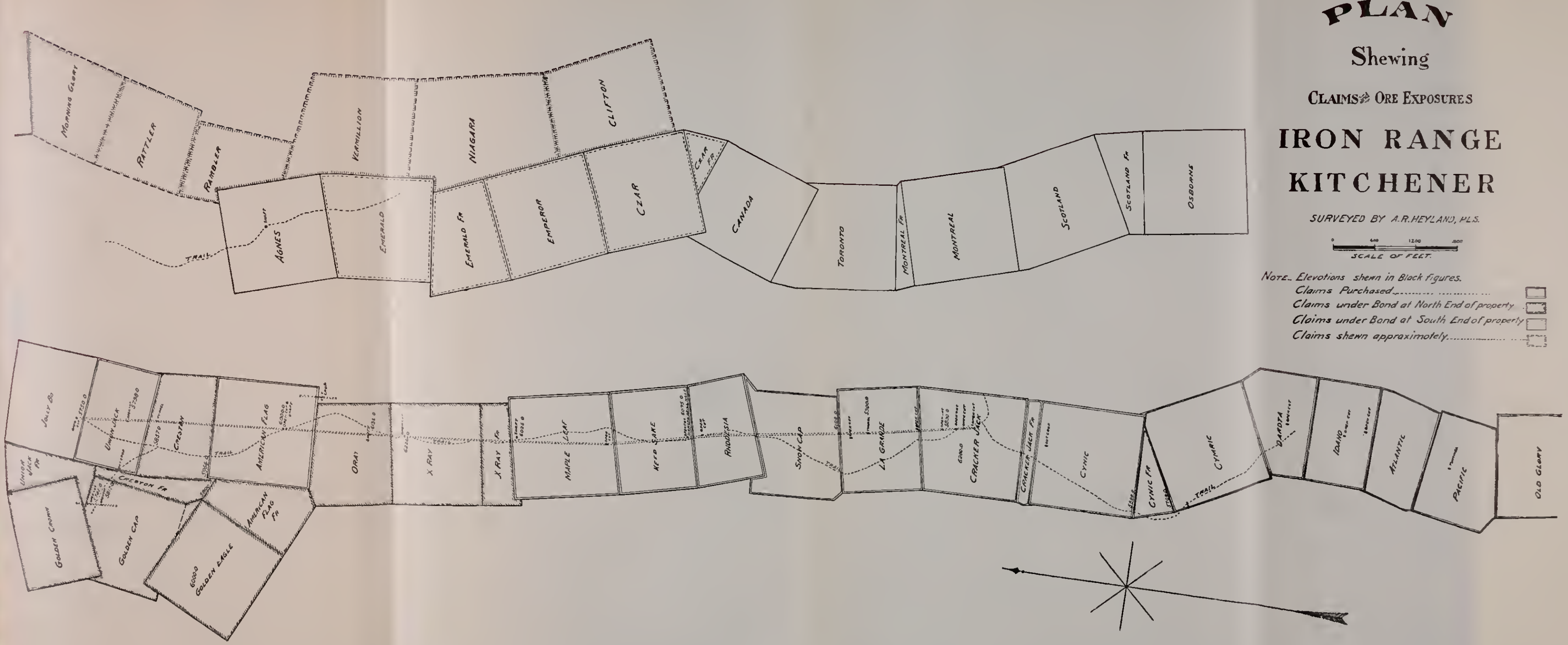


PLATE II.—Illustrating Mr. William Blakemore's paper on "The Kitchener (B.C.) Iron Ore Deposits."

78²

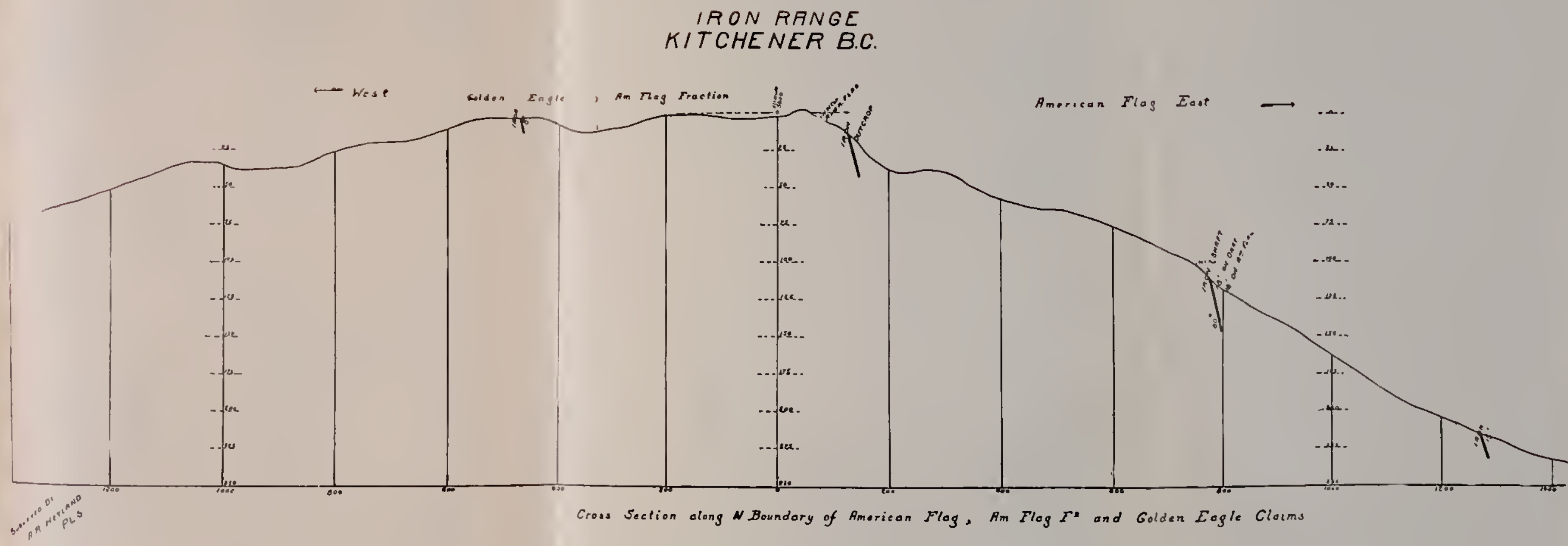
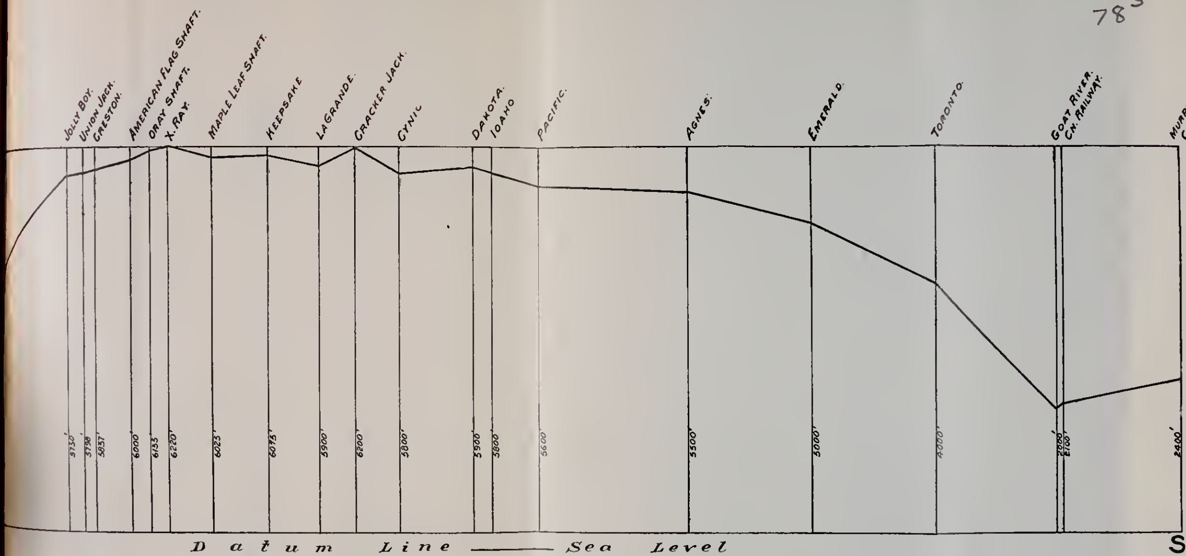


Plate III.—Illustrating Mr. William Blakemore's paper on "The Kitchener (B.C.) Iron Ore Deposits."

SECTION
IRON RANGE KITCHENER

78 3



Note — *Elevations* — shewn in figures

Scale. — Vertical 1000' to the inch
Horizontal ½ Mile " "

} or for reduction

0 500 1000 1500 2000 — V

0 ¼M ½M ¾M 1M — H

Plate IV.—Illustrating Mr. William Blakemore's paper on "The Kitchener (B.C.) Iron Ore Deposits."

SECTION

IRON RANGE KITCHENER

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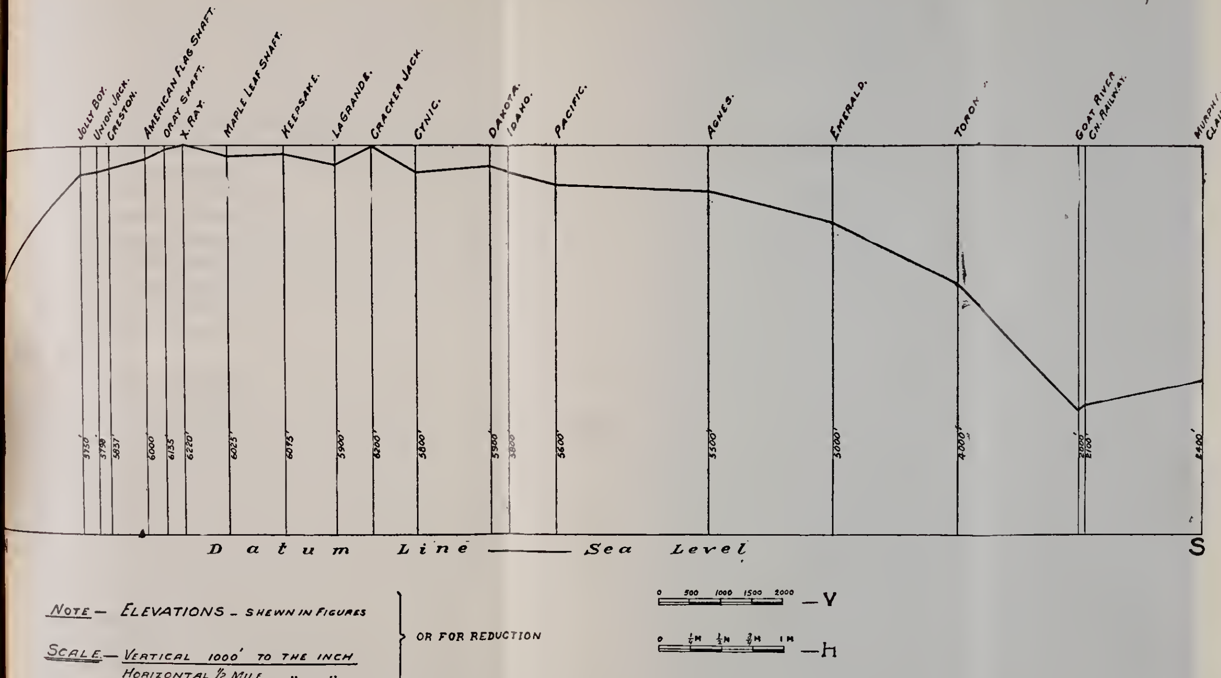
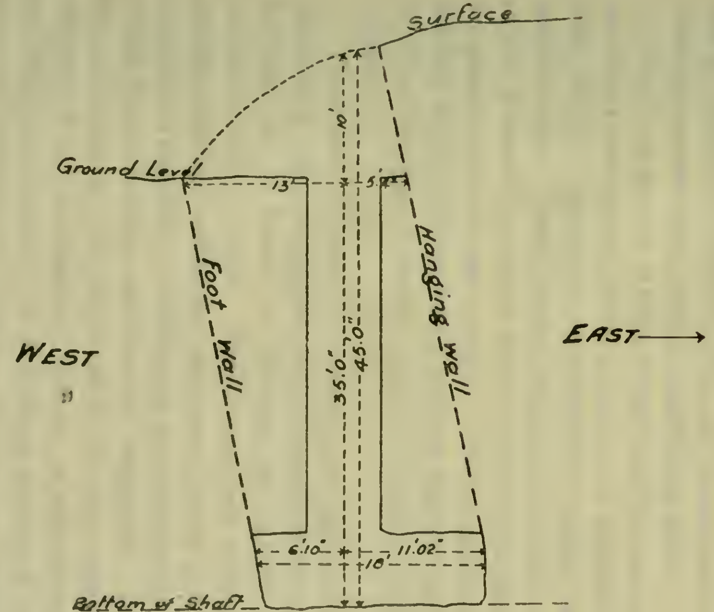


Plate V.—Illustrating Mr. William Blakemore's paper on "The Kitchener (B.C.) Iron Ore Deposits."

for themselves, and are the result of assays made by five or six independent authorities including McGill University, Mr. Milton Hersey of Montreal, and Mr. Robert Hunt of Chicago; they have also been verified by practical tests made at the works of the Dominion Iron and Steel Co., and as they are the results of bulk assays and not selected samples you will, I am sure, agree with me that the ore is one of the purest and highest grade bessemer ores to be found anywhere. More than 100 assays were made; of these 60 were taken from the veins, and taking those only into account, excluding float, we got an average of 60 per cent. of metallic iron, 5 per cent. silica, .10 sulphur, and .03 phosphorous. A comparison of these figures with those yielded by the celebrated Lake Superior ores, and with the Newfoundland ores, shows that the Kitchener ore is decidedly superior, being higher in metallic iron and lower in sulphur and phosphorous. An average assay of Lake Superior ores gives: metallic iron, 60; sulphur, .010; phosphorous, .06; and of Newfoundland: metallic iron, 55; sulphur, .012; phosphorous, .600.

Naturally the question of interest in connection with this matter is the future of the property and its value to British Columbia. Of this it may safely be said that sufficient iron has already been discovered to determine the existence of a first class fluxing proposition, and even for this purpose the property will in the future be valuable. But unless all my expectations are baseless, we have here a property which when thoroughly proved will be shown to contain such an extensive body of hematite ore of the highest quality, that it will be possible, whenever the Province is ripe, to establish a large iron and steel making industry in the West, which will compare not unfavorably with that of the East, All the local conditions for cheap manufacture are favorable. The ore can be mined and shipped for $2 a ton. There is abundant limestone in the neighborhood upon the west side of Kootenay Lake, which can be delivered to a smelter at 50c. a ton. The high grade coal and coke of the Crows Nest Pass is only 120 miles away, and can be brought to Kitchener at a cost of $3.00 for coal and $5.00 for coke. Allowing for the higher rate of wage prevailing in the west, I consider that pig iron can be made on this property at a cost not exceeding $10 a ton, and this iron can be delivered at a cost of $13.00 to $15.00 at the coast. At the present time pig iron delivered at any of the coast cities is worth $22.00 a ton, and even admitting that prices are above the normal, there would still be a wide margin in favor of the local product.

It may be too soon for British Columbia to support such an industry, but except in the face of a very high tariff the Western States would be customers for steel produced at Kitchener, and in any case the Orient trade would be fairly within our grasp, as under no circumstances would it cost as much more to produce steel at Kitchener as the difference in cost of transportation between Pittsburg and the Pacific coast and Kitchener and the coast, and this would be the final and determining factor in competition. The property is in the hands of men who will develop it in the best interests of the Province ; it will be made to serve Canadian interests every time, and the proprietors have not only the will, but the ability to handle it in such a manner as will, in my opinion, produce important financial results for Western Canada.



Iron Range, Kitchener, B.C.

SKETCH

Shewing

ORAY SHAFT.

Plate VI.—Illustrating Mr. William Blakemore's paper on "The Kitchener (B.C.) Iron Ore Deposits."

On the Copper-Bearing Volcanic Rocks in the Eastern Townships of the Province of Quebec.

By JOHN ALEXANDER DRESSER, M.A., Richmond, Que.

The copper-bearing rocks of the Eastern Townships of the Province of Quebec have long been known to comprise three principal belts which run approximately parallel to the north-easterly trend of the Green Mountains in their extension into Canada. These belts are about twenty-five miles apart where crossed by the St. Francis River, and are themselves some two miles wide in each case along that river, although elsewhere they are often considerably wider.

The most westerly of these, which is the first met in approaching the district from the St. Lawrence valley, is an extensive band of limestone which is sometimes associated with glossy black slates or graphitic shales. Small igneous intrusions are known to occur in the vicinity of most of the copper deposits of this belt, and in some cases the igneous rock itself carries copper. The best known deposits in this band are the once famous Acton Mine, the adjacent deposits at Upton, as well as the mines formerly worked at Roxton, Wickham and St. Flavien.

The central, or Sutton belt contains, amongst others, the Harvey Hill mine at Leeds, the Halifax, in the township of that name, the Viger in Chester, the St. Francis in Cleveland, the Balrath in Melbourne, and Sweet's mine in Sutton. The country rock of this belt has been generally described as chloritic, micaceous, talcose or nacreous slate, and has been regarded as sedimentary in origin and the correlation of various deposits has been made on that assumption. Within the last two years, however, it has been found by the writer that these rocks in most cases at least are disguised volcanics of early geological age and much altered in character. A preliminary mention of this was made in a recent publication ("Preliminary Note on an Amygdaloidal Trap Rock in the Eastern Townships," John A. Dresser, Ottawa *Naturalist*, 1901), in which it was shown that the rocks are somewhat variable, but that a considerable portion probably was originally a diabase, and that the greater part was amygdaloidal Copper is found, not in true veins, as far as observed, but in lenticular masses conforming to the well-developed cleavage of the rock. The gangue is commonly calcite and quartz, and the character of the deposits such as to indicate the deposition contemporaneously with the gangue. The secondary derivation of the ore from the country rock is further evidenced by the fact that the latter commonly yields a small percentage of copper on assay.

Still more recently, a similar discovery regarding the nature of the rock in the Ascot belt, the most easterly of the three bands, has been made by Mr. G. H. Pierce, C.E. This area includes, amongst many others, the widely known Albert and Eustis Mines at Capelton, the Howard and others at Suffield, the Ascot and the Sherbrooke near the city of Sherbrooke, the Moulton Hill, a few miles east of the St. Francis River, and the Garthby deposits forty miles farther eastward. The country rock has not been usually described as differing essentially from that of the Sutton belt in general character, unless it be that the micaceous and nacreous slates have been found to predominate in the former while the chloritic prevail in the latter.

During the course of a recent visit to the Suffield mines, Mr. Pierce observed a massive appearance in the hanging wall of the Silver Star mine which suggested to his practised eye the probability of its igneous origin, although the sedimentary character of the rock, a supposed sandstone, had not been thitherto questioned, as far as can be learned, by the many previous observers of it during the past fifty years A specimen which was handed the writer by Mr. Pierce proved, on microscopic examination, to be a quartz porphyry, the rapidly cooled equivalent of a granite. In structure it is a typical porphyritic rock having phenocrysts of quartz, orthoclase and plagioclase in an indeterminable base, which is probably a fine grained aggregate of quartz and feldspar. A little colorless mica and a few fragments of some carbonate which are present, are doubtless secondary constituents. Strain shadows in the quartz phenocrysts and a cataclastic structure point to the subjection of the rock to intense pressure since its solidification. This is also evidenced in the hand specimen by a well developed cleavage.

As the rock was known to be one of considerable extent, specimens were subsequently taken by the writer at various points across the belt between Sherbrooke and Lennoxville and from several of the nearest mineral deposits. From these it is apparent that the Ascot belt, like that of Sutton, is a complex mass consisting chiefly of old and highly altered volcanic rocks.

A specimen was taken from a cutting for the street railway on the northern outskirts of the village of Lennoxville, opposite the house of Mr. Alex. Ames, which appeared to be representative of a large part of the igneous belt, especially towards the southern side. In the hand specimen it is a greenish gray, fine massive rock with a rusty weathering in places. It carries a little pyrite, and also shows strings of epidote distinguished by their lighter yellowish green color. It is an exceedingly hard rock. By the aid of the microscope, it is found to have a finely crystalline quartz-feldspar base, in which are larger crystals of phenocrysts of quartz and plagioclase feldspar. There are no primary bisilicates present, any original constituents of that character being now represented by the secondary minerals, epidote and chlorite. The rock is, therefore, a variety of altered quartz-porphyrite.

Another rock, which cuts that just described in the form of a dyke near the locality of the last specimen, but which appears to comprise a larger independent mass elsewhere, is light gray in color and carries a little pyrite. Under the microscope large phenocrysts of feldspar can be seen, some of which extinguish parallel to principal axes, and hence are orthoclase. Quartz occurs in phenocrysts and also in the finer crystalline ground mass along with feldspar. Chlorite, brown iron oxide and a colorless mica are found in small amount. The rock is a granite porphyry. Subjection to pressure since solidification has given it somewhat of a cataclastic structure.

Another rock, forming large areas within this belt, is that which is frequently quarried for road metal and other purposes in the city of Sherbrooke. It is a very highly altered rock, gray or greenish gray in color, and is commonly spotted with reddish brown iron oxide. In the micoscropic section it is found to contain prominent masses of rhombohedral carbonate, a part of which at least are attacked by cold acid. Probably both calcite and dolomite are present, or a carbonate of lime with a varying magnesium percentage. The carbonate occurs in a fine base containing a certain amount of colorless mica, and is a secondary constituent, being one of the results of the decomposition of earlier lime bearing components of the rock. Grains of quartz occur in some instances so as to give the appearance of crushed phenocrysts. Owing to its excessive alteration, and to more detailed examinations being in progress (including some chemical investigations by Mr. M. F. Connor, B.A.Sc., Radnor Forges, Quebec), the specific character of the rock has not been definitely determined. The igneous origin of the more southerly of its two occurrences was announced by Dr. R. W. Ells in the annual report of the Geological Survey of Canada for 1886, who also noted that it "has a considerable development in the vicinity of some of the copper mines south of Sherbrooke" (p. 41 J). Its field relations, as far as known, seem to show that it is a differentiated part of the same mass with the porphyrite already mentioned.

These are the chief rock types yet noted besides certain sedimentary outliers generally of minor extent within this belt. It is noticeable that in their general characters these igneous rocks appear to be very similar to the Klondike series of the Yukon Territory as described by Mr. R. G. McConnell in the preliminary report of the Geographical Survey of Canada for 1900, or to certain of the Keewatin series described by Mr. W. McInnes, with microscopic notes by the writer, in the report of the Geological Survey of Canada for 1897.

The whole igneo-metamorphic complex is occasionally cut by dykes which, from their undisturbed position and fresh state of preservation, are evidently of a very much later age than the main rock masses. At Suffield, Mr. Pierce took a specimen of olivine diabase from a dyke in the Howard mine which appeared to be unaffected by dynamic metamorphism and was found mineralogically unaltered. A dyke of equally fresh appearance in the northern border of the village of Lennoxville was found to belong to the camptonite class. In both cases the country rock containing these dykes is in a highly altered condition. The dykes were the latest rocks to form in the region, while the country rock were the earliest, thus showing this belt to have been the scene of volcanic eruptions at very widely different times, at one or more of which the lavas ejected carried copper, silver and gold. From the fact that the ore bodies in many instances follow the cleavage of the rock, the form thus given the deposits causes them to easily simulate bedded veins, which they have commonly been thought to be, owing to the cleavage having been generally mistaken for stratification. In view, however, of the igneous character of the country rock, the correlation of various deposits on assumed stratigraphical grounds becomes useless, both in the case of the Ascot and of the Sutton belts, and opinions regarding the mode of occurrence of the ores also call for revision. This is all the more important as the copper ores commonly carry appreciable amounts of both silver and gold.

If a petrographic examination should prove the trap to be continuous between the Moulton Hill mine and Garthby that is to form the Stoke mountain, that hitherto little known district would call for detailed prospecting. That such is the case seems to be indicated by the latest areal map of the district by the Geological Survey of Canada (Report 1886, Dr. R. W. Ells). In this map the Precambrian, which practically coincides with this volcanic belt in the vicinity of the St. Francis River, is indicated as continuous between these points. Concerning the deposits of the Ascot belt, Dr. Ells also writes (Report Geological Survey 1888-1889, p. 56 K): "It may be very safely predicted that the real value of many of the mines which were opened twenty-five years ago and speedily closed, has never been ascertained, and that other masses of ore of equal importance to those so long worked, will, at some not distant date, by careful prospecting, be found. Much of the failure of twenty-five years ago was doubtless due to the speculative character of the work done. Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness; often on samples which were obtained from an entirely different location from that represented. The growing importance of these ores as a source of supply for sulphuric acid is being very fully realized by the men interested in this industry in the United States, and their superiority over most of the ore there found, for this purpose, being acknowledged. There are yet in this eastern belt many places thickly covered by forest growth, the prospecting of which is a difficult matter, but of the many mines already opened and abandoned it is highly probable, as in the case of those now worked, that deeper and more scientific testing would change the aspect of things greatly for the better."

A Few Notes Upon Gold Dredging.

By F. SATCHELL CLARKE, Vancouver, B.C.

A great deal of attention has been paid of late years to gold dredging upon the rivers and placers of the Pacific Coast and North-West Territories down to Lower California, and, generally, a quantity of literature has been published by various papers and authors upon this subject, but, with one or two exceptions, little has been written by those having a direct and intimate knowledge of this form of mining.

This is really what is to be expected in any class of tentative work, for that is what it really has amounted to in British Columbia. Any work in which the experts are few will always cause to arise a host of empirics willing to learn at the expense of others.

Gold dredging in British Columbia instead of being the leading mining industry owing to its enormous extent of auriferous gravels has been marred by such empiricism and marked with many failures by reasons so palpable to the writer, that it has often occurred to him to ask with amazement " what kind of business men are these who invest their money without having a consulting engineer in dredging to advise them ? " A consulting engineer is always necessary with other mining, yet in this instance, in work that above all requires a specialist to advise, matters are left to run with the promoter, or quondam manager who may be appointed.

In New Zealand, the home of this industry, the work of recommending the claim and the actual details and construction of the dredge with its design is left to the consulting engineer, who is necessarily an expert in designing and actually operating gold dredges, and stands between the owner of the claim, or rather, to speak more correctly, the intending buyer of the claim and all other parties, and is merely paid a salary for a specified time, or a fee to cover the intending operations until the plant is completed.

This proceeding saves both the buyer getting a claim sold principally by the silver tongue of an interested party, and in another case building a faultily designed plant, foisted upon the first party by some of the would-be experts connected therewith.

The chief and prime cause of these failures which form the subject matter of this article has been the appointment of managers who, prior to holding their position, were without the slightest knowledge of this class of work, simply because in most cases he is, or becomes, a stockholder, or had possibly sold the claim to the investor, and according to the old and obsolete custom still retained in placer mining, "who so able to manage a claim as the large shareholder, as he is looking after his own interests as well as ours." Never was a greater fallacy more exemplified than in dredge mining history in British Columbia. A little desultory reading in the mining papers and reports gathered of what other dredges are doing and the manager blossoms forth into the dredge expert.

After the appointment follows the usual trip to New Zealand, California, or other places, to investigate the best type of dredge suitable for the claim. It appears to the writer equivalent to appointing a manager to a quartz mine and then sending him round to other mines to find out the best way to work the mine. He may, of course, return with the right ideas, but in the confusion of different opinions and dredges he has seen, it would be a matter of chance than otherwise, and his advice to his principals would be merely "the blind leading the blind." In some cases he returns with exaggerated ideas that he is getting the right machine and no other, and of course probably has been talked into it by the ready-tongued agent of some manufacturing company, or taken by the advertisements of some concern. Now, no matter how excellent the work of the manufacturing engineers is, he is unable to tell from his inexperience whether they are right or wrong in the details or general design. Then another class of managers are the persistent billet-hunters, who must be included among the causes of these failures, as these men are ready to take any job, provided there is a salary attached, no matter how ill their qualifications may fit in to the work.

Now, to turn to the different types of dredges used. There are many engineers and persons still in existence who cling persistently to the centrifugal pump as a means of dealing with auriferous gravels This process has been exploded years ago in the great dredging centres.

As a rule, with rare exceptions, gold gravels are composed of rough boulders averaging anywhere from 10 in. in diameter, and mixed up with a compound of sand, fine gravel and clay, forming what is known in mining parlance "a tight wash." It is almost impossible to work this by a pump, owing to the almost cemented qualities of this wash, and the throat of no pump has yet been made strong enough to stand the impact of the gravels, should the pump strike an occasional body of loose gravel, and then it is superfluous work as loose gravels seldom carrries any gold.

In spite of the repeated failures in New Zealand, California, the Snake River, and many other places, even to the Mawdach Gold Dredging Co., in gallant little Wales, where an attempt was made to dredge for gold at Barmouth; an enormous amount of money was wasted at Ruby Creek, upon the Fraser River, in trying to make a centrifugal pump dredge for gold. Interluding a little foreign news, after having seen the Barmouth gold dredging claims, I will undertake to say that with a properly constructed dredge there should have been a handsome investment for the stockholders. This may seem news to some, but there is quite a large extent of auriferous country in Wales.

Next to the centrifugal pump came a giant clam-shell dredge which was built some years ago at Lytton upon the Fraser River. This was the old mud dredger system applied by a pair of semi-circular steel plate self-shutting shells, very like its patronymic in appearance, and lowered to the bottom of the river by means of chains. On lowering these into the river, two almost insurmountable difficulties were met with; in the first instance, the strong current carried the clams under the bottom of the scow upon which the machinery was placed, and rendered it nearly impossible to bring it up full. The next trouble was that when the clams did bite into the gravels, a boulder or large stone would be held between the jaws, and by keeping them that distance apart would allow the whole of the finer gravels and gold to escape back into the river. This experiment cost the unfortunate shareholders $60,000 before knowing it was a failure.

After this came an attempt to exploit the gravels by means of a caisson or air-lock, by which men went down to the bottom of the river and by hand labour passed the gravel into an air-lock, and from there to the deck where it was treated by means of an ordinary rocker. Owing to the writer being brought into a controversy over this machine by the promoters, the project was killed by the caustic remarks made about the enormous cost in labour and steam to bring up a yard of gravel yielding probably 25 to 30 cents from the bed of the Fraser.

The writer was working a ladder dredge upon ground over which a pneumatic dredge had passed over and thoroughly prospected according to its ability and found too poor to work, which turned in to the shareholders for some years over 100% per annum clear of all working expenses.

Later upon the scene of dredging operations came the dipper dredge. This, as far as working a hole in the gravel, is moderately effective, and many of this type have been built and launched upon the the Fraser and the Sascatchewan rivers. Yet there are great stumbling blocks to the use of this type as a gold dredger. Chief among these are the want of mobility in handling it in a rapid river, the great cost in working them, (they require at the least 5 men per shift under favorable circumstances as against 2 men with the bucket and ladder type), the intermittent discharge, the comparatively small cubic measurement of gravel actually worked in a week's run, and worse than all the inability to make a direct side cut across a river or bar, thereby enabling the ground to be worked upon a face and thus systematically clean up the bed-rock, or depth it is found necessary to go with the dredger. These points will always militate against it as a dividend-producing machine, except under very and exceptionably favorable circumstances.

All of this class of dredge which were built upon the Fraser and other places near have been started with a great flourish of trumpets (one was started last year) only to end disastrously. One manager of these dredges told the writer that his ground averaged 25 cents to the yard, and in the lower depths considerably more, yet he could not pay dividends owing to his intermittent digging. I understand that at 20 feet the gravel ran to as much as \$3.00 per yard, but he was unable to keep his cut open long enough to take more than an occasional bite at it, for the reasons mentioned above.

The first plant to work the Fraser river in its rapid current and heavy gravels successfully was one of the bucket and ladder type, built in 1899 in England under the writer's supervision upon New Zealand plans, altered slightly to suit the conditions met with in this country.

This is known as the Cobbledick dredge, and is now under another name, "The Fraser River Dredging Co." This plant failed dismally the first year to pay anything, although quite an amount of gold was won, owing to the want of experience of the then manager, who was also a large stockholder—made by selling the investors the claim. He was a clever man with extravagant ideas, and threw the old company into debt. It was re-organized, and under the present management is paying moderately well, and the writer has no doubt but that when those at the head of affairs have gained more experience, the company will pay handsome dividends upon its present capital.

Some Eastern capital after seeing this plant work, decided to place a similar type, but of more powerful design, upon the North Thompson river 15 miles north of Kamloops, and the writer was instructed to prepare plans for the same.

The whole of this machinery was built in Canada by the Wm. Hamilton Manufacturing Co. of Peterborough, who to their credit made a vast improvement upon the New Zealand and British work.

This dredge is capable of lifting from a depth of 40 feet below water, washing, treating, and stacking the coarse stones and boulders to a height of 30 feet astern of the dredge, a guaranteed capacity of 2,000 cubic yards of gravel per day, and cutting its channel through a flat of 20 feet in height. The girder, or ladder as it is known, for carrying the continuous bucket chain is of the box type, built of ½ in. x 3 ft. 9 in. steel plate, tapering from the centre to a depth of 3 ft. at each end.

The lower, or digging end, carries a five faced cast steel tumbler which weighs over 6,000 lbs. (also cast in Canada). This ladder runs in a fore-and-aft line from a radius point 60 feet back from the forward end of the scow and extends forward and outside of the nose of the scow to a distance of 10 feet, this latter fact enables the dredge to cut its own way when necessary and keeps a channel open for the boat.

The bucket chain, or belt, consists of 35 heavy built up steel plate buckets, with their necessary connecting links, each having an approximate capacity or slightly less than 6 cubic feet. There are also at mid distances upon this belt two large powerful rock picks for tearing up bed-rock.

The belt travels along the ladder upon rollers fitted upon the ladder itself. The buckets have hard steel links rivetted to the bottoms, which are bushed with manganese steel bushes to prevent abrasion, these bushes take the manganese steel coupling pins which connects the buckets to the connecting links between each pair of buckets. Manganese is the only metal so far known to be able to stand the enormous wear and tear that takes place in the couplings of the buckets. At the mouth of each bucket there is rivetted a heavy steel reinforcement or cutting lip, which is detachable and renewable when worn out, thus retaining the life of the bucket.

The upper tumbler, which is the driving sprocket, is square and also is a steel casting; this is driven by a heavy, half-shrouded, square-geared wheel of 4 in. pitch keyed upon the tumbler shaft, and then by means of pinion gear and belting from the main engine. The speed of the top tumbler is 6½ revolutions per minute, which gives a bucket speed of 13 per minute, or a theoretical delivery of 172 yards of gravel per hour. In practice it is found best to deliver about 120 yards per hour to enable the tables to clear themselves.

The gear is driven by a 22 inch belt from a tandem compound surface condensing engine 10 in. and 20 in. cylinders by 16 in. stroke, running 150 revolutions per minute.

The gravel drops into a heavy, steel-lined shoot, and falls by gravitation into the revolving screen 5 feet in diameter by 24 long, and perforated with graduated holes from 5/16 in. to 7/16 in. At the upper end of the screen is rivetted a steel gear for driving it the necessary revolutions, and this in turn is driven by a steel pinion keyed upon an intermediate shaft running from the main gear shafting. The screen is held in position by 4 rollers 24 in. in diameter, which revolve against a steel wearing band rivetted round the screen.

After the gravel has been sifted through this screen, the refuse is delivered into the stacker buckets by gravitation, and is conveyed by the stacker to the distance of 20 feet astern of the dredge and clear of any trouble the plant may experience by sitting upon its tailings.

The length of this stacker is 50 feet, and as it is little more than an ordinary elevator made much stronger for the large stones, etc., there need be no description given.

The water for washing the gravel, both in the screen and on the tables, is supplied by a 12 in. centrifugal pump, driven by a belt direct from the compound engine, and throws a body of water at the rate of 2,600 gals. per minute through the surface condenser, which has the effect of slightly warming the water to about 45°, thereby preventing it from freezing upon the tables in cold weather, thence through a perforated pipe leading down the whole length of the screen. The water and fine gravel carrying the gold then falls through the screen into a cast iron distributing box with shut-off gates each side, and through these gates evenly distributed to the tables set each side of the screen and at right angles to its length.

The tables for catching the gold are arranged in steps or drops similar to the deposition of a battery table, towards the sides of the pontoons, and the dirt is carried thence astern by a common launder. These tables have a width equal to the perforations of the screen, in this particular case 19 feet wide by 19 feet long, each respective table making a total superficial area of 361 feet exclusive of the launders and other catch-alls.

They are of wood, and in operation are first covered by calico, then cocoa-nut matting, overlain by expanded metal. This latter is found by long experience to be unexcelled for catching fine gold, in fact the percentage of gold which is lost upon dredges equipped in this way is very small.

That these tables are capable of saving gold extremely fine has been shewn by accurate measurements taken by trial from dredges actually in operation, by Mr. J. B. Jacquet, Government Geologist to New South Wales. A sample of gold from similar tables was weighed, and found to be about two grains in weight, which had been sifted through a sieve of 3,600 holes to the inch, was again sifted through one of 4,900 holes, and the gold which passed through sorted under a powerful lens. One hundred of the smallest of these pieces were thus selected and examined under a microscope. Measured with a micrometer their dimensions in fractions varied between 0.009 x 0.006 and 0.003 x 0.002, the mean of twenty measurements being 0.0065 x 0.0042. The hundred particles were then carefully weighed, and found to have a mass of 0.097 of a grain. The mean weight of the pieces was therefore 0.00097, or a little under one-thousandth of a grain. Several experiments also gave similar results.

As the life and working capabilities of a gold dredger depends upon the ease and rapidity with which it can be handled, especially in a rapid current, a careful design was shewn in the manœuvering winch. This is of most powerful design and construction, consisting of six barrels, self-contained within one frame. The first barrel is a double-geared drum to carry the 1,500 feet of 1¼ in. steel cable for the headline, which keeps the dredge up to her position in the face of dirt which it is working. The second drum carries the ladder hoisting line, and lifts or lowers the buckets into the gravel, being used extensively by the winch operator. The other four drums are in pairs, and are used for bow and stern lines respectively. The whole are driven by a pair of vertical 8 x 10 engines with reversing gear, whose main shaft is coupled direct upon a 6 in. worm shaft running the whole length of the frame carrying the drums. The worm shaft has three Hindley patent worms cut out of the solid shaft opposite each pair of barrels, and these worms revolve a 48 in. tangent wheel keyed upon the shaft of the drums. Each drum has patent friction clutches with powerful brakes attached also, and is therefore controlled independently of the others by the single operating winchman working a set of levers in a quadrant by the side of the frame.

The hull of this dredge is built of fir, and the frame is strengthened by heavy 10 in. x 16 in. chime logs running fore and aft, and braced by a simi-Howe truss of 6 in. x 8 in. timbers. The planking is 3 in. x 12 in., 4 in. x 12 in., and 6 in. x 12 in. The framing for carrying the top tumbler and gearing is brought up to a height of 40 feet above deck, and forms a main hogmast to both hold up the stacker and prevent the hogging of the pontoons, a frequent source of trouble with ladder dredges.

The total weight of the ladder, buckets, tumblers, and links is 43 tons, whilst the total weight of machinery is 150 tons

After this description it would not be amiss to follow up a little of her career.

The plant worked well, but, alas! in this case, it was not the management that was in fault, as latterly they had a first class dredge operator from the Snake River, but the paucity of the claim in gold. As far as the writer's knowledge goes, the claim was bought principally upon the reports made by the sellers, and whether these were good or bad is not within the writer's province to discuss. It suffices to say that beyond a thin layer of sand and gravel of about an inch in depth upon the surface, no gold was found below that, neither disseminated through the gravel underneath this layer nor upon the clay bottom met with at a depth of from 15 to 20 feet. A further fact was brought to light during the operations of this dredger, viz.: that there was, with a few exceptions, no gravel met with in the middle of the river, nothing but a bare clay bottom into which the dredger dug for a depth of 8 feet to see if there was gravel underneath this strata.

Yet, showing how a dredger may fail with a fortune in sight, within a few miles was a mass of gravel which certainly carried a minimum of 25 cents per cubic yard, and the working expenses under careful management should not amount to over 3 cents per cubic yard. However, so disgusted were the owners with the financial results that as soon as winter came on they shut down without a further effort to look elsewhere.

As would be natural in this instance, the claim sellers around blamed everything and everybody except the paucity of gold in the claim. One quondam claim seller and expert went so far as to state that a large quantity of "invisible gold"! was being lost in the tailings. Another, after showing all and sundry visitors (before the dredge commenced operations) the brilliant showing their was upon the surface, stated all that was necessary to make the claim a success was a cyanide plant (!) to treat the gravel and black sands.

It shows how careful one should be in investigating the values of a claim, and not to rely upon the general remarks of those particularly interested.

As a rule, with rare exceptions, one certain sign of good payable dredging ground is the immediate vicinity of sluicing or rocking operations other dredging conditions being present. This, at any rate, determines the fact that payable gold is near, and there is a strong probability that a proposition may be looked into for dredging.

Upon the North Thompson River these operations were conspicuous by their absence. Upon the upper reaches of this river called the Clearwater, I understand there are claims worth looking into, and as to the Lower and South Thompsons no person can dispute their richness, but the gold seems to have been cut out from this river by the dividing range. As a matter of fact, there is no class of mining so profitable and so certain of financial results as gold dredging, provided the conditions given of gold present, workable ground and a good machine. These points can only be determined by the expert, and not by the average engineer, as is generally imagined. The business then really comes within the realm of an industrial proposition, producing large dividends for many years, being merely a question of value of ground in gold, with a constant factor of cost in production. The average figure for handling gravels with a bucket and ladder dredge should not at the outside limit exceed 3½ cents per cubic yard, including labor, fuel, etc.

The writer some years ago dredged gold gravels for over twelve months at the rate of 2 cents per yard.

Given then the actual value of gravels by expert prospecting and drill holes in many number, it becomes merely the everyday industry of machine mining.

New Zealand has been quoted and referred to so often that one is almost afraid to mention that country in connection with dredging, but the Government returns of gold won and dividends paid by the whole of the dredges working there show an average of 30% profit. Some, in fact, of their dredges produce something like 600% per annum upon their capital. Members can judge what this means to the investor.

Hull of Dredge under construction.

Dredge completed.

Showing Dredge at work.

Manœuvering Winch for hauling Dredge.

Tailings stacked up by Stacker, end of Stacker showing.

View of Dredge, showing Tables.

Jamieson Creek, North Thompson River.—Dredge after completion.

Coal Mining in the North-West Territories and Its Probable Future.

By Frank B. Smith, B.Sc., M.E., Calgary, N.W.T.

This vast tract of land with which I will try to deal is too extensive to treat with in detail, but as far as possible I will give a general outline of the coal mining and its value.

The Territories were at one time known as the Indian Territories, but have now been formed into an organized district with a Legislative Assembly. The North-West Territories, however, is the only settled organized district in the Dominion with a Legislative Assembly that has not been granted autonomy.

The area of the three districts which is governed by this Assembly is about 304,340 square miles and comprises the districts of Alberta, Assiniboia, and Saskatchewan. Each of these districts has about an equal area, and are divided from each other by imaginary lines of longitude and latitude.

On the south we have our American cousins, separated from us by the 49th parallel; in the west we can shake hands with our British Columbia neighbors over the summit of the Rocky Mountains until the 54th parallel is reached, then from that point northwards we are divided from them by the 120th meridian of west longitude. On the north we have only a few Indian friends who cross and recross about the 55th parallel at their own sweet will. In the east our Manitoba friends are anxious to extend their boundaries from about the 102nd meridian of west longitude to a point as far west as they can reach, so as to secure a part of the valuable asset in the lignite coal fields of south-eastern Assiniboia.

He would truly be an imaginative writer who could picture the scenery over the 1,000 miles he would require to travel from the eastern to the western boundaries of the Territories. From the immense tract of level prairie, with its waving fields of yellow grain, to the rolling, grassy plains of the foothills, studded with cattle, until the traveller would strike the seemingly impenetrable mural escarpments of palæozoic rocks; and again, should he make a journey from the International boundary northwards, these former scenes would be repeated with many diversities, leaving the rich ranching plains of southern Alberta, crossing stream and lake until he reaches the valuable timber belts of the northern country, with its well stocked limits of wild game.

Geological.—The very important consideration, however, for settlers on these vast plains is the question of fuel, and thanks to a bountiful nature there is an unlimited supply of this necessary article within easy reach of every one, as I think it might be truthfully said that there is no point on this immense area that is more than sixty miles from a coal-bearing belt, either developed or lying dormant.

In the eastern portion of the Territories, as far as the eye can reach, there is not a tree or shrub to be seen, except it may be a few small scrub cottonwood on the banks of a river. The fuel supply here, then, is obtained from the lignite beds of the Larimie series. The seams vary in thickness from 2 to 8 feet, although at some points they have been found to attain a thickness of 18 feet. The coal underlies the level prairie at a depth of not much over 100 feet and the coal seam is usually overlain by soft, soapy sandstones and clays. The exposures along the Souris River are well defined, and the coal easily obtained by an adit level driven in from the river bank at a height of about 30 feet above the water. This lignite coal has a great tendency to disintegrate where exposed to the atmosphere on account of the large percentage of hygroscopic and combined moisture. An analysis from an average sample of this section is as follows:—

Moisture	16 92	per cent.
Volatile combustible matter	38.58	"
Fixed carbon	40.72	"
Ash	3.78	"
Total	100.00	"

This coal, however, will stand transportation in box cars and for some time withstand the action of the weather without being hermetically sealed as has often been sarcastically stated. The coal is lamellar in structure, but when freshly broken sometimes shows a conchoidal fracture and much resembles some cannel coals. Journeying further west we come to the coal of the Medicine Hat district, which is also a true lignite, but is an intermediate coal between the Souris lignites and the lignitic coals of the Bow and Belly River near Lethbridge. The coal of this district is very similar to the Souris coal in structure, although containing from 4 to 6 per cent. less moisture, but still has the tendency to split into angular fragments when exposed to the atmosphere. The next important point we arrive at is the Lethbridge coal field, the coals of which are termed lignitic and are much superior in quality to those lying farther east. The coal area in this district forms a low-lying synclinal between Lethbridge and the foothills, but even here we seem to trace in the workings of the Lethbridge Colliery, by faulting, the extreme limit of the waves caused by the tremendous upheaval of the Rocky Mountains. The coal, as has been already mentioned, is superior in quality to that farther east, and the closer we approach the foothills this becomes more marked, the coal containing less moisture and more bituminous in character. Whether this alteration has been produced by superincumbent pressure or metamorphism caused by the upheaval of the Rockies is a matter rather difficult of determination. A comparison of four different analyses of coal will admirably show this transition:

	Souris.	Lethbridge.	Blairmore.	Anthracite.
Moisture . .	16.92	12.08	2.07	0.71
Volatile . .	38.58	26.87	22.84	10.58
Fixed carbon .	40.72	54.93	68.35	82.14
Ash . . .	3.78	6.12	6.74	6.57
	100.00	100.00	100.00	100.00

Approaching the foothills of the Rockies, the coal assuming a more bituminous character has in many cases proved to be of good coking quality, although not equal to that of the Crow's Nest Coal Co. on Elk River, will still make a formidable rival in the smelting market.

The coal seams in the foothills are more numerous than on the plains and occupy a lower horizon in the Cretaceous series, no doubt being of the same contemporaneous age as the Cretaceous coal beds of Vancouver and Queen Charlotte Islands.

The Palæozoic rocks of the mountain ranges, with a general trend from S.E. to N.W., protrude through the Cretaceous strata, and form many detached troughs of coal beds hidden away in the valleys, the coal seams repeating themselves along lines of folding and varying in pitch from 10° to vertical.

Physical Geography.—To gain any idea of the physical features of this western country at the time of deposition of all these coal beds would require more data than we at present have, but some crude scene might be pictured of the general features. With the climate intensely tropical it seems probable that there was a vast swamp at least from the 55th parallel in the north and extending far south into the States and from the western borders of Manitoba to Vancouver Island in the west. This swamp being surrounded by high Silurian and Carboniferous mountains with numerous islands of the same geological age dotted all over it.

The area of these older rocks must have been considerable when we begin to examine the general thickness of the Cretaceous deposits as exposed in the mountains, forming at least a thickness of 3,000 feet, composed chiefly of conglomerates, sandstones, shales and coal. The earth's movements at the time of the Cretaceous era was no doubt extensive, but the general upheavals and subsidence of this part of the continent, from all indications, was more of a wavy movement than the sudden movements which subsequently happened to this area. The sandstones as a whole must have been deposited in shallow waters, and movements frequent, as seldom can one find anything but false bedding exposed. The great movement which subsequently took place, throwing up the great white limestone mountains, has defaced the previous physical configuration and with denudation, actions of the last glacial epoch and other forces of nature have left to us still, however, an immense monument of wealth.

Coal Mines in Operation.—The coal mines in operation over this vast territory are numerous, but few of them as yet have amounted to much more than a prospect or that of supplying the local consumption.

The principal mines are those of the Alberta Railway and Coal Co., at Lethbridge; the H. W. McNeill Co., at Canmore and Anthracite; the Souris Coal Mining Co., at Coalfields, Assa., and the Canadian-American Coal and Coke Co., at Frank, Blairmore District. Outside of these there are over thirty small mines working at Estevan, Medicine Hat, Edmonton, Knee Hill, and Sheep Creek all supplying the local trade.

The Alberta Railway and Coal Co. are now hoisting coal from only one shaft, with screening, loading, and general pit-head arrangements of the most modern type.

The room and pillar method is here adopted for working, being more suitable for flat seams of this kind and more economical The system, however, has been improved on here on account of the cover and the character of the roof and pavement. Two parallel entries are driven north and south with cross cuts between them every 60 feet for ventilation; from these entries rooms are driven off every 65 feet, with a narrow neck of 15 feet from the main entries then opened out to room width, which is from 20 to 22 feet. When these rooms have been driven a distance of 150 feet they are cut off by another single entry running parallel to the main entry. This constitutes what is termed the four entry system. From this 3rd or 4th parallel entry as the case may be, rooms are driven off at right angles with a narrow neck a distance of about 34 feet apart and continued room width for a distance of 250 feet, which is the limit unless special emergencies arise. These rooms driven 250 feet in the solid, are connected about every 90 feet by cross-cuts and, when the limit has been reached, long-wall retreating begins and is carried on till it reaches the 3rd or 4th entry, and part of the pillar is also taken from the lower side of these entries. This 3rd or 4th entry is cut off by a slant from the main entries about every 800 feet, so that all rails may be drawn from the long-wall retreating, and a pillar of at least 130 feet left each side of the main entries, which has been found ample to prevent squeezing until the section is completed and the pillars all drawn from that locality.

The seam is about 5 feet 6 inches thick, and is separated in the middle by a small band of clay varying in thickness from 2 to 6 inches. At this colliery, however, hand mining is practically a thing of the past, as both rooms and entries are cut by the Ingersoll-Sergeant punching machine. This cutting work is carried on double-shifted and the blasting and loading completed by the loader on the day shift, who is not necessarily a thoroughly practical miner, but at this work unskilled labor can earn from $2.50 to $3.00 per day.

The mine development is carried on very systematically and their system of endless rope haulage is equal to any on the continent, the auxiliary horse haulage seldom exceeding 1,000 feet. Their banner hoisting day has been reached this year, a tonnage of no less than 1577 tons being hoisted from one shaft in ten hours.

The ventilation is produced by a Capell fan, which is capable of producing 100,000 cubic feet of air per minute. This company also owns the narrow-gauge railway from Lethbridge to Great Falls, U.S., with a branch line running west tapping the finest ranching and grain country in the Territories, now that it is being watered from the irrigation canal supplied by the waters of the St. Mary's river.

The mine at Canmore, operated by the H. W. McNeill Co., is another steady coal producer, supplying all the steam coal used on the line of the Canadian Pacific Railway between Calgary and Revelstoke. Their system of working is the pillar and stall, which within the past two years has been modified by working across the pitch instead of up the pitch as formerly followed. This modification has been fully discussed in a former paper before the Institute by Mr. O. E. S. Whiteside, and to add anything to it would be presumptuous on my part, but this I must say, that I consider it will certainly reduce the number of accidents, and a less liability to accumulation of gas; also the amount of coal recoverable will be greatly to the advantage of the operators.

The number of seams being worked in this field are four, varying in thickness from 3 to 6 feet. The seams as a whole are clean, shipped direct into the cars and used on the locomotive as run of mine coal. The area of this field is curtailed by the close proximity of the limestone range, and from this cause also considerable faulting and folding is encountered which tends to make economical working a matter of great anxiety to the management.

Ventilation is here produced by two fans capable of producing about 80,000 cubic feet of air per minute, but each having separate districts to ventilate and acting entirely independent of one another.

The H. W. McNeill Co. also operate the mine at Anthracite, which produces about 100 tons per day. The coal here produced is equal in value to the Pennsylvania Anthracite, although just an advanced stage of the Canmore bituminous coal altered by metamorphism. The system of working is similar to that at Canmore, and ample ventilation is supplied by a force fan. The field here is considerably more disturbed as it approaches the west, but a new concession has been obtained in the eastern portion of the field which will ensure a steady output and a supply of this quality of coal in the market for many years to come.

The Souris Coal Mining Co., Ltd., operate four mines in south-eastern Assiniboia and have a shipping capacity of 500 tons per day. The mining is mostly accomplished by punching machines of the Harrison type. The seam is about 8 feet thick of clean coal, and burns to a very fine woody ash. Ventilation at present is produced by a furnace, but it is contemplated in the near future to install a fan.

Consolidation of all the small interests has taken place in this district lately, and will tend to give an impetus to mining in this locality which is impossible where so many small concerns are operating without railway facilities.

The Canadian-American Coal and Coke Co. operate one mine at Frank, which has been opened by two adit levels, and the whole development, for a producer of 500 tons per day, completed in one year. The seam has a thickness of 12 feet and stands nearly vertical with a footwall of hard sandstone and a hanging wall of metamorphosed shale. The system of working is a combination of pillar and stall and long-wall, rooms or long-wall being worked for a distance of 90 feet, and then with a pillar of 40 feet left with a manway in the centre and cross-cuts from them to the rooms Most of the coal at present is left in, but will no doubt be nearly all recoverable when the pillars are being drawn. Ventilation is produced by a 4-ft. Murphy fan, forcing into the workings and producing 20,000 cubic feet of air per minute. Six bee-hive ovens for coke testing have been built at the mine, and the coal has been proved to produce a strong coherent coke.

The mines in the other districts mentioned are carried on in a systematic manner, and all of them as far as consistent complying with the Coal Mines Ordinance.

Mining Laws.—About ten years ago mining regulations were drawn up by the Legislative Assembly and an inspector appointed to see them carried out, but on account of the great increase in coal mining in the Territories within the past few years, a new Ordinance was passed in 1898 by the Assembly which practically covers all the requirements carried out in other Provinces of the Dominion. A few alterations of course will be made from year to year, and one point which I consider should be carried out by all Provinces regulating coal or metal mines, and that is in the matter of enforcing a supply of all ambulance requisites being kept at the works. With regard to this ambulance work, great progress has been made in recent years by reason of the facilities for training which can now be obtained under the auspices of the various ambulance associations throughout the Old Country. If it was made compulsory that these ambulance requisites had to be kept at the works here, then we would soon have the medical men of this country also take up courses of lectures on the subject, and after a full course the students subjected to a thorough examination to test their fitness for undertaking the preliminary treatment of an injured person until a properly qualified practitioner arrives to take charge of the case. To those successfully passing this examination on ambulance work or first aid to the injured, a certificate of merit or proficiency might be awarded. The appliances required at every colliery or public work includes stretchers, boxes containing splints, bandages, tourniquets, needles, thread, antiseptics, oil paper, sticking plaster and other odds and ends. These requisites should always be kept in a place easy of access, and in the case of a colliery in the weigh-house on the pit-bank.

This matter, if taken up by the management, which is most desirable, would save many a laboring man hours of suffering and earn for the employers eternal gratitude from their employees.

Probable Future.—It might reasonably be asked why the development of this vast field of wealth has been so long delayed, but the answer does not require much enquiry for when a glance at the map is taken. Want of railway facilities to reach a foreign market, the sparseness of population and no industries to make a home market The coal mining of the past in the North-West Territories has been one long struggle for the companies operating to keep their head above water, but the dawn is now approaching and the cloud begins to show its silver lining.

Since the building of the Crow's Nest Pass Railway a magnificent stretch of country has been opened out, and the prospecting which has been carried on in that Pass for the last year has shown to the country a wealth of coal which is daily directing capital towards it.

The long-reaching arm of the Canadian Northern Railway will pass through the northern end of this coal belt, and as the country is settled closer to the foothills numerous additions will be made to our knowledge of this inexhaustible coal field. The coal of the foothills has been proved to be of good coking quality, and the past year marks an era in the history of the North-West which for generations to come will stand out pre-eminently as the golden year of the Territories.

To attempt to estimate the quantity of available coal in the Territories would be to attempt the impossible, but from what we know of the natural exposures and what has been proved, will ensure for us centuries of consumption and a surplus for exportation which will make of the North-West a Province second only as a coal producer to the State of Pennsylvania.

In the districts of Souris, Medicine Hat, Lethbridge, Red Deer, Edmonton, &c., the estimated quantity of coal per square mile is from 5 to 12 million tons and practically inexhaustible as a domestic fuel. When this point is conceded, it possesses no additional meaning when we attempt to estimate the quantity of coal buried in the foothills except for steaming and coking purposes it will be an immense source of wealth to the country. There are many points in the foothills coal area which will bear an immense amount of labor in prospecting and boring. The data thus gained will be of immeasurable value to the country, both scientifically and commercially. Part of this work, especially boring near the foothills, might receive Government aid.

In conclusion, I am sorry to say that the information here given is not as complete or probably as accurate as it might be, but I trust what I have said will be some matter for reflection for a few minds, and probably may be the means of directing additional capital to the development and settlement of this vast area.

The National Importance of Mining.

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By Mr. John E. Hardman, S.B., M.A.E., Montreal.

After agreeing to present or introduce this topic for discussion, I chose the title of "The National Importance of the Mining Industry" rather than "Government Aid to Mining," for the reason that I wished to emphasize the duty of the *nation*, rather than the duty of the Provinces, to encourage an industry which has grown to be of such great importance to the Dominion. In considering the discussion of provincial matters, I felt that as a "Canadian" or National "Mining Institute" we had neither a right, nor a duty, to discuss provincial matters, but that our remarks should be confined to such topics as were within the jurisdiction of the Minister of the Interior, within whose department lies the administration of all federal matters which affect the industry of mining.

After listening to the figures which the Secretary has just read to you, the *national* importance to which the industry of mining has attained is axiomatic, and needs no demonstration. A total production of over seventy millions of dollars is eloquent testimony of the importance of an industry which produces annually such a large sum, and the figures are all the apology which is needed for introducing to this Institute a discussion as to whether, and how, the federal government can best assist and promote such an industry, not only to greater dimensions, but also to greater perfection, while still preserving and maintaining fidelity to that branch of the British North America Act by which the control and administration of minerals found within the borders of any particular province was vested in that province; and in doing so the necessity for confining my remarks and suggestions entirely within the limitations imposed by the title becomes apparent. I allude, therefore, to such matters as are strictly of *national* importance as distinguished from matters which are particularly *provincial* in their sphere.

In so doing, I am quite aware, from the printed pamphlet which is before you, and from other information which I have received personally from the Secretary, that I shall have to disregard and put out of consideration many suggestions which are of great importance, but which deal almost exclusively with matters of provincial jurisdiction, and cannot, therefore, be considered in a discussion of this topic. Many of these matters are of the highest importance, and perhaps it will not be unwelcome to simply allude to them and run over them as suggestions to provincial authorities.

First, the question of transportation; and by this word transportation I do not by any means wish or desire to refer solely to long distance transmission on railways, but more particularly to the equally important question of highroad transportation, where the bulk of the material to be handled has to be transported comparatively short distances only. Such transportation necessitates good high-roads with easy grades and hard roadbeds so that a maximum load may be transported at a minimum cost.

Equally, the establishment of public assay offices, the giving of grants for the maintenance, or assistance, of mining schools, the assisting of schemes for deep sinking in the shape of subsidies, the establishment of governmental custom reduction works for the experimental beneficiation of ores, or of government diamond drills for the testing of private deposits: all are topics which interested mine owners may feel called upon to consider, but which the national government cannot consider inasmuch as all revenues coming from the working of these mineral deposits would go into the provincial treasury and not to the Dominion. To this may be added government aid to hospitals and accident relief funds, and the still more important question of proper governmental inspection of existing mines and mine workings.

Likewise, the question of import duties on machinery and upon supplies used by the miner, are not within the province of this Institute; they are more strictly political matters, and as such do not come within the domain of this Institute, and must be left to the consideration of those gentlemen now in session in Ottawa, known as the Parliament of Canada.

You will see, therefore, that the subject is not a simple one, but a very complex one, and worthy of extended discussion and most minute investigation; for while Canada, as a nation, derives no direct benefit in the shape of royalties, etc., (excepting from the Yukon and North-West Territories), yet the mining industry, indirectly, is a source of great national wealth by reason of the taxes, duties, supplies bought, etc., etc., all of which contribute to the national wealth on account of the increased consumption of foreign goods in the shape of machinery and supplies, on account of the greatly increased number of manual labourers, which implies equally the increase of labor for a large portion of the population working at remunerative wages, and thereby contributing its quota to the general prosperity of the merchants and of the whole country.

Now, for guidance as to what one may reasonably expect of the federal government in the shape of help, we must turn and consider what has been done by other governments in other parts of the world where similar deposits of mineral richness have occurred, and where similar requests for aid have been made, entertained, and (perhaps) granted. Britain's colonies, such as New South Wales, Victoria, and New Zealand, have been very generous in their efforts to aid their own mining industry, and they have given grants for many of the subjects that I have just enumerated. The older European countries cannot be looked to for examples, inasmuch as new ground and undiscovered deposits are the exception and not the rule in their domain. Perhaps one of the best hints that we can get to guide us in the consideration of this matter is given by the great commonwealth on our southern border.

And in entering upon this matter and discussing it, we cannot do better than to take our first lesson in the shape of noting that in the United States the mining division, or the Geological Survey department, is entirely and *absolutely divorced from politics* in every shape and sense of the word ; neither the head nor the subordinates of any such department are political appointees, neither are they under civil service rules, but they are considered as business employees to be used just so long as they give value received for their salaries, and to be summarily dismissed when such salaries are not earned. It has seemed to me, and I invite your discussion of my reasons, that no part nor branch nor department of the federal government is so well qualified to undertake assistance to the mining industry as a properly organized and well constitued Geological Survey. I see this evening, on looking about me, many gentlemen from the national capital who have been paying extreme and minute attention to my remarks thus far, and I am glad to see these gentlemen here, and I am sorry that they are not all of them members of the Institute. There are, however, a number of them who are members, and who will probably, I am glad to say, take part in this discussion, and will tend to elucidate those matters upon which I may be more or less obscure.

The question of what is the proper and legitimate field of a Geological Survey is a legitimate one for discussion, and is not out of place under the title of "The National Importance of the Mining Industry," and it may be well, particularly before so many mining men who, in my experience, are rarely acquainted either with what the Geological Survey is actually doing or what is its proper function to do, to review briefly what a geological survey is *supposed* to do. And before starting let me say one more word, and that is that the mining industry is an industry of *facts* and of *deeds*, all the better perhaps when it is aided by sound theory, and in what I am going to say I wish to announce that I say it solely and simply from the standpoint of the practical man who *does*, and wants others to *do*, but for whom theoretical discussions have always had a great attraction and a great value, and who is very much indebted to theoretical views for the small share of success which has been his portion.

The primary work of the Survey may be considered as (1) the determination and publication of facts concerning the local distribution of rocks; in other words, what is known scientifically as "Areal" Geology; (2) the determination and publication of the general facts of the geology of a country; to arrive both at the local distribution and at the general facts as mentioned, it is necessary to provide departments for the various branches of work, and first and foremost comes the necessity for accurate maps on which the facts of local, or general distribution, may be laid down. This is the first and essential prerequisite for the departments which follow, and I may say here that the ordinary maps provided by the various Crown Lands Departments are by no means of sufficient accuracy, or of the necessary character, to permit of geologic work being laid out upon them. The second subdivision is that of the Geological Division, in which is included Paleontology, by which the rocks are labelled, as it were, and their position on the earth's crust ascertained ; third, the Petrographical, with which is allied the Chemical and Physical divisions, and which are necessary to determine different rocks, and the different questions affecting those rocks as to composition and characteristics. The inter-dependence of these various branches with the more purely geologic is evident, and there must be a constant interchange between the Geological staff and the staffs of the Paleontological, Petrographical, Chemical and Physical divisions. Each of these divisions requires the supervision of an expert. But, in addition to the above departments, whose work is of interest only to a small number or fraction of the total population, there must be means of making these facts generally understandable by the public, and by that largely increasing body in Canada, the men who are directly interested in the production of metallic wealth. Without taking up your time, I may say that the other departments include the statistical work, the editorial, the supervision of illustrations, the care of the library, and the disbursements of money, with many other smaller branches, which thus create an administrative branch as well as a scientific one. In the present condition of our Dominion, as regards the fostering of the mining industry, and the equally important field of informing our citizens and the world at large of what our resources are, a distinct prominence must be given to *Economic Geology*, which, briefly described, is the practical application of geological investigation to the development of the mineral resources of a country. This division of Economic Geology is, by far, more important to Canada's citizens at the present moment than any descriptive or purely structural geology can be, although, as you will notice as this discussion proceeds, I am firmly of the opinion that no economic geology is worthy of the name unless it is preceded or accompanied by such accurate descriptive work as will fully elucidate the many problems which inevitably come up in economic work. In fact, it is not going too far to say that the lack of such proper economic geological work rendered possible to a great extent that inflation in British Columbia during the years 1896-97 which was so disastrous in its effects, and which I think I am right in saying was due more to the ignorance of the limitations of the deposits then discovered, than to the actual ignorance and incompetence which was displayed in the mining work then and afterwards.

Recognizing, therefore, the importance of this economic geology, which we may paraphrase into Mining Geology, I may say that the work of the Survey at the present time *should* be divided into (1) General Geology, and (2) Mining Geology; with the objects of providing not only a geologic map and a knowledge of areas of different formations with their structural relations, but also to provide special information concerning our mineral resources, and definite knowledge concerning the origin, structure and relation of the ore deposits which are found in Canada.

The section of Mining Geology, or economic geology, appeals to the mining engineer and to his clients, who are that portion of the public, native or foreign, which contemplates the development of the country's resources. The relation of the geologist to the mining engineer is a relation similar to that which the engineer holds to his clients and to the general public. The duty of the mining engineer to his employer is to place before him in intelligible shape the character, mode of occurrence and probable quantity and value of the minerals which are contained in such property, and also the best method of obtaining the same from such a property. The government geologist, having a wider field, should have more comprehensive views, and his study should consider, not particularly the interests of any single mine, but rather the general interests of a whole group of mines or of a mining region, for it is a truism to say that trustworthy results are only obtained when they are founded on sound and accurate knowledge of the geologic structure of the region in which the deposits occur. As a mining engineer, I am sure that I am giving the opinions of my confreres when I say that, if we do not give geology in our reports it is either because no data on the geology of the region have been published, or because our clients especially desire facts and figures, and not theories. From one of the heads of the United States Geological Survey, who I am glad to say was my old chief and instructor, I quote that there are three standpoints from which the relation of a geological survey to the mining industry of the country may be viewed: (1) the purely scientific or geological point, (2) the technical point, (3) the commercial point; and as from the nature of things the third point often demands only the consideration of a verv small portion of a particular district, it is not the business of the government to consider such a view point.

The governing principle of a government Geological Survey in economic work should be that it will do for the mining industry, as a whole, what the unaided individual engineer or mine owner can *not* do, that it should never undertake what can just as well be done by the individual engineer or owner, and also that it should never interfere, favorably or unfavorably, with the private business of individuals or corporations, nor should it in any way enter into competition with professional men, such as mining engineers, commercial geologists, and chemists. It goes without saying, that no member of the Survey should be permitted to make any examinations, execute any surveys, nor write any reports for private persons or corporations. The energies of the department should be devoted to such branches as are of immediate use to the greatest number of the country's citizens, and along such lines investigation should lead either to the establishment of broad general deductions, or to the publication of monographs which have the most immediate bearing upon the prosperity of the country, and which are of value to as great, if not a greater number, as the broad general investigations just mentioned. In a country containing so large an area as our Dominion, work by any force that can reasonably be employed must be confined for many years to such localities or districts as have contained the most extensive mining developments, or to such new sections as imperatively cry for authoritative investigation; and, apropos of studies in mining districts in which developments have been extensive, the geologist in making such studies often attains results which are of immediate value to the mine owners and prospectors in that particular section. Such results may be of secondary importance to the general public, but they are of immediate importance to the people interested, and are therefore justified, and the deductions from any such particular districts would, correctly generalized, be of benefit to the whole community.

It will be seen that many of the departments of the Survey are already equipped for the determination of such facts as I have mentioned, and if a new Bureau of Mines, or Economic Geology department, be established, any two such Bureaus would of necessity overlap each other, causing a waste of funds and of time if they were not correlated and under one jurisdiction. To separate such work into two departments would be a mistake, as neither branch in such a supposed case could, or would, avail itself of the information gained by the other. But in any proposed re-organization of the Geological Survey, or any organization of the proposed new Department of Mines, one fact should stand out clearly and distinctly, and that is, that the director and all subordinates of such department must, beyond any question or suspicion, be absolutely free from political interference or influence which can be exercised either to retain them in their office or to procure for them advancement. In my personal opinion, employees of such departments should not be on the permanent list; they should be made to feel that their status is dependent upon the work they do, and they should be treated as ordinary men are treated, and made to feel that so long as they perform their work satisfactorily they will be retained, but that no political influence, nor Civil Service Act, nor anything else will avail them against dismissal when dismissal is merited.

It is easy to forsee that, under such a Survey as I am attempting to indicate, demands would be made by citizens from all over the country, and to such an extent as to entirely overshadow the possible resources for any one year. The choice of field, therefore, in which work should be done may properly be governed by the principle, that developed districts give increased opportunities for obtaining a large number of facts, afford grounds for generalizations and for special studies, which not only are of permanent value to that particular district, but will be of great accessory value to other districts, with like or even dissimilar considerations. From partially developed districts only superficial facts can be obtained, and any expression of opinion as to the probable value of such a district is more properly the province of the mining engineer than of the geologist.

The general principle governing the work of any survey on economic lines should be that ore deposits must be studied where they can be studied to the best advantage, and hence that, although topographic work to some extent may be well distributed geographically, yet all geologic work must be free from local or provincial considerations, and must depend upon the importance of the problems to be solved, and of the best methods of solving them. It is within the knowledge of all of us that that British Columbia district of so much reputation, I refer to Rossland, was under study by the Canadian Geological Survey as early as 1896, that a map and some descriptive geological text was published, but consider the effect upon the commercial world if the Survey had undertaken an *economic* investigation and had published a monograph on the Rossland district of as complete a kind as this publication which I hold in my hand (exhibiting a United States Monograph). Again, consider the copper-nickel industry of Ontario, and the Sudbury District in particular, and with the exception of the preliminary sketch of elemental conditions published in 1891 by the present acting director of the Survey, what else can be found in the records of the Canadian Survey which bears at all upon an industry which may be roughly figured as productive of at least four millions of dollars a year for the last nine or ten years? I mention these two cases because, in my capacity as President of this Institute for the first two years of its existence, and also in my personal and private capacity as a practicing engineer, I have been repeatedly approached by agents of both English and American capital for information contained in Government reports bearing upon these two districts, and, although in our Library downstairs we have a complete set of the Survey reports, and although these reports were consulted by such agents, yet, I was forced to admit in many cases that it was not creditable to the Government of Canada, and particularly the Department of the Geological Survey, that they had no information to give to investigators which was of *commercial* value, or of assistance to capital which was willing to invest if proper data could be furnished to it.

Coming now to the special question of what a geological survey may, or should, do towards technical investigation, or making technical studies in aid of the mining industry, it is difficult to attempt definite limitations. There is the danger of encroaching upon what is the legitimate field of the professional man, the mining engineer or the metallurgist, but the same principal can govern this that should govern every other department, viz: that in such technical matters the Survey had better confine itself to those investigations which the State is better fitted to make than is the individual.

The prominence given during the last two or three years to the iron industry of the Dominion demands a satisfactory and technical monograph which should describe and give all information possible respecting the various iron ores of the Dominion, the facilities for transportation of such ores, and the opportunities or difficulties of reaching markets. The concentration of that important metal, nickel, in one small area in the Province of Ontario fully justifies an extensive monograph on the occurrence and origin of the ores, the associated metals, the methods of mining, sorting, smelting, refining and marketing the product, together with information of the amount of precious metals contained, and, in general, going into all such details as would not be of prejudice to the owners in that section but which would be of immense advantage and aid in studying similar occurrences of similar rocks in other fields.

The depressing conditions which have attached to the silver-lead mining industry during the last twelve months might well be made the subject of an exhaustive inquiry in which actual facts might be obtained, actual costs laid down, and the proper avenue for disposition of the product indicated.

It may be objected by some of our neighbors to the south that we are going too far in asking for such authoritative information, but we in Canada have a greater right to ask for such inasmuch as not only does each of the provinces impose a royalty upon the various metals produced, but even the Dominion Government, in the lands still within its control, imposes a heavy royalty which entitles us to ask for a *quid pro quo.*

Manifestly it is impossible, within the limits of such a paper as this, to notice the numerous pros and cons of argument which inevitably accompany the consideration of such a topic, but the duty which has been assigned to me has been simply to hand you out these various items as one might throw out so many balls which may be caught up by some of you and thrown about so as to provoke such a discussion as is absolutely necessary in order to obtain complete information.

I have spoken briefly of the primary work of the Survey, and its necessary subdivision into topography and geology with the correlated branches of petrography, paleontology and chemistry; there remains to be considered one of the chief, and I may say *most important*, functions of a properly constituted bureau of mines, or mining division, of the Geologocial Survey, and that is the collection of accurate statistics relating to the production of metals and minerals throughout the country.

This is the most important rock in the foundation of the mining business and is a first class reason for a mining bureau, if no other were forth-coming. It has been said, and well said, that no branch of statistical science is in greater need of technical knowledge and scientific system than that one which deals with the production of minerals, and I may add that none is more liable to bias and to be erroneous if the data are supplied by persons who are interested. The late Clarence King, in his introduction to the Tenth Census of the United States, (in which for the first time the collection of statistics of production from metallic mines were entrusted to a separate and expert corps of enumerators largely gathered from, and under the direction of the United States Geological Survey) said that the experience of the United States at that time was that the best method for conducting such investigation seemed to be the one then employed, viz: of utilizing trained experts in the collection of these figures, and that such a system would produce the most perfect results, under favorable conditions of sufficient time and sufficient money. He added that such agents required a considerable experience to become thoroughly familiar with their duties, and that this work would be best accomplished by making such a bureau a permanent one, thereby retaining the services of men familiarized and accustomed to their work. Such a method is perhaps too expensive and too ambitious for our young country, but there is nothing to prevent approaching it, and emulating the example which was then set by Mr. King.

One of the necessary adjuncts for such a bureau of statistics must be a sufficient fund to permit of the prompt publication of its reports; a branch of the Survey with a single chief and a competent corps should be included in any project for a mining bureau or for a reorganization of the present Survey. Its field is large and its functions should include the issuance of bulletins regarding the location and descriptions of known mineral localities, including even those of the rarer substances. In each yearly publication, in addition to a general statement of the production of the country and of the distribution of the useful minerals, there could be monographs or short articles on the growth of each industry and on each important metal or mineral, by an expert in that particular method or mineral who was an authority on his subject, and who would present a strong, terse, and lucid exposition of the conditions attaching to that particular industrial mineral. Such chapters being necessarily as different in scope and methods of treatment as the minerals and methods themselves, could also contain such technical information as would be of interest to the mining public particularly, and the common public generally. For examples of what has been done in this line, and as object lessons, I may bring to your notice the annual reports of the State Mineralogist of California, and also the bulletins which have been issued by that office. With such publications coming from a responsible head, the government would practically issue an annual census of the mineral industry, and a production of over $70,000,000 a year fully justifies, in the eyes of the electors of this country, the study of the original sources of such mineral profits by a permanent bureau of sufficient size and properly endowed.

The minor questions of the water supplies of the country, the investigation of water powers and of possible irrigation supplies, is an undertaking worthy of any intelligent and self-respecting nation, and the utility of such a measure has already been recognised by an interested party—I refer to our great railway corporation—which has spent time and money in investigating the possible redemption of the arid lands of the North West Territories

While on the subject of monographs let me say that the more purely geological branch can also follow such a method of promptly communicating results of their studies to the public. Discussions of smelting processes, of milling methods, of concentration and of the equally important matters of transportation and marketing can easily be fitted into their proper places, and are legitimate objects for the direct recognition of the Government. The fact that jurisdiction over the different mines is lodged with provincial governments should be no drawback to a proper elucidation, description and recognition of the same by the federal government.

I have presented to you only a skeleton of the subject, but I trust that those who follow me will supply the sinews, flesh and covering so that by the end of the session we shall have a comely figure as the result of our combined efforts.

MR. C. A. MEISSNER, SYDNEY, C.B.

The subject of Government Aid to Mining is one well deserving careful attention from the members of the Institute. It is one that has distinctly two sides, which need careful consideration of both their merits and demerits. To a certain extent, the whole system of bounties and Government action is involved in this discussion. On the one hand, opponents of the system claim that in principle it is wrong; that it saps the energy of the people in making them less self-dependent; that it is likely to cause an influx of foreign capital under unhealthy conditions, not because of natural resources and advantages, but for the purpose of taking advantage of such bounties or aid offered, and thus get what the opponents call a fictitious value out of the products, instead of a purely legitimate one obtained by the actual worth of the raw material or manufactured articles, and that in the course of time these will likely stand dependable on this outside aid, instead of strictly on their own merits. On the other hand, it is stated by those favoring reasonable Government aid and bounties, that while, theoretically, these objections have perhaps some basis of truth, yet practically they are entirely dependent on the actual existent conditions, and must be studied and carried out with these actual conditions in view.

Where a country is well populated, or the growth of population is noticeably rapid and steady from year to year, where the mineral resources are by nature good and inviting, and where distances from point of production to market, from raw material to finished product, are not too great, and where the home general market is large and active, or a foreign market is easily accessible, and distances to that market not too great, then it is quite possible that too much dependence on Government bounties and aid is a weakening factor, and likely to make the people neglectful in taking initiative, and create a tendency to look to the Government, making the latter more paternal than is generally good for the nation. The same may be said of the last objection, *i.e.*, the entry of foreign, or even domestic capital for the purpose of taking fictitious profits out of the producing power of the land, which, having to be paid by taxation of the inhabitants, are likely to drain the country without adequate return to it as a whole, or only to isolated sections.

In taking up this whole question, therefore, it is necessary to carefully keep a wise middle path, which avoids too great paternalism, and yet gives such encouragement that any natural resources which are not surrounded by great advantages for development, should be made available in such a way as to prove of real and substantial value to the people and to their Government which represents them.

It appears to me that in Canada we have conditions which are of such a nature as to distinctly call for some such Government aid, judiciously applied to the development of its resources, outside of that which private capital, whether individual or corporate, can give to it, even if, apparently, it draws by taxation from sections that are not directly benefited by such development. The consideration is simply one of the greatest good to the greatest number of people, and by doing this you have solved the problem for a self-governing nation. You can never hope to satisfy everybody, and frequently the individual is not in position to be able to judge for himself what really is best for him as a unit of the whole nation. If such Government action is of ultimate benefit to the whole nation, then sooner or later, each individual unit is bound to derive some small part of that benefit.

Taking Canadian conditions, therefore, as they are, considering the natural resources, the vast area, the scattered and frequently thin population, especially in districts not having the best agricultural conditions, or not having good or easy transportation facilities, too far apart to be in close touch with each other, or to the capital-furnishing world, then it does seem that those interested in industrial development are warranted in going to the Government and saying,—"We are unable to develop our country as we would. We lack the money, the knowledge and the facilities for placing our resources before the world ; we lack transportation ; we are practically isolated ; we do not, as a fact, know what we have, and we cannot develop what we have, so as to show and convince the outside world, or the capitalists at our centres, that what we have is good and worthy of their attention. Come to our aid, therefore. We will do what we can, and you may apply your resources as a government, and your facilities to get expert knowledge, and put us on a record of such nature as will inspire confidence in such capital to come to us."

I think in this they are perfectly justified, and point for such justification to the Government railroad. That the West was developed by private railroads does not alter the argument, for here again it was purely a question of natural conditions. The early promoters saw, not only a vast country of great possibilities, agricultural as well as industrial, but they also saw a great outlet to the Western Continents, which promised large returns. In the East, it was different. The country was not promising for large agricultural possibilities ; it was not promising for large mineral or industrial developments, and it did not show large immediate possibilities as a carrier route to foreign countries, being too near the routes long established, and provided with all facilities and advantages of a large population behind them, which lay to the south of these Eastern sections. The Government railroad, therefore, became necessary,—was undoubtedly a heavy tax on the Central and Western sections,—but was the life-giving principle to the Eastern ones, and now surely has paid back to these more populous sections all the expenditure in taxation they made for it.

The same principle now applies, in many cases, to Government aid in mining, and while it applies more generally to the Central and Western sections than did the Government railroad, yet it specifically applies, just as did the Government railroad, to the Eastern sections. It is my object in this paper to take up the discussion more from the Eastern standpoint, and apply to it especially the suggestions I desire to make, and further, to more specifically confine myself to the practical metals and minerals, rather than to the precious ones. leaving these latter to be championed by those who are better posted and more able to discuss their merits than I am.

To begin with, my idea of Government aid is practically on the same lines as the Geological Survey, which is carried through all districts alike, at exclusive Government cost, but to be devoted more to economic and commercial conditions than is the Geological Survey, which of its nature is more technical and scientific, and not of a specific material value to the individual, as a mining department would be.

The Geological Survey has already been of inestimable value, as a whole, and in many cases has done scientific service which has carried with it great commercial advantages; yet it does not cover the ground sufficiently, and a mining department, giving judicious and cautious aid, in showing the number, location and valuation of the minerals, is the supplement that seems to be required for this and many other less favored or more isolated localities.

The difficulty lies in adopting a method which cannot be subserved too greatly to individual benefit, so as not to swamp the Department with demands that would wreck any treasury, or could be made to further political aims. Especially in New Brunswick and Nova Scotia have we natural conditions that are difficult for an individual to take hold of in such a way as to give permanent and practical results. Our mineral resources have only been scratched on the surface. They are evidently, with few exceptions, not of a very large nature, and even those that were beginning to indicate more valuable properties have for many years lain idle or been looked upon with a large degree of uncertainty. Nature has not been particularly kind in exposing her secrets underground, excepting, perhaps, in coal, and yet already, in several cases of local government aid, valuable results have been obtained, where private capital had not felt sufficient courage, from the indications, to do that exploring necessary to show what really was available. The population, also, is thin. There are few large centres, and there has been little opportunity for knowledge as to how to proceed when a mineral has been discovered. The result is, that already a vast amount of private capital has been misspent, and properties abandoned at the very beginning, owing to this lack of knowledge on the part of the early prospectors. Then again, money has been put into many properties that were worthless, and would have been determined worthless by men having knowledge of mineral formations. Unscrupulous prospectors, I regret to say, "experts" have even taken advantage of this lack of knowledge to paint deposits in glowing colors, being themselves utterly indifferent as to ultimate results, after they had been enabled to spend a certain amount of time and to pocket their fees. Then, again, transportation facilities are poor, and frequently what would be deserving properties are not looked into further, because, unless they are of a large nature, it would be manifestly impracticable to give them the necessary transportation facilities.

To cover the ground for such work, I have the following suggestions to offer: The mining department having in charge this work should be divided into minor departments, covering various sections, all through Canada, each of which requires a competent, honest, well informed man; fearless, and as free from political affiliations as possible; broad minded, and of good judgement and insight into human nature. From him would emanate the work to be done in his section, and he should exercise great care in the selection of men who would do the actual prospecting or development work of his particular section. It appears to me, that for New Brunswick, Nova Scotia and Cape Breton, one such man, or commissioner, as I will call him, should be sufficient; and he should have under him one mineralogist for New Brunswick, one for Nova Scotia and one for Cape Breton. These mineralogists should be like our geologists—cautious, conscientious, and with a full realization of the import of their work. Above all, they should not be given to jumping at conclusions. They should understand the formation of ores, of mineral deposits, and their relation to the geological formations. In the present day, when this branch of investigation is being so thoroughly gone into, and so much having been written about it by such men as Posepny, Emmons, Beck, Van Hise, Kemp, etc., and the whole formation of ore deposits is being more and more clearly understood from day to day, there should be no great difficulty in finding men capable of filling these positions. It would be merely a question whether the Government, in undertaking this work, would be willing to go into expenditure to get good men, especially at the beginning, who would then train up under them a corps of assistants, who could, in comparatively short-time, be drawn upon to fill either additional positions, or vacancies which would be constantly occurring. These mineralogists should be definitely assigned to their sections, so that they would make it their special work to study the section, first geologically, and with what knowledge is now available, and then from the special mineral standpoint, when they would soon become thoroughly familiar with the work required. All such work needs going over and over the same ground again, each time with some new information, which brings out points and data overlooked, or unnoticed, or not quite understood on previous visits. It is only by careful co-ordination of all available data that accurate practical results are obtainable in mineralogical work. . We have all had the experience of examining a location or deposit, and coming back to it again some time later, after having given it more thought, and having obtained all sorts of data, etc., to find that we looked at it in a very different way, and that many of the important factors appear to us, on the later examinations, very differently and more clearly than at first.

Fully as great care if not greater should be taken in the selection of these men as in the Geological Survey. The information here is concrete, and such that upon it large amounts of money may be represented. These men must be incorruptible, conservative, yet not too timid, nor too confident. As a rule, actual immediate results will come from their work. This will be tested and checked by experts from any part of the world, and in this respect it differs from the Geological Survey work, which deals by nature more with the large general questions of the whole formation, detailed as finely as practicable, but not subject to that quick, decisive test or accuracy of judgment or of work, and definiteness of results that will characterize the work of the Government mineralogist. I enlarge on this somewhat because, to me, the character of the man seems the gist and crucial point of the whole question.

These men could further be used for the inspection of mines already in existence, without at all interfering with the system of inspection of coal mines, which, being of a well established nature, should be kept separate, and continued, as now, with whatever modifications are necessary or desirable.

The whole work would, of course, be under the direct control of the Mining Department and this, and the Geological Survey, should work very closely together, and thus make the likelihood of success much greater.

Of course, we must look for occasional failure. There is no mineralogist who can look beneath the ground any deeper than any other man. He puts to use his knowledge and previous experience, but nature has a way of playing scurvy tricks, and she seems to be in a particularly tricky mood in these Eastern sections. The element of luck and good fortune rests, in a

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certain way, with all of us in our work, but this should be minimized by a well-planned, systematic course of work, and I only mention this because no man should be condemned too hastily, if he has been too cautious or too hopeful, as long as we see he has been conscientious in his work, and his reasonings have been logical.

Records, collections and general information all can be obtained from anywhere ; yet the whole result hinges on the personality of the man. You can lay down no set rules. No definite lines of formation regulate them. They are only governed by general rules, and the specific formation is always the result of local conditions and disturbances, which are seldom alike in two places ; hence the need of this extraordinary care in the selection of men, which, as a rule, we know Governments are not always inclined to exercise. Above all, there could be no greater misfortune than to endeavor to make this a political opportunity. This is, therefore, the most serious consideration that the Government has to keep in view in making its decision on this subject. It may probably be considered well to go slow, starting with certain sections, and let the work grow as the heads become familiar with the requirements, and as the results begin to show, and warrant further increase of force or work.

The matter of next greatest importance is the one of keeping proper records. There should be in the office of the commissioner a careful and complete record kept of every report made, giving in short detail the gist of the information, starting with the date of report, the name of mineral location, analysis, the owner the informant or examiner, the date of examination, estimate of quantity, and decision of examiner, with comments thereon; also a number corresponding to that of the report, for readily finding the latter in the files. The books should be sub-divided under the various mineralogical headings, thus : Coal, Iron Ore, Manganese, Limestone, Gold, Silver, etc., etc., Minor Metals, as well as such material of practical use as Sand, Building Stone, Clays, etc., etc.; so as to make it possible at any time to refer quickly to any subject, and get a general insight as to what it represents, and then be able, if desired, to immediately get the full report. Reports should be printed at not too infrequent intervals, and not too long a period after they have been made out. How much of the mineralogist's report should go into print is a question for the Commisioner to decide. Reports of importance should be printed in full. Reports of failure to find available mineral, or of minor importance, should be printed in extracts, giving a general outline. Anyone desiring further information could obtain this separately from the Commissioner's office. There can be no objection to this on any individual score, as no one who does not desire the fullest publicity as to his property has a right to call upon the Government for aid in examination or report. Anyone desiring secrecy as to his property should be made to do the work at his own expense. I can see right here a very great advantage to the general public, as the habit is only too frequent of having properties examined time and time again that are utterly worthless, and which each time are represented as new discoveries, or even as having had previous favorable reports made on them. I know of cases where properties have been optioned several times, with cash payments for option, by such misrepresentation. A quick examination of the Government records would immediately develop such representation, and prevent the further investigation of many worthless properties, which frequently are likely to lead to the subsequent condemnation of the whole section, or even of its people.

Particular care should be exercised in keeping the record of the drill holes. This is a matter in which we frequently come across cases of gross neglect, either purposely or unwittingly. I know of cases where drill work in very valuable measures was made absolutely worthless by the slovenly and incorrect manner of keeping the records. There should be specially printed and ruled sheets available at each drill, for the marking of every change in the core from beginning to end. Such sections should be blue-printed, and the blue-prints filed with the records. The compilations of such sections, when not too far from each other, are frequently of inestimable value in determining the strata and the thickness or continuity of ore bodies.

Another important feature is the proper keeping of collections, to which especial attention should be devoted. Accompanying the ores should, if possible, be samples of the foot and hanging walls. Specimens should be kept and carefully labelled from all properties examined, and also samples sent in should, in a separate place, be boxed and labelled, first, under locality, and second, under various mineralogical headings.

In the record book should also be kept a short outline of all information sent in to the Government, under the various mineralogical headings. This would include inquiries and statements of any nature, which may sooner or later become valuable to refer to.

The Commissioner's office should, in my opinion, be centrally located, so as to be as accessible as possible.

As to how far the Government should go in its expenditures on any one property, and what sort of compensation it should expect for its work, this is naturally largely dependent on circumstances. The rule adopted in many cases at present, I believe, is that the Government pays 45 per cent. of the expense, while the owners pay the balance. I am not quite familiar with what steps the Government takes at present to reimburse itself in full, in case of valuable discoveries. As a rule, the actual expenditure is not very great, and it would appear to me that the Government's expenditure, whatever it may be, should be practically a charge upon the property, to be paid for by this property, either in total, or on a species of royalty basis. In cases where the owners are manifestly unable to pay even 55 per cent. of the investigations, and yet the preliminary visit of the mineralogist indicates prospects that are worth while further investigation, then it would seem to me that the Commissioner, after referring the matter to the Head Department, should be permitted to make the Government investigation without calling upon the owner to participate in the expense, but in such cases, again, the whole expenditure should be a charge against the property, to be repaid to the Government out of any actual commercial results that arise therefrom, and an agreement with each owner to this effect should be entered into.

In such case, the Government assumes the full liability for only such investigations that prove valueless, and in thus wise directly carries out the whole essence of this proposition ; namely, to develop what is good and what is worthless. It will also be a strong incentive to each section to be as cautious as possible in its expenditures and examinations, so as to have charged up to it at the end of the year the least possible amount of Government liability for which there can be no return expected.

An assay office or laboratory should be in connection with the work. Whether each section or Commissioner should have one under his control, or whether there should be one central Government laboratory, is a question for discussion. The central laboratory would be more economical.

The charges for Government samples would, of course, be included in the general charges against the property. For individnal inquiries a fixed schedule of charges should be had, in order to prevent the swamping of this department with non-paying work. I have little to say about this subject, because all general rules governing laboratories and chemists cover it.

The great value of keeping careful records, for future reference, even of ores that appear too lean to be worked at present, is evidenced by the fact that Scotland smelted last year some 880,000 tons of ore containing only 30 per cent. in iron, while England smelted some 10,000 000 tons of ore running from 30 to 33 per cent. ; these being mixed with richer ores, domestic or foreign, and in some cases smelted alone. Hence, low-grade ores in this country may in time become of value.

As to the equipment required for the exploration, the first is the ordinary list of tools for putting down trenches, pits, etc. Then, when the property has been superficially examined, and some definite idea obtained as to the course of the formation and the probable extent and direction of the deposit, it is for the mineralogist to determine whether he will put down a short shaft or drive a tunnel in-a-ways, or whether he will use the drill direct. The two classes of drill, diamond and calyx, are the most desirable to use. The diamond drill is expensive, on account of the high price of the carbons, the difficulty of obtaining good ones, and the much greater care and experience required to successfully run it without too great a loss of carbons. The core also is small and not so representative. It is more likely to break up and crumble, and more difficult to measure the angles of formation through which it passes. Its main advantage lies in the fact that it will permit drilling at almost any angle. The calyx drill gives a larger core—from 2½ to 5 inches—admits of the use of either the steel cutters or the sheet barrel, according as the rock is soft or hard, and requires much less experienced or skilled men to run it, and would appear to me to be the more available under the special conditions which would govern this work. As to the comparative cost, I have seen such low cost on both the diamond and the calyx drill that I draw no comparison between them.

The report of the mineralogist should contain a surface description of the locality, its distances from various shipping or consuming points, the geological formation; then deal in detail with the character and formation of the ore; should describe its availability for mining purposes, the most economic methods, and any data pertaining to the economical mining; it should, further, give the transportation facilities, if any, or what transportation faciiities would be required; refer to the available timber, the available population for mining purposes, and be as general in its details as practicable.

In this paper, I have purposely not discussed the questions of Government bounty on ores mined; the reduction or entire cancellation of Government royalties, under certain conditions, or of Government encouragement to larger and better school facilities for technical education. Each of these are subjects to be taken up separately, while I have confined myself to practically but one phase of the problem. That my suggestions may meet with opposition in some quarters, I have no doubt. Practising mineralogists and mining engineers may feel that it will interfere with their own work; ye why should it, any more than the work done by the Geological Survey interferes with practical geologists? On the contrary, I think it may stimulate private investigation on all properties that have shown favorable results, just as the work of the Geological Survey constantly leads to study and examination by others of such sections as indicate favorable conditions.

Of course, all of this is mere outline, subject to modification in many particulars, but it may act as a basis of discussion, and as such I submit it to the Institute, regretting extremely that I cannot be personally present to attend what I know will be a very careful and thorough elaboration of all matter bearing on this subject.

MR. R. C. CAMPBELL-JOHNSTON, M.E., NELSON, B.C.

The premises are granted, namely that Canada is more than favoured by Nature in minerals, these minerals to be regarded as raw material.

To promote the development of this raw material, the material must be wrought and manufactured as cheap or cheaper than in other lands, in order to share in the world's market. For cheap working the most skilled miners, workers and officials must be attracted to the country to secure the greatest output per man at least expense. To produce skilled workers technical education in the different branches of their labour is of paramount importance. To make life attractive to them, the conditions of working, sleeping and leisure hours must be made healthy, and the amount of wages saved above living expenses must be a considerable item. Therefore cheap living of good quality is essential, and inspection by Government of working and living places to ensure safety and health must be undertaken.

The law of universal habit to buy in the cheapest market and to sell in the dearest demands free trade in the supplies used to produce the raw material at the lowest cost. To encourage the manufacture *in situ* of the material, only when free trade exists to cheapen production, an export duty on raw material is a logical sequence, so that outsiders using our raw material are handicapped and pay a tax to ease our own. These factors, free trade und export duty, are indirect bounties of use when the raw material is in abundance ; when the raw material is absent or scarce with the fuel to manufacture it, then no bounty can build up an industry.

The sturdy independence of Britons, who have made our Empire throughout the universe, must be continually encouraged, and not enervated by grandmotherly government, but by allowing private enterprise to work out trade problems untrammelled by interfering laws.

The living pictures of this are before our eyes, comparing Germany with her bounty-fed industries and Great Britain with her free trade (the greatest good to the greatest number). Who in troublous times weathers the storm most successfully ?

Should a Government encourage cheap transport by controlling freight rates ? Certainly, and even more so when the nation does not own its own transport facilities, since transport is one of the means of cheap production and manufacture.

A Government should insist on the employers furnishing statistics. It should then collect, tabulate, and widely publish the general results as an incentive both to fresh capital to invest here, and new buyers to do business here. Monographs, maps, and bulletins to advertise and facilitate the present and fresh production of mineral in a country can only be worked out by a Government.

Should a Government institute assay offices? By doing so it works a gross injustice to private interprise. The profession of assayers and metallurgists protect themselves by forming associations and by getting private Acts passed to weed out frauds and unskilled men. Let them be treated like other professions as doctors and lawyers, and let them work out their own salvation, and uphold their *esprit de corps*. Skilled metallurgists are scarce enough already, without a Government by competition discouraging new recruits.

A Government's duty towards mining is to allow it to be self-supporting, to enable it to produce cheaply at home by enacting light taxes, to collect and publish any data to push a market.

It should remember that the world is their market, and not only its own country. The working classes of the United States pay dearly among themselves, that their surplus products may compete in the world's market. This is a quixotic and shortsighted policy on their part to enrich their employers, and is not the greatest good to the greatest number.

MR. W. A. HUNGERFORD, DELORO, ONT.

I do not propose to go into all the many important questions, such as the laws, inspection, statistics, etc., but will confine my remarks to what I consider would be the practical result of a strong liberal mining policy. At a meeting held in Madoc on the 15th October of the representative mining men of this section, to consider the question of a bonus on arsenic, I stated what I considered the wisest and best policy our Government could adopt in order to open up and develop the mineral industries of Ontario, which, of course, would apply to the Dominion as well. My letters also appeared in the Belleville *Intelligencer*, Marmora *Herald* and the North Hastings *Review*, which have been commented on by many of the leading papers of the county. Having, therefore, already expressed my opinions on this subject, I must of necessity refer to some of my former remarks.

I have already advocated that the Government should assist mining along the lines that the Government of Australia assists that industry. And if you will consider this policy you will see how thoroughly in earnest they are, and how practically every detail in the interest of mining is assisted. Their policy has been successful, and it is safe to say Australia would not stand as high today as any of the great mining countries of the world, had it not been for the policy of their Government. The fact that the Government had faith in their mineral deposits and encouraged the mining industry in every legitimate way, gave capitalists confidence and the result has been success.

The mining policy of Victoria, New South Wales and West Australia are about the same.

New South Wales maintains public metallurgical works for treating all kinds of ore free of charge. They also maintain public assay offices, free assays to *bona fide* prospectus, charges to others.

An appropriation of $125,000 yearly is made by the Government Prospecting Board to be spent in assisting *bona fide* attempts to sink shafts, and part of the money goes to keeping up at least 13 diamond and other drills which are used in locating and exploring the size of deposits, part is spent in assisting private miners to sink shafts, who for lack of means could not carry on the work. In case either attempts prove satisfactory and a mine is the result, a refund is demanded by the Government as soon as the industry is paying dividends.

4. A school of mines is kept up to train men in mining.
5. A full staff of geologists is kept up at the Government's expense.

West Australia besides maintaining assay offices and assisting in development work, maintains public stamp mills for treating ores in different parts of the country for the use of prospectors to test ores, and also for custom mills at no charge to prospectors. They also maintain a full staff of experts to do Government work.

It is difficult to imagine what better policy could be pursued to open up and develop their country than this. Apply such a policy to Canada, and I am not stating impossibilities when I say that there is no reason why we should not be one of the largest gold producing countries in the world. When you consider our mineral belts, reaching from Cape Breton to the Yukon, I doubt if there is any country that would compare with us.

Knowing how satisfactory the results have been in Australia, it is hard to understand if our Government had faith in the mineral resources of this country, why they have not had some such policy as this before now. It has not been for the want of information regarding our mineral deposits, nor is it from the want of satisfactory reports from the best experts in the Dominion. But from the fact that our representatives have not brought this question before the Government as they should have done.

What we want is practical assistance, on the lines mentioned :—

1. A Dominion Department of Mines.
2. Free assay offices for prospectors.
3. Government assistance in developing properties.
4. Government stamp mills in certain sections to test ores for prospectors free of charge.
5. A full staff of geologists kept up.
6. A staff of experts to do Government work.
7. A school of mines to train men in mining.

8. Government metallurgical work (as in New South Wales) for treating all kinds of ores free of charge and determining the process to treat the same.

If a policy like this were adopted and assistance given to those who from want of experience or want of capital could not develop their properties, I venture to say that in five years, mining would be established on a permanent and successful basis. The fact of the Government having confidence to expend money in developing a property, would be one of the strongest recommendations for capitalists to invest in that property. The fact that the property had been examined and reported on by the Government expert and the work done by practical men, under the supervision of a Government mining engineer, with favorable reports would place the owner of the property in a position to sell at a figure that he could not otherwise expect to do.

If assistance of this sort were given to this district where we have large deposits of free milling as well as refractory ores carrying enough mispickel to supply the world's demand for arsenic. How long would it take to see a dozen mills in operation in North Hastings alone? All we want is developed properties in order to get capital to work them. Let the Government assist us in doing so and I have no doubt but that the experiment would be a success.

MR. JOHN MCAREE, RAT PORTAGE.

Inspection.—In addition to thorough inspection of the mine, mill and other works in order to secure the greatest protection against accidents, the sanitary condition of the camp should come under investigation to see that the sleeping and dining apartments are cleanly, and adequately ventilated. The system of water supply for the boarding camp should be carefully examined, especially as to the source of supply.

Statistics.—In addition to the usual information regarding the output of the mine, number of men employed, &c., an attempt should be made to collect statistics as to the cost of mining, sinking, drifting, explosives, duty of stamps, &c.

Monographs, Maps and Bulletins.—Monographs on various subjects connected with mining might be advantageously published by the Government. The little Manual on Explosives, by the Ontario Bureau of Mines, is a good example. A good manual on absolute mining is needed ; also a manual for mining investors, giving such general information on the subject as will enable those intending to put money into mining ventures to secure an investment instead of a speculation. An intelligent mining investing constituency is one of the needs of the Canadian mining industry to-day. It is growing, of course, but it will pay to foster it.

The most complete maps obtainable should be accessible to all mining men, and to any who may become investors. In new districts, meridian and base lines, to serve as tie lines, should be run.

Bulletins should be issued monthly, and should appear in newspapers as well as in technical journals; this kind of news would be sought after and would cost the Government nothing for publishing. They should give information of working mines, new discoveries, laboratory work, etc. Those issued from the Government assay office at Belleville have been quite interesting.

Government Assay Offices—Are a good institution. The one at Belleville is a good example: there should be one at Rat Portage.

Duties—Should be removed from all technical literature, mining or otherwise. chemical and philosophical instruments and apparatus, engineers and surveyors' instruments, assaying apparatus and supplies, and be light on all kinds of mining machinery. An export duty may be advisable in certain cases.

Technical Education—Is, of course, very important; must be obtained at the mining school. Each school should have a professor of mining engineering—a practical man who has had experience in mining—not a mere chemist or geologist. There should be adequate laboratory room for assaying and analysis, and a large collection of minerals and rocks illustrative of mining geology.

The mining inspector should be a practical man and a mining engineer of experience, and a sort of consulting engineer for his district. Such an officer would be invaluable in a new region, such as Western Ontario, *e.g.*, in giving hints on mining generally, in laying out work, etc. If mining in the district of Rainy River had been conducted under such an inspector from the beginning many thousands of dollars would have been saved, and the mining interests would have been in a much more advanced state than they are. There are agricultural colleges, experimental farms, travelling dairies, farm instructors for the Indians, and why not also mining instructors? The Indians know about as much about farming as the average Canadian in Western Ontario does about scientific mining. The latest phase in educational methods is to send the teacher to the pupil—witness our summer mining school. The knowledge acquired in this way is that which experience has shown to be actually needed, and the circumstances under which it is acquired are such as to ensure its being mastered and firmly retained.

MR. J. C. GWILLIM, B.Sc., M.E., Nelson, B.C.

Monographs, Maps and Bulletins.—During the past few years there has been a great advance in the mineral industry in Canada, and with it an increase in publications concerning this industry. The Geological Survey Department has to some extent supplied special information concerning our mineral resources, in connection with the general working out of the geology and natural resources of the country. This work has given us maps of a very large part of the Dominion, and very useful they have been towards the opening up of new districts.

In the West there have been special and early reports and maps of Rossland and of the Yukon by Mr. McConnell, and others on the Yellowhead Pass and Crow's Nest coal fields by Mr. McEvoy.

These have been of great and timely use. It is necessary, however, to also let the people know where and how such information can be obtained.

Individual enterprise, and the various organizations interested in development, publish more or less inaccurate maps and accounts of new districts some time before these districts receive official attention. This material is well advertised and extensively used. It is perhaps impossible to get reliable information at the time of the first rush of prospectors into a new district, but its economic resources can be looked into at an early date and receive attention from some authoritative source.

It is not enough to get an accurate and full report upon a district several years after the examination is made, and as long after a pressing need for the economic portion of this report was felt. Such work has a scientific merit and is necessary, but its economical usefulness has lost much by its late appearance. It seems advisable to have the earliest possible maps and bulletins of the mineral resources, in a separate form.

In the publications of the Geological Survey Department and the various Provincial Mining Bureaus we can get, on application, a great amount of information, courteously given, or at a nominal price. Ransacking this mass of information the mining public can get much that it wants, but the phases of mining are many, and while these reports are good for the time of examination, they fall short in describing mining development after a time. The geology and resources other than mining, once worked out in detail after several years' study of the districts, may be given in a standing report, good for all time.

Many of the mines and mining districts of the United States have received special examination from specialists in mining geology. Their work has done much to enlighten us concerning the economic and scientific aspects of mineral deposits. Evidence of the usefulness and demand for early bulletins upon mining operations may be seen in the publication of Mr. Carlyle's Bulletins of Trail Creek and Slocan, in 1896. Messrs. Schrader and Brooks, of the U.S. Geological Survey, published an account of the Nome gold fields before the second season opened in that district. This was very useful to the few who read it.

At present there is some demand for information concerning the Horsefly River district of British Columbia, but there is very little of a reliable character to be obtained.

Canada in the East has some mineral resources which are both valuable and uncommon, such as the asbestos, nickel, mica and corundum. Coal and iron in both east and west are very important. The gold, silver, copper and lead of British Columbia and the Yukon is a great mineral asset.

A better knowledge of these mineral resources is needed. Information contained in statistics, maps and bulletins, prepared from reliable sources and *widely distributed* will do much to relieve the mining industry of the gambling element.

The Provincial Mining Departments do very well in collecting statistics and accounts of the year's progress in the several Provinces, but they lack unity, and depend largely upon correspondents and inspectors. Office work takes up much of the time of those who are qualified to make field examinations. There is no central office from which the latest information concerning mineral developments throughout the Dominion can be obtained. When it does exist it should be well advertised.

MR. E. A. SJOSTEDT, Sault Ste. Marie.

In expressing my opinion in reply to this wide and important question I will avail myself of treating the subject in the order and from the different standpoints suggested by our Secretary, merely limiting the same to the more specific question, How the Dominion and Provincial Governments may promote the interests of mining and the development of the Canadian mineral resources—by the judicious framing and liberal interpretation of their mining laws, by the intelligent inspection and safeguarding of the mining operations, by the systematic use of mining and mineral statistics, by the issuing of monographs, maps and bulletins, by maintaining an efficient assay office, and a high standard of their technical schools, by a careful and just but always most liberal consideration of the demands—in the way of light royalties and duties, and sufficiently high bounties and protection—of every individual or corporation with a *bona fide* proposition to establish a new industry or the opening up of a new mining district.

Laws.—Owing to the diversified character of the mineral resources of Canada only a very general Dominion law would apply and be effective only in the unorganized portions of the older provinces and in those provinces which are not as yet vested with full legislative powers. The mining interests of this country would, therefore, be best promoted by laws framed by each province to meet the local requirements, and by legislatures fully conversant with those conditions. Such laws should aim to simplify the formalities by which a secure title to a mining property may be obtained, avoiding as much as possible the triune control of the lots, resulting from the sale of the timber to one person, the agricultural right to another, and the mining right to a third party.

Inspection.—The inspection of mines should be under provincial control, and the regulations for the guidance of same should be prepared by a special board appointed by the Premier of the Province, composed of the Director of the Bureau of Mines one resident mining engineer and one resident mines' operator, of such wide range of experience as to make them familiar with the different kinds of mining as well as with every detail of the same. The Director of the Province should be a mining engineer of high repute, by preference a graduate from a Canadian Mining School, or else from an American or European College of high standing; he should also have been actively engaged, and have held respon-positions as mines manager. Among his duties would be to make annual visits to each and every active mine, assist in advice wherever requested, and in general take an interest in the development of the same. Subject to the approval of the Premier, there should be appointed by the Director a sufficient number of district inspectors whose duty it should be to make frequent visits (not less than four a year) to each mine, besides keeping the director posted on any new mineral discovery made in his district, stating character and importance of the same. The district inspectors should be practical miners of wide experience and with sufficient education to know the more general minerals and rocks, and to enable them to report intelligently the conditions of the mines and the compiling of statistics (in regard to number of men employed, their different nationalities, quantities and qualities of material raised, number and cause of accidents occurring, etc.) They should also be residents of the district to which assigned. All orders or instructions to the mines owners as regards the safety and precautions to be observed at the mine should come direct from the Director, but the district inspector should be vested with full power for inspecting mines under his jurisdiction at any and all times, and the mines owners requested by law to give the inspector (after his credentials having duly been presented to the manager in charge) a courteous reception and ample opportunity for carrying out his duties, including the obtaining of maps and data for statistics desired.

Maps, Monographs and Bulletins.—All efforts should be made on the part of the Government to secure and make public the geological conditions at each mine as developed, and through the Geological Department and the Provincial Mines Office aid in the work in making such maps and plans as would be best calculated for the intelligent prosecution and the further development of the mineral leads discovered. A great assistance in this respect would be a more detailed work by the Geological Department which possibly could be accomplished by offers from mining corporations to bear a portion of the expense so far as their individual holdings may be affected.

The issuing of monographs and bulletins on any subject of interest to the mining fraternity and their *early publication* and *free distribution* to every mines owner and professional mining engineer in the Dominion would be a great boon, and an advantage which would greatly assist in promoting the development of the mining industry. Mines owners should be compelled to make proper surveys and accurate maps in connection with the progress of the mine work and to furnish copies of such maps to the Director whenever so requested; and copies of these maps, as well as reports about any mine or mining prospect recorded in the Director's office should, for a small consideration, be provided to persons making such requisitions and having consent thereto of the mines owner.

Government Assay Office.—A Dominion Government Assay Office, well equipped and in charge of a competent staff is an essential auxiliary to the Geological Survey; but for the accommodation and advantage of the prospector and mines owner in determining the value of any mineral find, a Provincial Assay Office in charge of the Director is necessary, and the same should be maintained at such a point of efficiency as to secure quick returns from samples submitted. Such replies should aim more at giving practical information than abstract results, however, and should be free of cost; but more specific information, entailing minute investigation and accurate quantitative analysis should be given only at the discretion of the Director, he being guided in such matters by the general importance and interest of the subject matter to the mining industry generally.

Royalties, Duties and Bounties.—The question of royalties, duties and bounties is one of political economy principally. To promote the interest of the mining industry the royalties should be made light and be assessed per ton saleable product recovered from the properties operated under lease from the Government; and on a patented property a tax proportionate to that of other taxable estates would seem proper. Duties on all mining and smelting machinery, as well as on apparatus for the manufacture of coke, charcoal and peat, should be of the lowest; and in cases where the machinery and apparatus required are not made in Canada but as a specialty at the factory of a foreign country from which they are ordered and imported, the same should be admitted free of duty. Bounties should be given to mine owners in the way of Government assistance in construction of good roads and their maintenance or any other transportation facilities, at the recommendation of the Director. Such assistance would not only help in the development of the mines, but also in opening up the country for settlers and thus be a lasting incentive to other new industries.

Technical Education.—It is hard to over-estimate the benefit to the mining industry generally, and the metallurgical industry particularly, that will result from the paternal care and liberal expenditure of money by the Government for the technical education of a sufficient number of mining and metallurgical engineers. As a rule the man who has acquired his knowledge of mines and minerals by years of practical experience only has at the same time fallen into grooves and ruts which seriously handicap him in his efforts to obtain successful results; and the guidance by a broader and more enlightened brain is becoming more and more essential in these days of competition and close margins. Whatever the Government can do, therefore, to raise the plane of intelligence of the men engaged in mining and allied industries would doubtless tend to promote the development of its mineral resources. The strength and prosperity of a country rests to a very large extent on its mineral wealth and the degree of development of its mineral resources, and to attain this in the highest degree the whole educational system should be on the highest plane, to reach which the liberal support of the Government and individual endowments to high institutions of learning as well as to the great common school system would be a necessity.

Technical schools and universities of the Dominion should be sufficiently equipped and endowed to provide the best course in mining, engineering, metallurgy and chemical and electrical engineering, and the endowments of the chairs should be large enough to attract men who already hold lucrative positions as captains of industrial enterprises. The establishment of closer relations between the university and the mine and factory namely is of the greatest importance. The fact that instructions were to be given by professors who themselves have participated in active operations instead of by book worms possessing no knowledge of the practical side of the subject would be an incentive to a class of young men eager to lay hold on the world of industrial activity, which in itself would be a great stride forward in an educational system of this kind. The courses referred to should be of a practical as well as a theoretical character, so as to not only equip the student with a broad, firm, scientific knowledge as a basis for further work, but also afford him the time and opportunity necessary for a certain amount of practical experience which will give him some kind of "working idea" of his profession. For instance, a chemist on graduation should not only have a theoretical knowledge of his subject, but he should be required to understand the reactions involved in the assays and analyses of the various types of ores and technical products. He should also have such a drill in these manipulations that he will know the various "short cuts" and "quick methods" which are required in the technical laboratory of today. Unless a graduate has had some such drill it takes nearly as long to "break him in" in a technical laboratory as it does an uneducated boy.

The summer vacations during the college years in question should be devoted not only to visiting mines, furnaces and mills for a stipulated number of weeks, but in performing actual work and detailed duties in connection with certain specified operations in mining, smelting, converting and refining—this to be necessary part of the course, just as is the practice in some of the European countries where the standard of technical education is the highest, and where the advantages of this practice have been fully demonstrated bp the high degree of perfection reached in the industries mentioned.

DR. W. L. GOODWIN, Kingston.

In reply to your request for my views upon the ways in which a government may promote technical education, I wish in the first place to point out that the word *technical* is used in two senses,—(1) As covering manual training and what may be described as trade schools, and (2) as referring to higher education in applied science Governments have duties in both these directions ; and both Provincial and Dominion Governments have so far been active in the discharge of these duties, as witness the agricultural college and schools, the experimental farms, the dairy schools, the travelling dairies, and the Ontario grants to schools of practical science, and to secondary schools (to aid them to establish technical courses). But if Canada is to keep pace with the rest of the industrial world, much more must be done by Governments to forward not only technical education in both senses, but also scientific education in the broadest sense of that term. For *applied* science implies *pure* science ; and the nation which relies on others to carry on scientific discovery, and thus borrows its science for application, is in a position which is neither advantageous nor self-respecting. Through lack of scientific schools and colleges and of the scientific spirit among her manufacturers, Great Britain has lost industry after industry which rightly belonged to her. She is now in the humiliating position of supplying the greater part of the raw material (anthracene) to Germany for the manufacture of olizarine, a manufacture worth $20,000,000 a year; and her dyers import the manufactured article. She is in the same position now with regard to the manufacture of indigo, which has heretofore been a distinctly British industry with a turn-over of more than $15,000,000 a year. But the German dye manufacturers have spent $5,000,000 and twenty years of research in finding a manufacturing method for converting napthalene (largely from British coal tar) into indigo; and they have succeeded. The statistics of trade show that the German synthetic indigo is rapidly taking the place of the product of the plantations of India. Already one-fourth of the world's supply is synthetic indigo. These are two instances of the way in which those British industries have suffered which depend more particularly upon scientific research for their advance. At least a generation has been lost,—three decades of apathy; but at last an earnest effort is being made to retrieve the position; and three great forces have been brought to bear: (1) Imperial legislation and grants of money, (2) municipal aid, and (3) private munificence. In all these respects we in Canada have made a beginning, but *only* a beginning, and I shall confine my letter now to a short discussion of the directions in which the Dominion Government might reach out to aid technical (or preferably, *scientific*) education. It is quite plain that the resources of the provincial treasuries are very limited, and that the provinces unaided will not be able to keep pace with the needs of education in applied science. While education is set down in the British North America Act as in the jurisdiction of the Provincial Governments, there is nothing in that Act to prevent the Dominion Government from giving aid to education. Indeed it has already adopted the principle in establishing the Royal Military College (which had turned out more engineers than soldiers), the marine biological station, the experimental farms (stations for scientific research in agriculture), and the other means for disseminating a scientific knowledge of agriculture and forestry. But it should now turn its attention to manufactures and to metallurgy and mining, and formulate a comprehensive policy of aid to scientific education, and particularly to those parts of it which have more direct connection with industries. It is always good policy to strengthen the forces already working. The Geological and Topographical Surveys are in reality institutions of scientific research. The same may be said of the corresponding parts of the Departments of Fisheries, Agriculture, and the proposed Department of Mines. Much can be done to strengthen these, by providing greater facilities for work, particularly for research, and by paying such salaries as will attract and keep men of the first rank. Following the example of the Imperial Government, the Dominion might well establish in existing scientific colleges regius professorships of subjects bearing upon industries of national importance. The founding, equipping and maintenance of research laboratories would be a paying investment of public money. Governments are wont to plead that in such matters they must not be in advance of public opinion. But there is public opinion *and* public opinion, and in this case the matured opinion not only of scientific men but of the leading manufacturers is in favor of a vigorous and expansive policy. The Canadian Manufacturers' Association has recently been instrumental in forming a Canadian branch of the Society of Chemical Industry, a British institution which has done much to awaken interest in scientific education in Great Britain. The Manufacturers' Association has also asked the leading Canadian Universities to make provision in their curricula for the special education of men for a business career. Manufacturers, mine owners, and others requiring men with technical skill and education are everywhere calling for applied science graduates to fill the most responsible positions. Here is the kind of public opinion which will justify action on the part of the Government.

Germany spends freely upon both universities and technical high schools. The latter should rather be called engineering colleges. They rank with the universities and grant degrees in engineering. The Universi,y of Berlin has an income of $715,000 a year, and the Government contributes 83 per cent. of this. Another at Bonn receives from the Government $250,000 a year; and similarly for other towns. The technical high school of Berlin receives $165,000 a year from the State, that in Hanover $75,000, and the Aachen school $80,000. In Great Britain the direct grants to universities and technical schools are still small, ranging from $10,000 to $12,000 a year for each of twelve university colleges receiving them. But large annual incomes available for technical education are now being derived from the operation of the Customs and Excise Act of 1890, by which a sum of about $3,750,000 was set aside for this purpose. There is also an annual grant of $750,000 divided among the four Scottish universities. In the United States scientific education is generously supported, not only by the State legislatures but by Congress. The Morrill Bill of 1862 provided funds for "colleges for agriculture and mechanic arts" by the sale of public lands. The amendment of 1890 provided for making good any deficiencies by direct payment from the United States Treasury. The Congress of 1900 passed a bill providing appropriations "to establish and maintain schools or departments of mines in connection with colleges and universities."

It may be urged that Canada is too young to begin this kind of work and that it should be left to gradual development by private enterprise and individual munificence. This is the policy which Great Britain has pursued up to the last few years, with the disastrous results already indicated. On the other hand Germany initiated her system of technical education more than one hundred years ago. At an even earlier date the University of Göttingen had a course in technical chemistry and technology, and Beckmann (1777) published the first text book on the subject. It dealt with weaving, dyeing, paper-making, brewing, starch, oil, tobacco, glass, sugar, gun-powder, &c. In 1796 this university (in a comparatively small town) had two professors of chemistry and one of technology. Before many years had passed, the other German universities had followed Göttingen in making provision for the technical side of science and in particular of chemistry; and in addition the technical high schools had been founded. Many of these have been in existence for more than half a century; and, in the words of a recent British consular report, "it has been found that the foundation laid during the scientific courses at the technical high schools formed the soundest basis for the practical experience to be gained during professional life." How these results are attained may be indicated by a glance at the staff of instructors as compared with the number of students in the chemical departments of some of the technical schools. The Berlin school has 44 instructors for 278 students; the Stuttgart school, 10 for 88, and the Carlsruhe, 15 for 139. Compare these figures with those for some of our universities. Toronto has 9 instructors for 594 students of chemistry; Queen's has 5 for 220; and McGill has 14 for 410. It appears, then, that we have very much to do and a long road to travel before we can take our place with the most enterprising manufacturing peoples.

But will it pay? In chemical manufactures alone Germany produces about $250,000,000 annually. If, as Beaconsfield held, "The chemical trade of a country is a barometer of its prosperity," Germany has become very prosperous. Her chemical trade grows. The present crisis is an incident merely and the chemical trade is the only one not seriously affected by it. The electro-chemical industries of the United States are now worth $100,000,000 a year. These are examples of industries which can be built up only upon a foundation of scientific education. The latter is a direction in which Canada is certain to make great advances, if her population receives a sufficiently thorough and widespread education. There is no other country with such a great amount of water-power available; and this will inevitably give us the advantage over those manufacturing peoples which depend on coal. The cheapest way of generating elecricity is by a favorably situated waterfall. Thus, given raw materials of the right sort, and Canada can compete successfully with the world in electro-chemical industries. But the application of electricity for such purposes is comparatively new, and advances must be made by devising new processes and new applications, such as, for example, the reduction and refining of metals which are now worked by other and more expensive means, and the decolorizing and purification of beet sugar. Each country has problems of its own to work out, differing according to the varying conditions ; and no country can afford to depend upon help from without to solve its problems. England is now importing 90 per cent. of the dyes used in her dyeing industries, although the beginnings of the manufacture of artificial dyes were made in England, and it only required a widespread appreciation of the value of scientific education and research to have secured for her this immense industry. As it is, she exports the raw material and imports the manufactured articles. Germany solved the problem of finding uses for England's immense supply of coal tar, and Germany reaps the benefit.

A few examples of what might be done:—We have some of the largest and best deposits of pyrite to be found anywhere in the world. One of these is now being worked and the raw pyrite is shipped to the United States for the manufacture of sulphuric acid, &c. We import the acid for the manufacture of nitro-glycerine, &c. The pyrite is worth three or four dollars a ton. Each ton will make about 1½ tons of acid, worth $40.00. It would certainly be a great advantage to make our own acid and even to make it for export. If this were once begun it would be the basis for a dozen other chemical manufactures in which sulphuric and sulphurous acids are used. Another problem—one involving both mechanical and chemical engineering —is the utilization of our immense peat bogs. This problem is being worked at in Europe, particularly in Norway and Sweden, where peat is becoming constantly of more importance as a fuel. It is also looking up as raw material for the manufacture of paper. Experiments have been made by the Rathbun Co. in Deseronto to test its value in the charcoal retorts. But we are still far from a solution. Again, Canada is certain to become a great pulp manufacturing country. Immense quantities of sulphite waste will be produced. What is to be done with this waste ? Although there has been much investigation, no process of utilization has yet been devised which gives complete satisfaction. For such investigations as have been indicated here, the highest scientific skill is required, and this must be combined with a knowledge of the economic conditions prevailing in Canada. All this implies that the work must be done mostly by Canadians, and that they must be educated in Canada. Our duty to ourselves seems plain. We must devote to scientific education a sufficient part of our revenue to provide the best scientific and technical schools and colleges for the youth of Canada. Such education is necessarily expensive ; but the experience of those nations which have tried it prove that it is cheap at any price. The Canadian statesman who is far-seeing enough to inaugurate an adequate system of Dominion aid to scientific and technical education will win his place in the history of Canada.

MR. JAMES McEVOY, FERNIE, B.C.

In considering this question, it will be admitted, in the first place, that such aid should not, except perhaps in the commencement of an entirely new enterprise, take the form of a spasmodic attempt to foster any particular industry. The plan of action should be broad enough to include all.

The great successes of to-day in mining are generally due to the proper application of knowledge gained in many previous attempts. Even the complete failures of the past often materially help to present success. They have been as danger signals on the road, and at least enable the new comer to avoid falling into the same errors of his predecessors.

So much being admitted, it will be seen how useful a careful monograph of some of our older mines would be. It should contain an honest criticism of their workings, wherein they failed, as well as where they were successful. The effect should be to stimulate the miner of to-day to better efforts in the right direction. It is certainly within the functions of a government to do this, in fact it has been done to some extent at least by the United States Geological Survey.

It is necessary, however, to do more than look backward if we are to accomplish much. The best methods of mining and treatment must be studied, and the knowledge made available to the operators, and then the necessary raw material to work upon must be found. By helping in the discovery of such suitable material a government can best promote the mining interests, and it seems to fall naturally to the lot of the Geological Survey Department to furnish the information required. There is no disputing the fact that this department has done, and is still doing, really good work, but the complaint is made that it is too hard to get at. Very often there is as much reason for the complaint as there is for admitting the fact. To illustrate the point, let us take for example the industry with which the writer is best acquainted, viz., coal mining in the west. Supposing some one wished to get a general knowledge of the coal deposits in that part of the Dominion, and consulted the Geological reports for that purpose. What information there is, has been published of course, but it is scattered in fragments through about twenty huge volumes, to the last fifteen of which there is not even a general index. Even a man who has spent years of his life in the department will find it difficult to discover any particular reference. Imagine then the predicament of an outsider.

Now, if the whole of this information were concentrated in a monograph or bulletin on the Western coals, and the bushels of chaff fanned away, it would be possible for anyone with ordinary intelligence quickly to see just how much was known about the subject. The work should be freely illustrated by diagrams and sections, and as much as possible placed before the public in a graphic form.

The same reasoning will apply with equal force to any other mining industry in the country.

Even if all this were done, however, it does not by any means meet all the requirements of the case, as it only makes available the information of the past. It is necessary to reach out after new discoveries. More particular attention might well be called to places where, owing to the geological conditions, further discoveries may be reasonably expected.

In order to have a reliable account of our mineral wealth, it is necessary to have more geological field work—good work, and more of it by experienced men. Then have it placed before the public in an available form.

It need not be inferred from the foregoing that purely scientific research should be abandoned or even neglected. Such work often leads to the most practical and important results. The theoretical and the practical should go hand in hand.

The separation of these into two departments, or separate branches of the one department, unless closely in touch with each other, would be a grave mistake, as in such a case neither branch would be likely to avail itself promptly of the information gained by the other. It would also mean a duplication of work, and the unnecessary and wasteful expense of duplicate laboratories and libraries.

Until there is some definite plan of action decided upon, and there is a reasonable hope that suitable men can be found to fill the different parts, it would be useless for a government to pass any largely increased vote of money. One thing at least is certain, something should be done. It is possible that by picking out the best points in the various opinions on the subject a decision may be arrived at, which, if carried out, would greatly benefit not only the mining industries, but the whole of our Dominion.

MR. J. T. DONALD, M. A., MONTREAL.

By these I understand offices where any individual can have samples of ores assayed free of charge or at a nominal cost, *i.e.*, in reality at the public expense. Although I am an assayer myself, I am in favor of equitably conducted Government Assay Offices. These if properly carried on should be a boon to prospectors and residents of regions where economic minerals are likely to be found and in no wise harmful to the private assayer. From tne point of view of a private assayer, the only fair way in which to conduct a Government Assay Office is to man the same with a staff, the members of which receive a fixed and adequate salary and devote their whole time to the work. They should not enter into competition with private assayers in canvassing for the assay work that is required by those engaged in mining operations. A Government Assay Office will undoubtedly take away from the private assayer work that would naturally go to him, but in the end the private assayer will be more than compensated for such loss by the demand for assaying that will arise as a consequence of the work done by the Government office.

MR. J. WALTER WELLS, Belleville, Ont.

In my opinion the proper function of such offices or testing laboratories is that of acting as referee or umpire in cases of disputes between different assayers who may report differently on the same sample, and also in case of disputes as to grades or qualities of ore between shippers and the smelters. A large proportion of the work done by Government Provincial Assay Office here is umpire or checks on assays in case of parties buying properties, or ore, who may wish to check the reports of the owners of the property or ore. I would like to see more done along this line.

DR. JAMES DOUGLAS, New York.

That Government should encourage all national industries does not admit of contradiction ; but the form of aid to be given to mines and metallurgy will depend on the divergence of view as to the principles on which ownership should be held. Under the rule of Old Spain, and of the Republics of Spanish-America, minerals are accounted public property, and do not pass into the possession of the owner of the soil. The laws of Spanish-America, therefore, having always been framed with a view of yielding the largest revenue to the public treasury, either as rental or through export duties, or through both. In Mexico, for instance, the present mining law reserves the right to work every "pertenencia," or area of one thousand meters square, on the payment of $10.00 Mexican currency per year, and these rights are transferable and inviolable to the holder of the patent as long as the rent is paid. In addition the Republic levies 3 per cent. on the output of gold and silver, whether the metal be retained in the country or exported. A large revenue is thus derived by the public, and encouragement given the miner to explore and to acquire the rights and to benefit by his discovery through either working the property or by sale. On the assumption that the mineral resources, being at best limited in quantity and incapable of reproduction, should not become absolute private property in the same sense as land, the mining law and practice of Mexico and of most South American Republics are well worthy of study.

Considering the risks of mining and the vicissitudes through which most mining enterprises pass in attaining success, State ownership and State operation of mines would hardly be advocated by the most ardent socialist, if he happened to be a practical miner, or even a mine owner. While the phenomenal growth of the mining and metallurgical interests of the United States might be quoted in favor of private ownership and of State aid through a protective tariff, the still more extraordinary development of the gold and silver resources of Spanish America, immediately after the discovery of America, may be as cogently used as an argument on the other side.

The opposite view to the Spanish is that generally held among the English speaking peoples, and mineral property is in most of these countries alienated from the public domain and allowed to pass absolutely into private possession. But in these countries, legislation should none the less aid at making the mines as beneficial as possible, not to a single class, still less to the few who may be so fortunate as to own the good ones, but to the people at large, and special assistance in the form of either preference duties or State bonuses should be very cautiously and sparingly accorded. These forms of assistance may be usefnl in stimulating certain branches of industry during their initial stages, but such privileges are liable to stimulate, in addition to the infant industries, very mature political corruption. It is moreover certain that they prove very difficult of cancellation, when the time comes that they are admitedly no longer needed. The enormous wealth they put at the disposal of a favored industry, or of the individuals who profit by them, is very liable to be used in securing their perpetuation. It may be taken for granted that there is so much money seeking investment that any really good enterprise will sooner or later receive public support without State aid, and when thus established will be in a healthier condition than if unnaturally fostered.

Above all, in alienating the mineral wealth from the public domain, the law should provide against, not so much the absorption of the mines into large blocks by a few, but the holding idle of large areas for purely speculative purposes. This can probably be secured by the imposition of a fair tax on idle mining property. It is also competent for Government to impose rules and regulations which shall aim at reducing waste. The mine owner to-day is heedless of the future of his property, if he can wring the maximum of profit out of it; but on the conservation of a country's mineral wealth will depend its future prosperity, and that ever living entity—the

Government—which we all hope will subsist from generation to generation, is charged, as one of its functions, with looking onward as well as backward, and to to-day. Waste of coal by faulty methods of mining and burning is for instance not only a nuisance, and as such comes within the province of Government to prevent, but it is robbery of the national treasury. Such legislative enactment may seem to aim at retarding, rather than encouraging, the mining and metallurgical industry, but looked at from a wider point of view, they will be seen to insure the most permanent and solid advantages to the public as well as to the mine owners, however harrassing they may be for the moment.

MR. C. A. MEISSNER, SYDNEY, C.B.

The advance copies containing the papers on Government Aid to Mining, for discussion at the meeting, reached me too late to be able to say anything further at the meeting.

There is one point in particular, however, that I think is well made, and is one of very great importance, that is, the difficulty of getting at any of the information obtained by the Geological Survey on any particular metal or section. Mr. Jas. McEvoy very correctly shows the difficulty, almost impossibility, from the practical standpoint, of obtaining such information. No practical man has the time to spend hours hunting up the subjects that he wants. In some cases it might even require days, and this is a matter that ought to be remedied as quickly as anything else. We have here most excellent work done by the members of the Survey, and most valuable information gotten together and published, and yet. through the lack of even ordinary indexing and compilation, this information is practically lost and buried. All the money spent on it is of practically no avail, and one wonders for what purpose all these investigations were made, and all this money spent, when after all it is so completely unavailable.

The same applies to the publication of maps, and we in Nova Scotia are especially sore on this point. It is, again, a mass of valuable information, obtained at great expense, and for years utterly unavailable.

I think this is a most serious fault that can be found with the Government work in this direction, especially serious because it is utterly needless. I am sure there is plenty of time and talent in the Geological Survey to be able to prepare this information. It is evidently a question of lack of organization more than anything else.

MR. J. OBALSKI, INSPECTOR OF MINES, QUEBEC.

a. We consider that being not only a mining country, the Law must protect also the farmers. The Government has therefore abandoned to the proprietors of the surface the mining rights in the properties patented previous to the 24th July, 1880. Since that date, the mining rights are reserved by the Crown, and the farmers have only a right for the damages done to their properties, such damages being estimated by arbitration.

b. The inspection is made in order to keep the Government well informed as to the progress of the mining industry, to provide for the safety of the men, and to give to prospectors and small miners all the technical help they need.

c. Regarding the statistics, the Companies are obliged by the Law to give an annual report of their production and operations, and we check their figures by the statements kindly supplied by the Railway Companies. We give the figures as market value at the mine, or at the nearest shipping point; of course, for some products, we give the value at the mill, as for asbestos fibres, concentrates of chrome, galena, graphite, etc. Mica has to be specified if cut, trimmed or rough. We consider the figures given as correct, being the total of those mentioned by the operators of the mines. Those figures appear in bulk for each mineral.

d. We publish, every year, in February, a general report giving all the information collected for the previous year, and moreover, we prepare special detailed monographs and maps.

e. An Assay Office, in Montreal, at very low rates, for the prospectors of the province, under the supervision of the Bureau of Mines, affords every facility for cheap tests and identification of minerals. We also give, free of charge, all the information wanted on specimens sent to our office, analysis and special tests being made when needed in the public interests.

f. Royalty is not exacted in the province, and the question of bounties has not been considered so far. Personally, I do not consider that the mining industry can be made a source of direct revenue for the province, and that every possible encouragement must be given to this industry, real benefit being derived from the development of the districts where the mines are operated, thus giving employment to the people, and developing the mechanical, construction, transportation business, etc.

g. The question of technical education is not considered in view of schools, like McGill and Polytechnic school, teaching mining and civil engineering.

In any case, the Government is always ready to consider any demand which may be suggested for encouragement of mining, such as amendments to the Law, building of roads, exploration of new districts; the regulation concerning the prospectors has so far been fair and satisfactory.

Regarding the creation of a Department of Mines for the Dominion, I consider it should take charge of the statistical and mining branch of the Geological Survey, and that the head of this Department should be a mining man independent of the ordinary routine of a Department, and being in direct touch with the mining Community of Canada and other countries.

[For further discussion of this question see proceedings of Annual General Meeting.]

Compressed Air.

By W. L. SAUNDERS, New York.

In introducing the subject of compressed air before the members of this Institute, I feel that I am addressing those who are not only interested in the subject, but through the discussion which will follow I hope to gain a good deal of practical information. To me compressed air has been a close study and a pleasant pastime for more than twenty years, and yet every time I attempt to climb up on a pedestal and pose as an expert, I see all around me things that I did not know. Though one of the oldest of the sciences, there is really less known about compressed air than about steam, hydraulics or electricity, and however deeply we may dig into the theories of thermodynamics, we find every now and then a practical mining engineer who shows us by a little experience that the formula which has been guiding us is nothing but a cobweb without substance or strength.

I remember very well my first researches on the subject of compression. After learning what was meant by isothermal compression, it appeared very plain that a serious loss was suffered to take place in the cylinder of an air compressor by attempting to compress without injecting a spray of cold water into the cylinder during the process. All theories and most authorities taught me to advocate the "wet" type of compressor as distinguished from the "dry," and yet it is a fact that at the present time I do not know a single builder who follows the wet process. It must not be inferred, however, that the importance of cooling during compression was over estimated. We have learned to cool by compressing in stages and have abandoned water injection because of its complications of apparatus, the inevitable destruction of wearing parts, and because it is not advisable to bring air and water together while the air is at a high temperature. The reason for this is that the capacity of air to take up moisture is in direct proportion to its temperature, and even with the most efficient system of spray injection it is difficult to start the compressed air on its journey to the mine at a temperature low enough to produce dryness. During the building of the

Washington Aqueduct Tunnel a central air compressing plant was located at the foot of a hill. The transmission pipe leading up the hill to the shafts would at times become practically filled with water which would be taken up and sent forward like a piston into the workings. It is interesting here to note that this difficulty was overcome by pumping fresh cold water into the air receivers at the foot of the hill, thus condensing the moisture of compression. Dry stage compression actually gives as a pressure line more nearly the isothermal than was obtained by the injection process. In stage compression there are two or more air cylinders each surrounded by water jackets. Intercoolers are placed between the cylinders, and in this way the air is alternately compressed and cooled until it is discharged into the receiver. By this process the air is maintained in a dry condition, and as it at no time reaches a diabatic, or the heat maximum of temperature, it is not "burned," but is delivered into the mine in a fresh and healthy condition. Too little importance is sometimes given by engineers to the intercooler. The The common or cheap form of intercooler only partially serves the purpose, but the intercooler which is composed of nests of tubes around which the air circulates, splits up the air into thin layers and as cold water passes through the tube these thin layers are rapidly reduced in temperature; so that with cold water, which I judge is not difficult to obtain in Canada, it is quite possible to obtain air temperatures in the intercoolers considerably lower than was the temperature of the air before it entered the compressor. This is an important point as affecting both the actual and the volumetric efficiencies of the air compressor. The theoretically perfect compressor is one which draws in air at a temperature of zero or lower and discharges it compressed at normal or outside temperatures. We must always bear in mind that during compression the temperature of the air at any stage depends upon its initial temperature, and that the higher the initial temperature is the higher will be the temperature throughout the process of compression. This is not a theoretical but a practical question, which concerns those who are engaged in the evety day practice of air compression. Engine rooms are usually warm and dirty places from which to draw a supply of air for the compressor. Hot air means thin air, and thin air drawn into a compressor means a low volumetric efficiency. The mine owner who pays for an air compressor of a certain size naturally wants to get out of it all the compressed air he can. He should therefore see that the compressor draws air from outside the engine room and from the coldest spot on the property. He should also see that his compressor is provided with a thorough system of cooling, because no matter how cold the air may be, when it goes into the compressor it is sure to warm up by the action of the piston. This warming up process causes the air to expand and to resist the act of compression in degree directly in proportion to the increased temperature—that is, the hotter it is, the harder it is to compress the air and the more power is consumed for a given volume. To express this in figures, we find that when air is compressed in a single stage machine from atmospheric pressure and 60° Fahrenheit temperature to 80 pounds gauge pressure, the maximum theoretical loss due to increased resistance through heat is about 33 per cent., when represented in foot pounds of work. As a matter of fact no such loss is ever suffered, because maximum temperatures are never reached even in single stage compressors, cool metallic parts brought in contact with the air absorb some of this heat, so that we may safely say that a well designed water-jacketed single-stage compressor suffers a loss of 20 per cent. in foot-pounds of work when compared with isothermal or perfect compression, and under the conditions of temperature and pressure stated above. We may therefore say that in compressing air to 80 pounds pressure without compounding, it is possible to lose one-third in power though we usually lose one-fifth. To illustrate with these figures the importance of compounding, I would state that under the conditions stated a two-stage compound compressor, when properly designed, would suffer a loss of a fraction over 15 per cent., and in a four-stage machine we are able to get this down to near 5 per cent. As some of you may be using air at 100 pounds pressure, you may be interested to know the figures under these conditions. The maximum loss in a one-stage compressor is 38 per cent.; this in a two-stage machine may be brought down to a fraction over 17 per cent., and in four-stages to 8 per cent. Even at 1,000 pounds pressure the heat loss in a four-stage compressor is brought down to 17 per cent. All representing foot-pound of work.

The subject of cooling is not complete without a brief statement about after-cooling. It is easier to get our ideas about intercooling carried out than it is to get any hearing when we talk about after-cooling. Assuming that you agree with me that air should be cooled before it enters a compressor and that this process of cooling should go on *during* compression, I would also like you to agree that even after we have bottled up the air in the receiver something might be gained by inflicting it with a further and final cold bath. This is really the last time that the cooling process should be applied, and from this time on we are to turn square about, reverse our treatment, and begin to warm up. An after-cooler between the compressor and the receiver, or just outside the receiver in the main line, is a good thing because it will serve as a condenser to abstract moisture from the air by bringing its temperature below the dew point. Air at all times contains moisture, the average moisture being about 50 per cent. of what is required to produce saturation, and it is safe to say that during our cooling process in the compressor we are not likely to abstract any of this moisture. The only mechanical way as distinguished from the chemical process by which we may get moisture out of air is to lower its temperature. But we must lower it below its initial temperature to produce any results. Notwithstanding the best systems of jacketing, compounding and inter-cooling, the compressed air is usually discharged into the receiver at a temperature about double the initial temperature, and as this air cools on its journey to the mine, it is likely to condense moisture on the interior walls of the pipe In cold weather this freezes and accumulates, sometimes restricting and even stopping the passage of the air. In other cases it condenses its moisture in the ports and passages of the drills and pumps. These troubles can be reduced to a minimum and even overcome entirely by a thorough system of after-cooling, which means nothing more than reducing temperature and abstracting moisture just outside of the engine room.

Before leaving the subject of compression, I would say a word about oil. Air cylinders do not require oil either in quality or quantity like steam cylinders. What is good for the one is bad for the other. A steam cylinder needs an oil of low flashing point, and plenty of it, because the tendency of the wet steam is to wash the oil out of the cylinder. Not so with air, there is no washing tendency and very little oil will last for a long time. This oil should be of the best quality obtainable and of a high flashing point. It should not be a coking oil, that is when evaporated on a piece of hot metal it should not leave a carbon deposit. This is a subject which has been very much neglected, and this neglect is responsible for much waste of money, and worse than this, for explosions which destroy property and threaten lives. The actual amount of oil that should be used in an air cylinder is one-quarter that which should be used in a steam cylinder of the same size. I would call this a maximum, for very much less will often suffice, especially where the oil is of the best quality. Too much oil where there is a coking tendency results in choking the valves and ports. A discharge valve might stick through coking, and when stuck it will admit some of the hot compressed air into the cylinder against the receding piston, which on the return stroke is compressed and carried to a temperature beyond the flashing point. Sometimes when discharge valves give trouble, they are cleaned by injecting kerosene; this is a fatal error. Kerosene should never be used in the air cylinder, but instead of this, fill the oil-cup with soap-suds made preferably of soft soap, and feed this into the cylinder; let the compressor work with soap-suds instead of oil for a day each week and no harm is done, care being taken to feed with oil a half hour before stopping, so that the parts may not be subject to rust, which is the only danger from soap-suds.

Compressed air has always been and still is supreme in mining. As a means of transmission and for surface work it must in many cases give place to electricity and hydraulics, but as an underground power its supremacy is admitted. No power is so safe, none so free from objections in mining work. It aids ventilation and cools the heading. If the conduit pipe is large enough, you will suffer no loss by friction and may convey compressed air several miles from the generating station. In recent years compressed air economies in production, transmission and use have opened up a large field in directions other than mining. All of our large railway systems are now provided with pneumatic appliances in the shops and many of them use the system for switching.

Machine work of all kinds, such as drilling, chipping, riveting, moulding and hoisting is done by compressed air. The air lift pump, for lifting water, salt water and oil from wells occupies a field of much usefulness. The compressed air locomotive has an established place in and about mines, nine of them being in constant operation in the Anaconda Copper Mines in Montana, and several are now at work for the Cambria Steel Company in Pennsylvania. The use of compressed air in bridge and tunnel work has made possible many of these large undertakings. The Blackwell tunnel under the Thames, in England, is one of the most recent evidences of the utility of compressed air for such work. The stupendous scheme, which has been inaugurated by the Pennsylvania Railroad, to bring its terminal into the heart of New York City, is made possible only by the use of compressed air.

In conclusion, it may be interesting to call your attention to a column of " Donts," which I found in an engineering paper published in far off New Zealand, and from which we may all, I think, carry home some useful lessons.

" Don't install a compressor just about equal in capacity to your present requirements, for when once you have compressed air available its number of uses becomes legion. Good practice is to provide a compressor at least 50 per cent. greater in capacity than your immediate necessities demand. Duplex compressors are made divisible, permitting the installation and operation of one-half at first and the other half later when the additional capacity is needed.

" Don't accept the theoretical capacity of an air compressor stated in the list of the maker, as the equivalent of the actual volume of air needed for your service. Remembering the difference between theory and practice, allow a small deduction for friction, heat, clearance, etc., being unavoidable losses in air compression, before calculating what your actual delivery in compressed air will be.

" Don't buy an air compressor because it is cheap. It will prove the most expensive proposition of its size that you have ever encountered. If a water pump fails in its work, you will know it at once; if a steam engine is deficient, its shortcomings are self-evident, but if an air compressor is poorly designed or badly constructed, it may continue in the evil of its ways until the scrap-heap claims it for its own, unless, as is more than likely, an absolute breakdown calls attention to its deficiencies, and you learn all too late that the hole it has made in your coal pile, added to the loss of keeping it in repair, would have paid a handsome interest on the additional first cost of a properly designed and properly constructed compressor.

Don't buy a second-hand compressor unless you know it has given satisfaction in work similar to your own, and that its working parts retain their full measure of usefulness without deterioration. An air compressor with valves, pistons, etc., worn out or in bad repair, can waste more good power than anything of its size known.

Don't buy a compressor that your neighbor used for operating oil burners because you intend putting in pneumatic tools. For, even if all compressors look alike to you, experience teaches that oil burners operate under 12 pounds pressure, whilst pneumatic tools require 100 pounds, and the oil burner compressor, with unevenly proportioned cylinders, devoid of water jackets, will equal your service as well as a low pressure boiler for heating will run a high speed engine.

Don't use air brake pumps or direct acting compressors. Statistics show that their steam consumption is about five times that of a crank and fly wheel compressor for the same volume and pressure of air delivered.

Don't install a steam driven compressor if your steam supply is short and plenty of belt power available.

Don't put in a belt driven compressor if you have plenty of steam and are short of belt power.

Don't draw your intake air to the compressor from a hot engine-room, or from any point where dust is abundant. The volume of air delivered by the compressor increases proportionately as the temperature of the intake air is lowered, and dust or grit entering the compressor clogs the valves, cuts the cylinders and generally impairs the efficiency.

Don't use any old thing for an air receiver. Compressed air under 100 pounds pressure will leak a horse-power through a 1-16 in. diameter hole in five minutes, and a well made, strong, and tight air receiver is the second essentially important factor if you would realize to the utmost all the advantages which compressed air provides.

Don't connect your air admission and discharge pipes improperly at the receiver. To secure the best results and eliminate moisture from the compressed air, connect your pipe leading from the compressor at the top of the receiver and lead your air pipe to points of consumption from the bottom of the receiver.

Don't have leaky air pipes. Test your piping when it is installed, and at regular intervals thereafter, allowing the full pressure to remain an adequate length of time, and if the gauge indicates leakage locate and remedy it.

Don't install your piping without properly providing for drainage of condensed moisture at regular intervals in the system. The simplest method is to slightly incline the branches leading from the main line and insert drain cocks just before the hose connection is reached."

Mining and Concentration of Corundum in Ontario.

By M. F. Fairlie, School of Mining, Kingston.

Although corundum, in a deposit capable of being economically worked, was discovered in Ontario some twenty-four years ago, the mineral remained unidentified till the year 1896, when its occurrence in the Township of Carlow, Hastings County, was proven.

During the ensuing two years the corundum-bearing rocks of this district were accurately traced, and conditions of occurrence discovered. The prevailing country rock is gneiss, composed chiefly of hornblende, biotite and felspar, which is cut through by dykes and masses of felspar and mica and in some cases nepheline syenite; these dykes and masses carrying corundum as well as small quantities of magnetite, pyrite, garnet, etc.

The largest deposit of corundum yet discovered in Ontario, and the only deposit which has as yet been economically worked, occurs on the Robillard property, Raglan Township, Renfrew County. In this instance the occurrence is on the southern face of a high hill, at whose base lies a marsh, into which empties a stream running along the western base of the hill. The corundum occurs in a broad dyke of almost pure alkali felspar outcropping at intervals on the face of the hill, which is thickly covered with underbrush. The corundum itself is in the form of hexagonal crystals usually barrel shaped, scattered through the felspar, the crystals varying in size from half an inch to five or six inches in length, and varying widely in color although usually of a brownish and greenish shade. The crystals occur in varying profusion throughout the felspar, being thickly concentrated in one place while a few feet away the felspar will be practically barren; this concentration of the corundum in the felspar apparently follows no definite law. The property was secured by the Canada Corundum Company in 1900, and during the year work was begun in developing the deposit and in constructing an experimental plant for the concentration of the ore and preparation of the raw corundum for market. Since then the process has been gradually improved, and from personal experience in this plant, I shall endeavor to first give a description of the mining of the ore and method of concentration as at present practised, and then discuss the methods in use.

Regarding the mining little need be said, as the operations are exceedingly simple. As yet no sinking or tunnelling has been done either on this or on any other Ontario corundum deposit, a fact which is to be regretted, and the winning of the ore merely consists in stripping the dyke, drilling being done by hand and dynamite being used in blasting. The ore is roughly sorted at the mine and waste rock discarded; the picked ore carrying probably an average of 10 to 15 per cent. corundum, being transported by wagon to the mill, situated three-quarters of a mile away on the creek before mentioned. This method of minirg will probably be improved by the installation of a steam breaker plant at the mine and the use of power drills.

The concentrating proposition presented by the ore is the separation of the aluminum oxide with a sp. qr. of about 3.9 from the felspar gangue with sp. qr. of about 2.4 to 2.5 and the elimination of such impurities as magnetite and pyrite as well as mica. Previous to this time the only attempt at concentrating corundum had been made on the North Carolina and Georgia deposits. In the case of the North Carolina deposits the corundum occurred either loose in chlorite and vermiculite scales or enclosed in a gangue of felspar, margarite, etc., or as a constituent of a solid rock. Where the gangue was sufficiently soft it was merely washed in sluice boxes, through which flowed a strong stream of water, carrying away the lighter gangue; where the ore was not adapted to this method it was crushed in breakers and rolls, then stirred in boxes with a strong current of water, thus removing part of the gangue, and was then passed through a machine in which a coarse worm, like a screw conveyor, revolved on a shaft. Most of the gangue was thus cut away by the friction of the corundum grains on each other and was washed out by a current of water. To finally clean the corundum it was placed in a machine called a "muller," a low tub in which two rolls moved round the circumference on the corundum Iron teeth in front of the rolls kept the ore stirred up and a stream of water carried the light gangue away. The methods used in Georgia were on the same principle, depending on the grinding together of the corundum grains to effect a separation of the gangue and corundum. These methods were not adapted to the Ontario ore owing to the hardness of the gangue and the close connection existing between the felspar and corundum; so that any experience gained in the South was of little value in designing a plant for the treatment of Ontario corundum.

For treatment of the ore at the Ontario mine an old saw mill was remodelled, additions made to it, and concentrating machinery with a capacity of about 25 tons of ore per day was installed. For the operation of crusher and rolls, water power is used, a head of 50 feet being available. The creek is dammed above the mill and the water led through a 14-inch pipe for about 100 yards to a five nozzle water wheel of the Cascade type. The wheel is belted up to shafting and from there power is transmitted to the mill by means of wire cable. The rest of machinery of the plant is run by a 25 h.p. high speed engine.

The ore as it comes from the mine, is dumped into ore bins situated at the crushing floor and from there is fed by hand into a No. 2 Gates Gyratory Crusher, with a rated capacity of 12 tons per hour. This rating is, however, far above its actual accomplishment on account of the tenacity and extreme hardness of the corundum, and also the toughness of the felspar which is finely crystalline and devoid of cleavage lines. In crushing, the corundum and felspar do not part readily, and a clean separation cannot be effected unless crushed to at least 12 mesh.

After crushing to pass through a 1½ inch ring, the ore is elevated to a storage bin and is thence fed to a set of 16 × 24 inch belt-driven Gates rolls, and crushed to ½ inch size. The crushing in these rolls, as well as all subsequent crushing, is done wet. The ore is now elevated to a two-compartment Trommel 1 fitted with 4 mm. and 8 mm. punched steel screens, giving three sizes. (1) The 4 mm product passes to Trommel 2. (2) The 8 mm. product passes to a double-compartment Hartz jig fitted with 7 mm. screens, thus giving both heads and also hutch product; the overflow is run off as tailings, although a considerable amount of corundum is here lost owing to the fact that until more finely crushed, the corundum and felspar do not break cleanly and a large piece of felspar attached to a smaller piece of corundum will escape into the tailings. (3) The oversize from Trommel 1 goes to a double-compartment Hartz jig, whose overflow returns to the rolls. The 4 mm. product from Trommel 1 passes to Trommel 2, which divides it into three sizes. (1) 1.5 mm. product going to a Wilfley concentrating table. (2) 2.5 mm. product going to a double-compartment high speed Gates jig (3) Oversize going to another double-compartment Gates jig with a slightly longer and slower stroke than latter. The overflow from these jigs is run off as tailings. The hutch product and heads from all the jigs go for recrushing to a set of 30 × 6 inch high speed Colorado rolls, and after crushing are elevated to Trommel 3, which divides into three sizes :

(1) 1 mm. product going to Bartlett table.
(2) 1.5 mm. product going to Wilfley table.
(3) Oversize returning to rolls.

On the Bartlett table a fairly clean corundum-magnetite concentrate is got on the two top shelves ; the product from third shelf passes to a Wilfley table which also receives the 1½ mm. product from Trommel 3, and on this table also a concentrate of probably 85 per cent. is recovered. The capacity of one of these tables on corundum ore is about 12 tons per day, but of course depends on regularity of feed, and manipulation. The concentrates from the Bartlett and Wilfley tables are placed on a steam drier, heated by exhaust steam from engine and thoroughly dried, then elevated and passed through an electro-magnet. This first passage through the magnet removes practically all the magnetite from sizes coarser than 24 mesh, but the percentage remaining in finer sizes increases directly as mesh increases in fineness.

The dried corundum is now ready for sizing, and is elevated and run onto "splitters," long horizontal frames, fitted with screens and given a reciprocating motion by means of an eccentric. These splitters "split" the corundum into the primary sizes, 90 mesh and finer, 80 mesh, 30 mesh, coarser than 30. Each of these sizes, with the exception of 80 mesh, goes to a separate "grader" working on same principle as "splitter," and there the corundum is graded into sizes 12, 14, 16, 20, 24, 30, 36, 46, 54, 60, 70, 80, 90, 100, 120, 150, 174, 200 mesh. Approximately 50 per cent. of the product is in sizes 12 to 24, 45 per cent. is in sizes 30 to 80 mesh, and 5 per cent. in fines.

In order to get a sufficiently clean product for shipment it is necessary that the sizes from 24 up to 200 mesh be "rewashed" to remove the remaining felspar. Each size is washed separately on a Wilfley table used for this purpose alone, and corundum practically perfectly free from felspar is thus secured; whereas, without sizing, such a result was found to be impossible with this ore. After this rewashing the corundum is dried and again run through the magnet to remove any remaining magnetite. It is then sized again as before and put in 200 lb. sacks ready for market. The sizes from 12 to 24 are entirely freed from felspar and magnetite by one operation, so require no rewashing. Of the other impurities in the ore, the mica causes no trouble and is easily removed on the jigs, while the pyrite, which, however, is almost negligible, remains in the finished product.

To discuss the methods of corundum concentration: The crushing machinery, of whatever kind, necessary for corundum ore, should in the first place be of the very best owing to the extreme hardness of the corundum itself; which, in fact, is only exceeded in this respect by the diamond; and to the felspar also, which, although not as hard as a quartz gangue would be, is more tough. Repairs to crushing machinery used on this ore is a very important item of expense, so that an ordinary jaw breaker of the Blake type would be more profitable than a gyratory of the same rated capacity, owing to the ease, rapidity and low cost of repairs of the former compared with the latter.

Regarding the rolls also, the best are necessary. Manganese steel shells are here used on the roughing rolls, the life of a set being limited to about two months, as it is impossible to prevent uneven wear of the shell face and the forming of flanges on the edges. The shells, however, can be turned down in a lathe and again used. For recrushing the jig products high speed rolls are best adapted, as the object is to produce as small a proportion of slimes and fines as possible. The high speed roll does this admirably, as it is possible for the ore, when once crushed fine enough, to drop away from the coarser, thus escaping the further crushing which results where "free crushing" conditions do not prevail. The Colorado high speed rolls used here are especially adapted for this hard work, owing to the side adjustment by which the free roll can be shifted laterally to effect the even wear of the shell face. Centrifugal rolls, driven by a single belt at a speed of 800 revolutions, were tried here for recrushing concentrates, but owing to the rapid wearing out of the shells, and the wearing out of the bearings from the jar caused by the crushing of such hard material, they were found entirely inadequate for the work.

Regarding the trommels it will be noted that all the material from the roughing rolls passes first over a 4 mm. screen; this of course causes excessive wear on such a screen, and a better arrangement would be a a set of short trommels each fitted with one size of screen and placed in a series beginning with the coarsest and ending with the finest, but the method in use is best suited to this mill as the fall required is not so great.

Hydraulic classification is not employed here and as a result slimes, formed by crushing, escape into the tails from the jigs and tables. Owing to the character of the ore, however, by the proper arrangement of the feed to the rolls, the production of fines can be reduced to a minimum. To save the slimes hydraulic classification would have to be resorted to, with subsequent treatment of the overflow in settling boxes and some form of slime table. Although practically all the product passes over jigs before going to the concentrating tables, it will be noted that no final product is obtained and that both concentrates from the jig bed, and also hutch product from all the jigs, go finally to the concentrating tables. This seems to be open to criticism. From experience with both Bartlett and Wilfley tables on corundum ore I think that they will take 1 mm. and 1.5 mm. material direct from the trommels without previous classification or jigging, and give a fair concentrate. This would necessitate another table for a plant of this size and another set of recrushing rolls, but the expense of jigging would be removed, and loss of corundum in jig tailings obviated. As the jigs are at present run it is necessary in order to prevent loss in tailings, to keep the bed on the second compartment very low and, as a result, felspar gets into the hutch. Of course without the use of jigs, so clean a concentrate might not be obtained on the tables; but when this concentrate is sized and rewashed on Wilfley, as is necessary in any case, no trouble should be found in getting a pure corundum product. The increased crushing necessary, where jigs were not used, would result in an increase of corundum fines, but this increase would be unimportant, as the corundum does not readily form fines.

I have already mentioned the necessity for careful sizing of the table concentrates, and then final concentration of each size separately on a Wilfley table, in order to secure pure corundum; this was proved by experience In experimenting, the "30 to 80" mesh material, as it came from the "splitters," was run together over a Wilfley table, but practically no further coucentration took place; however, when this was sized on the "graders" into the intermediate sizes 30, 36, 46, 54, 60, 70, 80 mesh and each size run over the concentrator alone a perfect corundum product was obtained.

A machine which may yet have a very important bearing on the economical concentration of corundum, is the Hooper Pneumatic Concentrator, one of which is in operation at this plant, being used only for reconcentrating the sized material. As its name implies, no water is used, the concentrating being effected by air blast. This is a great advantage in the work for which it is used here, *i.e.*, reconcentrating the sized product, as it saves the redrying and resizing necessary where the Wilfley is used; and it also gives a magnetite and pyrite concentrate, thus affording an opportunity for removal of the latter impurity. It has also the added advantage of slightly greater speed than is possible on Wilfley, but it has the disadvantage that it cannot treat a finer size of corundum than 100 mesh nor coarser than 24 mesh A change in design may, however, obviate this difficulty. If this concentrator were used for general work, the crushing would be done dry and the ore carefully sized, as the machine will not work on damp, unsized material.

It might be added that, in the case of corundum occurring in "nepheline" syenite, as is very frequently the case in Ontario, the difficulty in getting a pure product might not be so great, as the corundum breaks very freely from the gangue.

The Production of Copper in the Boundary District, B.C.

By DR. ALBERT R. LEDOUX, New York.

While the general public receives its impression of mining as an industry from reports of rich strikes and phenomenal yields, it is probably safe to assert that the industry itself depends upon the low grade mines. As a rule the rich veins are narrow and uncertain, and railroads looking to permanent returns hesitate to build into a region of "one man" fissures or rich pocket deposits, but hesitate less to invest large sums for construction in districts where large ore bodies promise some degree of permanence from their size alone, even if low in assay.

It may be stated in the outset that so far as my observation goes the mines of the Boundary Creek District belong to the latter class. The ores are very low grade, but the ore bodies large, if irregular. Nature has compensated to a great extent for the grade of the copper ore by making it self-fluxing, so that probably nowhere on this continent can smelting be carried on more cheaply, given fair railroad rates and fuel at a reasonable cost.

It is also nothing but simple justice to say that Boundary is today a producing district *because* of the railroads; that it is doubtful if there is a mine within its borders that would pay except at very favorable freight rates and reasonable coke charges. It certainly required considerable courage and considerable faith to build the Columbia and Western Railroad, and no one making the trip from the Columbia River to Phoenix can fail to realise at what expense such excellent railroad facilities were supplied to the various camps. But it is not enough for railroads to build into a district such as this; they must be prepared to handle its product at a minimum cost and to bring in the timber, machinery, supplies and fuel at the very lowest rates that will pay, if the prosperity of the country is to be established and maintained. There is little or nothing in the way of traffic to be gotten out of the Boundary District, excepting that produced by or relating to the mines.

I ought to say in the outset that my personal observation of the Boundary District has been limited, but from many assays and analyses of its ores ; from having handled its entire copper product since it became productive, and from the reports of mining engineers who have carefully examined for me several of the camps other than Phoenix, I feel confident that I know pretty well the characteristics of the Boundary mines and of their ores, and know what may be reasonably expected of some of them, and what has been their record.

Geology.—It is not my purpose to go into the complicated geology of the Boundary District. This has been studied with the usual painstaking accuracy of your Geological Survey, and I understand that the results are soon to be made public.

From such personal observations as I made it is plain that the district is one of great disturbance; that within very small areas almost every variety of later and earlier igneous rock can be found, with the faulting, crushing, folding and metamorphosis due to these. This is nowhere more apparent than at Phoenix.

I may venture to generalize with the assertion that the ores of Phoenix Camp are almost exclusively altered limestone. On the north side of the ravine which divides the town the limestone cap is in place, massive and unaltered save by the pressure which has crystallized it, the outcrops of ore being largely at contacts between intrusive eruptive rocks and the body of the limestone. This is notably true of the outcrop at the Brooklyn Mine, where the uplifting of the limestone by the intrusive igneous rock is very marked and along the vertical crushing zone there has been a second flow of pasty porphory, forming in the most interesting manner a brechia containing sharp, angular pieces of unaltered limestone and of the older porphory. I may say here that in using the term "porphory" I generalise, not having attempted to distinguish the varieties of eruptive rocks, extending vertically or horizontally between the granites and limestones, or filling fissures in the granite itself. These igneous rocks have doubtless received careful classification at the hands of the Survey. In the mines on the north side I am informed that the ore bodies exist in irregular masses of great size in unaltered lime, largely resembling caves which have been refilled with the ore-bearing material. The average ore of the best developed mine, showing nearly 500,000 tons in sight, is said to contain 38 per cent. of silica, 16 per cent. of oxide of iron, 15 per cent.

of lime, and about $4\frac{1}{2}$ per cent. of sulphur, copper 1.80 per cent, besides gold and silver.

In all of these claims on the north side of the ravine the ore is frequently cut off unexpectedly by vertical dykes or horizontal floors of porphory in a way which would be the despair of those whose duty it is to develop the property, were it not for the great size of the bodies when found. On the south side of the gulch of Phoenix I venture to affirm that the mountain was originally divided by a strong dike of fine grained felsite, which crops out boldly in the railroad cut where it crosses the Victoria claim, and is traceable for 4000 feet to the south, crossing the Aetna and disappearing on the War Eagle. This dike has not been cross-fissured by any subsequent geologic action, so far as can be observed by its appearance on the surface and at depths attained at present or by the result of exploration with the diamond drill which has penetrated it for several hundred feet at various depths and in different directions from the westerly side. It seems to me probable that on both sides of this main dike, which forms a sort of wall, and for a thousand feet or more to the east and to the west, the limestones originally overlying the granite, shattered by innumerable disturbances and cross-fissured by secondary intrusions, have been more or less mineralized and entirely altered by the solutions following up the main igneous dike and spreading, until nowhere that I could observe was the limestone left unaltered, so practically all of the original limestone that was not eroded has been mineralized to greater or less extent. There is everywhere a notable quantity of calcite, a secondary redeposit of the lime.

To the east of the dike which divided the Phoenix Hill the same general characteristics are noted which I have outlined above, being observed on the Gold Drop and Snow Shoe Claims, and on the Monarch, except that on the Knob Hill, Ironsides and other westerly claims there is a large, altered, oxidized zone, in which the copper is carried by magnetic iron oxide, while on the easterly side the iron cap is not so extensive.

The Ore.—I have already stated that the ore of the mines on the north side of the gulch of Phoenix is said to contain on an average 38 per cent. of silica, 16 per cent. of oxide of iron, 15 per cent. of lime and 4½ per cent. of sulphur, there being little change between the surface and lower ores so far as the chief constituents are concerned. This is about the composition of the lower ore from the south side, although many other conditions are distinctly different. Here the upper ores are largely oxidized and, as stated, consist of massive magnetic iron ore carrying copper sulphide and gold ; this surface ore changing at an average depth of perhaps 25 feet to ore more nearly resembling that of the Brooklyn, the iron being largely combined with sulphur, or as sesquioxide, rather than in the higher oxidized form. By mixing these surface ores with those from lower levels an ideal mixture is obtained, enabling the furnaces to produce a 45 to 50 per cent. copper matte, carrying practically all of the gold and silver which the ore contains.

I have said something about the characteristics of these ore deposits at or near Phoenix, but nothing concerning the quantity of ore which may be depended upon. Of course "available" ore depends on cost of treatment and price of its valuable constituents. With adequate railroad freights and fair charges for coke it is probable that there are reasonably in sight in the Phoenix Camp today several million tons of ore, which with copper at 12½c per pound can be treated successfully. In Deadwood Camp the ore deposits are also enormous, averaging over 130 feet wide, and so situated that surface working can be prosecuted by quarry, a single drill dislodging a train-load of ore in a day. The tonnage that can be extracted from the mother lode is also up in the high figures, and cheap smelting a welcome fact. But the problem of mining the lower levels of all these mines without excessive cost of timber or the permanent abandonment of one-half or one-third of the ore, necessarily left in pillars, must be causing serious thought.

There have been numerous published guesses as to the grade of these Boundary Creek Ores, and this after all is the vital point from which all the others depend. On the north side of the Phoenix ravine the large amount of ore developed is estimated to run about 1.80 per cent. copper, $2.40 per ton in gold, and 25c per ton in silver. The workable ores from the south side of the Phoenix ravine contain on an average copper 1.70 per cent. gold $1.60 and silver 33 cents per ton. The ore from the easterly side of the main dike, dividing the Phoenix

Camp, as represented by the Snow Shoe, Gold Drop, etc., probably runs by the carload as shipped about 1.60 per cent of copper, $1.50 in gold and 30 cents in silver. The run of the mines in the Greenwood Camp, as shown by the smelter returns, is probably 1.60 per cent. of copper, $1.80 in gold, and 50 cents in silver.

I may say that I have had unusual opportunities for ascertaining what are the facts. In arriving at these figures I have not been obliged to depend on statements of managers. The entire product of the Granby Consolidated Mining, Smelting and Power Company and of the Briti-h Columbia Copper Company passed through the hands of my firm, Ledoux and Company, and from the freight records it is readily ascertainable from how many tons of ore came the matte and blister copper which we have handled. The statements given me of ore mined tally with those of the railroad company representing ore delivered to the smelters, and the statements of the superintendent as to the grade of this ore tally closely with those figured from the copper matte handled by us in New York, checked again by my personal investigations on the spot.

I was accorded every facility in several cases both for ascertaining the ore in sight and the relative assays of the product from different claims. The Granby Company, especially, has kept complete records of all shipments from each claim, not only because this was a proper business policy, but because prior to the recent consolidation of the various interests now included in the Granby Company the Knob Hill, Ironsides, Victoria, and other claims were owned by separate corporations, so that it was necessary to render separate statements of the ore shipped from each claim. It may, therefore, be taken as a safe estimate that the very large amount of ore available in the Boundary District will vary from 25 pounds to 35 pounds of copper per ton of 2000 lbs., with from 25c to 40c of silver per ton, and from $1.50 to $2.50 per ton in gold. It may be stated that there are some mines, like the "B.C." near Eholt, whose ores as shipped contain considerably more copper than the above, but the figures I have given are well within the limits for the average.

Costs.—Next to the quantity and grade of ore, the all-important question is how cheaply can the values from these Boundary ores be extracted and marketed.

I may say that one of the objects of my last visit was to enable me to assure prospective buyers of the product of the smelters that they could safely depend upon the tonnage contracted for, and need not fear a sudden stoppage from lack of ore. There had been various rumors prevalent in New York, such as that only the surface ores were being mined: that these surface ores were richer than those lower down: that when depth was attained costs of mining would prohibit shipments: that the costs of mining were necessarily excessive considering the grade, because the ore was sorted by hand: that only surface ores were self-fluxing, etc., etc.

It is easy to disprove the statement that only surface ores have been treated, because the records at the smelters show from what portion of the working, as well as from what particular claims, shipments were made. For instance, take the Knob Hill Mine as an example. During the year 1901 there were mined:

From the surface	6	per cent.
" " 200 ft. level	57	"
" " 250 ft "	19	"
" " 300 ft. "	18	"
	100	"

Taking the Ironsides and Knob Hill together for the years 1900 and 1901, the figures show that 74 per cent. was from below ground and 26 per cent. from surface ore, varying with the time of year. In the summer time a great deal more ore was taken from surface workings than from beneath; in the winter time surface mining was largely interrupted. The cost of mining these large ore-bodies in the Boundary has varied from $1.66 per ton to $2.10 per ton, the first mentioned figure being the more recent. It is a difficult problem, as I have already hinted, and the one uncertain element in the prosperity of this district, how to handle the very large ore-bodies without the risk of caving and ruining the mine, on the one hand, or the necessary employment of excessive amounts of timbering, or leaving in the mine large blocks of pay ore as a support. The management of the companies have been studying the problem and the Granby Company have commenced ore-handling with steam shovels, and propose to still further decrease the cost of mining by stripping from the surface down to the present level of the railroad track, and by the introduction of the caving system for lower workings.

Smelting Costs.—It has been seen that cost of mining in the district, even with high wages to miners, is very low, the conditions being most favorable. I come now to the all-important statement of these smelting costs.

The Boundary ore being self-fluxing, indeed rather basic in character, allows the admixture of a certain quantity of silicious ores from the Republic Camp or other districts whose ores carry gold and silver, and the sulphur being low permits of smelting without preliminary roasting. With the advent of railways from the south the Boundary smelters can procure more dry silicious ores at profitable rates. It may also be stated at this point that the freedom of the ores from bismuth, arsenic and antimony renders it easy to obtain a ready market for the copper product.

In considering the cost of smelting it is also necessary to take into account the losses in slag and otherwise. I was allowed to sample the slag dumps and to take portions of weekly slag samples which had been preserved in the laboratory. Before the establishment of bessemerizing the slag loss of the Boundary smelters averaged copper 0.46 per cent, gold 12 cents per ton, and silver 3 cents per ton. With a consumption of about 11 per cent. of coke, and with freight charges as they exist today the cost of smelting at the most favorable location in the Boundary District, after charging against the smelter the costs of marketing the product, must be considerably under $2.00 per ton. Adding the present cost of mining, the total outlay for mining and smelting must be less than $3.66 per ton.

With the introduction of caving and steam shovels at mines, and of bessemerizing at smelters; with further reductions in cost of freight and fuel, sure to come with or without the advent of competing railways, I unhesitatingly affirm that the copper ores of Boundary should be mined, smelted and their contents marketed with profit with copper at 12 cents in New York, and as railway extensions make other ores available that can be purchased cheaply, the profit should increase. But there must always be, as elsewhere, many shipping mines too small to justify their own individual smelters, and mutual co-operation and a broad business policy should allow them all to prosper.

On the Use of Wood Gas in the Manufacture of Iron and Steel.

—

By Dr. James Douglas, New York.

Since suggesting in my paper, which appeared in the *Transactions* of 1899, the utilization of the waste wood of Canadian Lumber Mills for the reduction of iron ores and the making of high grade steel, I have been experimenting on the gasification of wood for gas engine purposes. The object I had in view was to make a fixed gas immediately in the generator, and avoid the complication and waste which result from gathering the volatile products of combustion in any form of condenser. We have obtained this object by using the Loomis-Pettibone Generator and apparatus, but modifying their method of working. The essential feature of the Loomis process is that the air and steam are drawn by an exhauster downward, and therefore the volatile products given off on the surface of the charge, in passing through the incandescent lower layer of fuel, are converted into fixed gases. When the apparatus is used for making water-gas from coal, the operation, as described in the pamphlet of the Loomis-Pettibone Co., is as follows:

"In starting fires in the generators, a layer of coke or coal, about five feet in depth, is put in, and ignited at the top, the exhauster creating a downward draught. When this body of fuel is ignited, coal is frequently charged, raising the fuel-bed to about eight feet above the grates, and there maintained. Bituminous coal is generally used, and is charged at intervals as needed through the feed-door in the top of the generator.

"Air is also admitted through the same doors, and, by means of the exhauster, is drawn down through the fresh charge of coal, and then through the hot fuel-bed beneath. The resultant producer, or generator-gas, is drawn down through the grates and ash-pits of generators 1 and 2, values A and B, up through the vertical boiler 3, valve C, to scrubber and exhauster, valve D being closed, and is delivered into a small gas-holder for supply to the furnaces. When the exhauster has brought the fuel up to incandescence, the charging-doors E and F are closed, valve

B lowered, valve C closed, and valve D, leading to the water-gas holder, opened. Steam is then turned on into the ash-pit of generator 2, and, in passing through the incandescent coal, is decomposed, forming water-gas. From generator 2 the gasses pas through the connecting pipe shown near the top of the generators, and down through machine No. 1. The gas passes through valve A into and up through the boiler 3, and thence, after being washed in a scrubber, is conducted into a holder. Water-gas is made for five minutes, when the temperature of the fuel-beds having been considerably reduced, the steam is shut off, valve D closed, valves B and C opened, and the charging-doors E and F opened.

"This process of making water and producer gas is alternated at intervals of about five minutes.

"In making the next run of water-gas, the course of the steam is reversed, *i.e.*, valve A is closed, and the steam is turned into the ash-pit of generater No. 1. Valve B is left open, but the other valves, C and D, and the Charging doors, E and F, are operated the same as in the first case.

"While the fires are being blasted, and during the making of a run of water-gas, the hot gases in passing through the boiler give up a large proportion of their sensible heat, which is converted into steam. This in turn is directed under the fires in the generators for decomposition. Another advantage of the double-generator apparatus is that, as all gas is made to pass through the fire, the tarry matter from the coal is converted into fixed gases that can be conducted any distance through ordinary pipe, and at any temperature or pressure. Again, as the steam is forced through two fires, the percentage of condensable water-vapour is exceedingly small."

The process above described is modified at the Nacozari works with a view of making a uniform gas of calorific power, higher than producer-gas and lower than water-gas out of wood. This is effected by introducing very little steam with the air, and drawing the steam and air almost continuously downward through the incandescent fuel. Every half-hour or so the heat of the burning fuel becomes excessive, the feed port is closed, and steam alone in a larger volume is drawn through the layer of fuel In two or three minutes the temperature is sufficiently reduced to permit of the door being reopened, and of the mixed air and steam being supplied to the charge. The effect of thus drawing the gas, whether water-gas or producer-gas, through a layer of incandescent fuel, is to decompose the tar and all volatile products of combustion so perfectly that little more than a trace escapes to the scrubber, and none reaches the gas-engines, which are situated 400 feet from the gas-holders.

When using wood, a layer of incandescent fuel, coke or charcoal, must be ignited on the grate bars of the generator before the feeding o wood billets commences. The Nacozari generators, having been designed for coal-fuel, are only 6 feet 9 inches internal diameter, and it is found desirable to cut the green wood into lengths of 18 inches, which are fed in the same way as coal through the open port. The feeder, who can see perfectly the surface of the charge, is careful to prevent the formation of cavities, whether the fuel be wood or coal. When using wood, a stack of billets cut into smaller lengths is at hand on the feed-floor for the purpose of correcting irregularities in the surface of the charge. When using wet wood the mixed water and producer-gas is made without the injection of any steam, as the water in the freshly cut wood supplies the necessary steam.

The composition of the mixed gases and their variations from day to day, when made from coal, may be judged of from the following series of analyses taken on consecutive days from the record, two or three minutes being taken to draw off the samples and to make the simultaneous calorimeter readings :—

Gas made from Mixed Anthracite and Soft Coal, Nacozari Gas Plant.

Date			CO	H	CH_4	C_nH_{2n}	CO_2	O	N	B. T. U. at 62° F. and Sea Level
2-27	Mixed Gas	Anthracite	20.80	11.47	2.78	0.10	8.80	0 10	55.95	132.66
3-7	"	"	19.90	13.84	2.30	0.20	8.40	0.00	55.36	134.18
3-12	"	"	20.90	10.40	2.31	0.20	7.30	0.50	58.39	126.4
3-12	"	"	24.40	9.90	1.10	0.10	5.10	0.40	59.00	122.4
3-2	"	Soft Coal	20.30	14.43	2.28	0.20	8.20	0.00	54.59	137.13
3-3	"	"	22.20	11.58	1.74	0.20	7.40	0.20	56.68	128.70
3-4	"	"	18.40	12.42	2.11	0.20	7.80	0.00	59.17	122.82
3-5	"	"	21.60	12.99	2.78	0.20	6.50	0.00	55.93	141.70
3-6	"	"	19.50	13.21	3.01	0.20	7.70	0.00	56.38	136.37

Composition of Wood Gas made by Nacozari Gas Plant, from Eight Consecutive Analyses, is as follows :—

Date			H	C O	$C H_4$	$C n H_2 n$	$C O_2$	O	N	B. T. U. at 62° F. and Sea Level
3-14	Mixed Gas	6.05 p.m.	13.50	11.70	2.30	0.60	16.20	0.00	55.20	113.2
3-14	"	9.35 p.m	18.91	11.00	3.10	0.30	17.90	0.00	48.79	131.5
3-15	"	10.15 a.m.	20.61	14.80	1.67	0.30	14.70	0.00	47.92	134.8
3-15	Water Gas	....	51.38	10.30	2.38	0.80	20.20	0.00	14.94	233.97
3-15	Mixed Gas	4.40 p.m.	22.31	11.80	3.10	0.40	17.20	0.20	45.19	146.55
3-16	"	11.35 a.m	22.35	14.00	2.45	0.20	15.20	0.00	45.80	144.00
3-16	"	3.40 p.m.	22.35	12.50	3.06	0.30	16.40	0.10	45.29	146.9
3-19	"	11.15 a.m.	19.28	15.50	2.31	0.20	14.40	0.40	47.91	137.59
Average of Mixed Gas Analyses			19.90	13.04	2.57	0.33	16.00	0.10	48.00	136.36
			19.28	15.5	2.3	0.20	14.40	0.40	47.91	137.6

Calorimetric Tests on Wood-Gas from Nacozari Gas Plant.

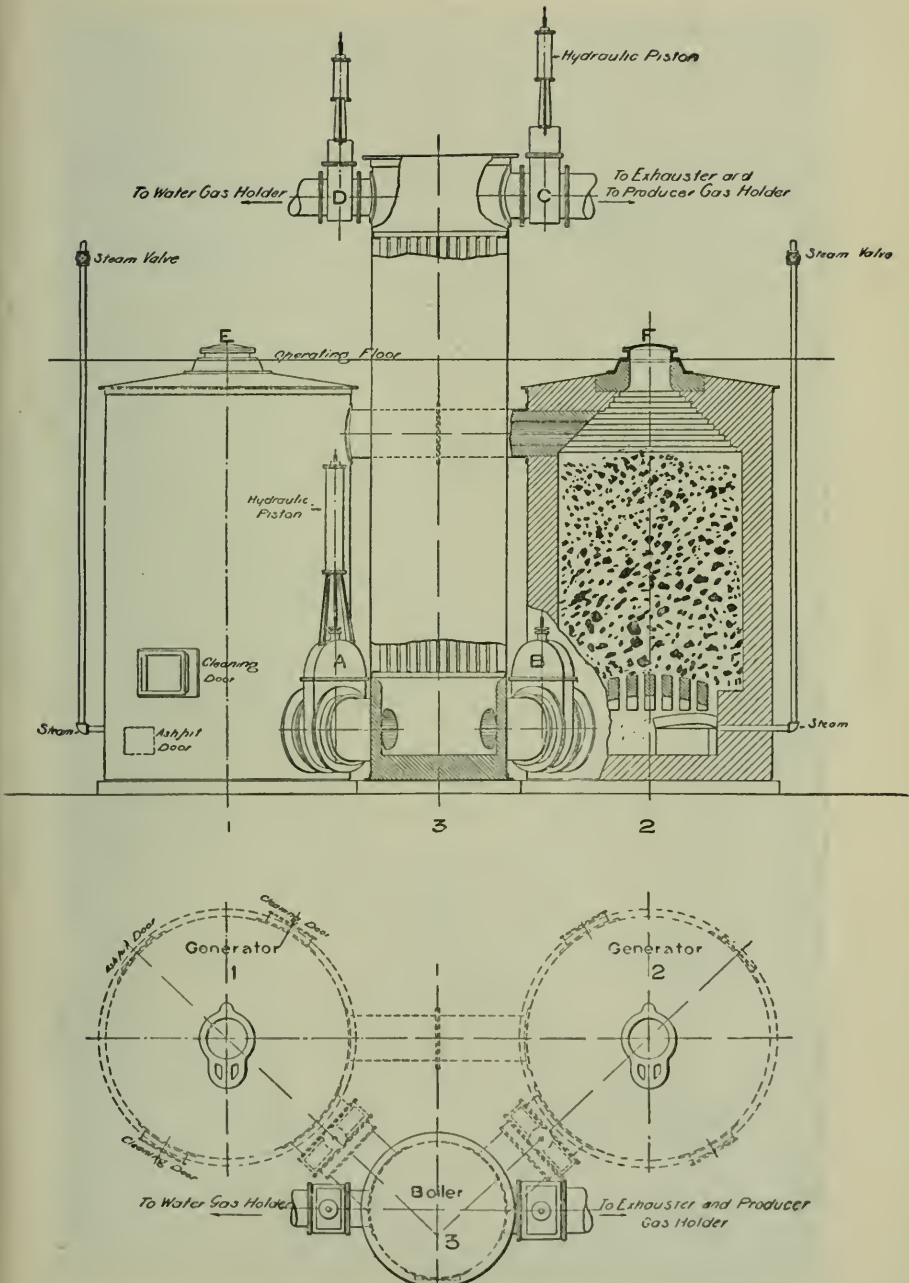
Date		B. T. U. Actual	B. T. U. at 62° F. and Sea Level	Date		B. T. U. Actual	B. T. U. at 62° F. and Sea Level
3-30	Mixed Gas..	108.8	125.8	4-16	Mixed Gas..	120.8	139.9
4-8	" ..	105.2	122.5	4-16	" ..	118.7	138.1
4-8	" ..	112.34	128.77	4-17	" ..	113.4	129.6
4-8	" ..	110.84	128.14	4-17	" ..	112.0	128.9
4-8	" ..	115.72	134.93	4-17	" ..	112.0	129.5
4-9	" ..	112.4	131.7	4-18	" ..	110.7	128.4
4-9	" ..	111.9	128.1	4-24	" ..	116.5	135.7
4-9	" ..	109.4	126.9	4-30	" ..	115.4	134.2
4-9	" ..	112.2	130.61	4-30	" ..	119.9	140.6
4-10	" ..	113.2	129.1	4-30	" ..	123.9	146.5
4-10	" ..	113.7	130.1	5-8	" ..	104.8	122.4
4-10	" ..	122.9	141.6	5-8	" ..	114.7	136.4
4-11	" ..	108.58	126 86	5-8	" ..	118.3	140.7
4 15	" ..	109.7	128.1	5-9	" ..	115.8	134.8
4-16	" ..	111.8	128 85	5-9	" ..	118.8	139.2

The efficiency of the mixed gases, whether made from wood or coal is substantially the same in the gas-engines. The engines are direct belted to generators, which give continuously, with wood or coal-gas, 48 kilowatts per generator, equal to 70 B.H.P. per engine. The capacity of the engines is reduced, due to the works being at an elevation of 3,500 feet above the level of the sea. A gas as high in hydrogen as the wood-gas would give much trouble from back-firing in the engine. No inconvenience, however, is experienced on that score, which is probably due to the retarding influence of the high percentage of carbonic acid.

I have no doubt whatever that this apparatus and process would be admirably applicable to the conversion of the coarser waste from saw mills; but in using sawdust the grate bars would, as in the Swedish sawdust producer, have to be dispensed with, and in their place probably a deep layer of coke supplied. The combustion of this coke would be slow, and therefore it would need to be replaced only every three or four days, when the accumulation of wood ash would necessitate cleaning out one generator and lighting another. It would probably be most advantageous to use a mixture of sawdust and the coarser waste.

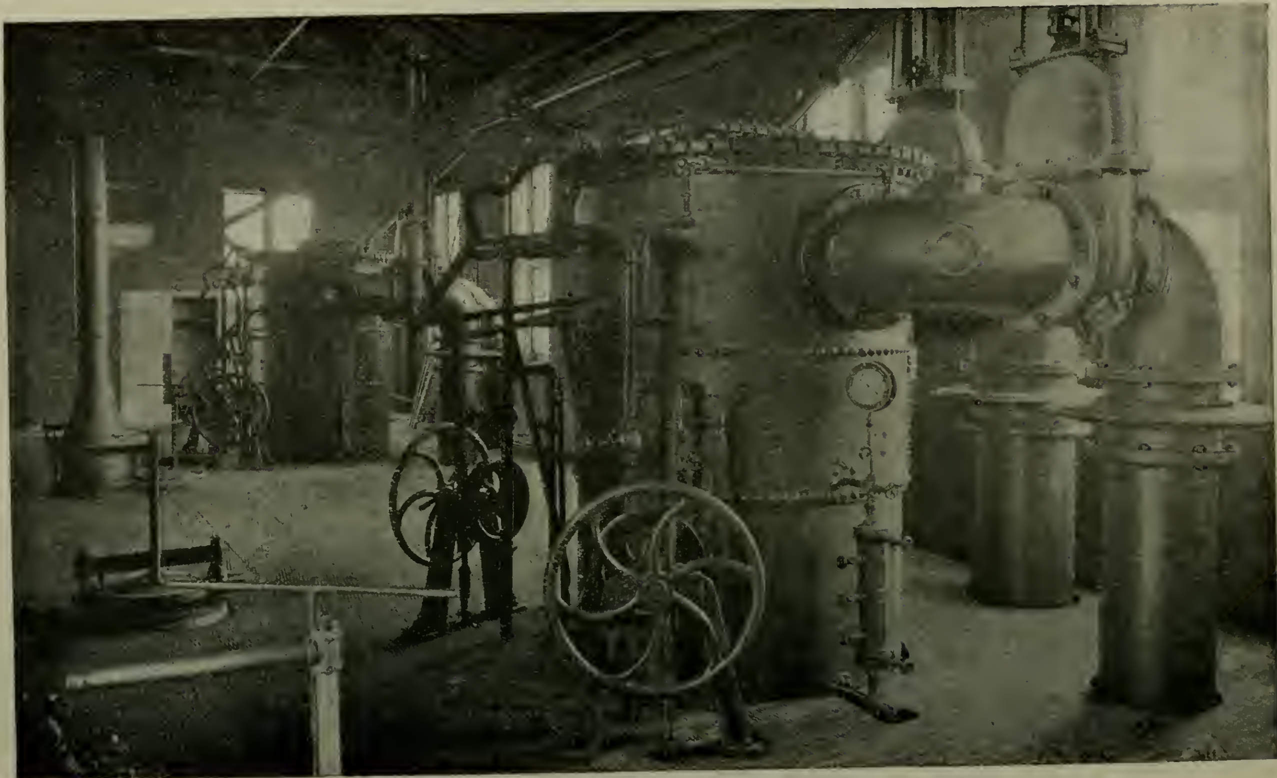
The wood used at Nacozari is a green scrub oak, which, however, remains stacked in the yard for six weeks or two months before being burnt. The very green wood does not give a gas of as high calorific composition as wood thus partially dried; and therefore the probability is that sawmill waste would have to be stacked for a time before being gasified. Whether, therefore, the gas be used for steam generation at the mill, or for heating in metallurgical furnaces, or as a source of heat for other purposes, it would seem that the practicability thus afforded of turning the large quantity of waste, which is annually disposed of at considerable loss, into fixed gas, capable of being used at a distance from the mills, should excite some interest among our lumbermen. At Nacozari the quantity of wood-ash, as made, is large enough to warrant us in recovering from them the potash salts, and the same would be true at any mills which might adopt this method of disposing of their waste.

PLATE I.



Showing Pair of Generators and Boilers.

PLATE II.

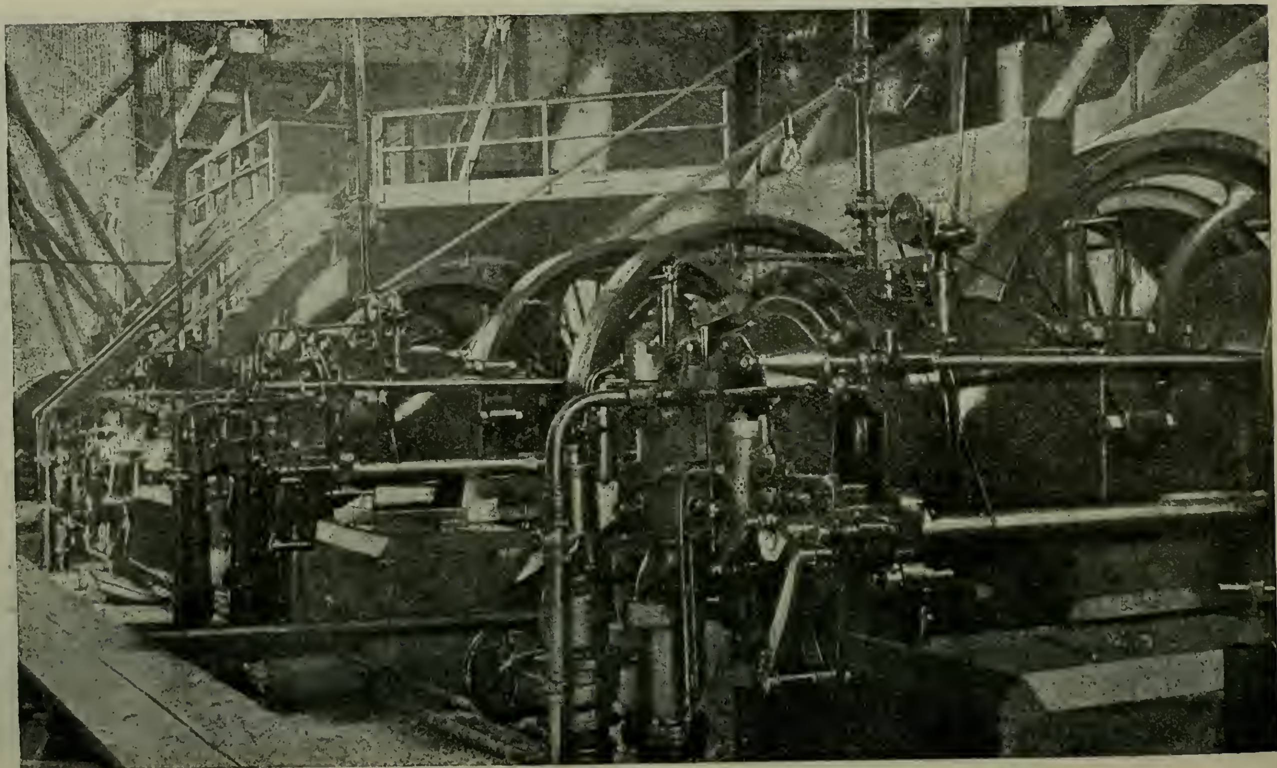


Operating Floor—Winchester Repeating Arms Co.

PLATE III.

Concentrating Mill, Morenci, Arizona—Power furnished by three 80 H.P. Gas Engines.

PLATE IV.



The Concentrating Mill is operated by three 80 H.P. Gas Engines, placed in the center of the mill, belted to clutch pulley on countershaft. Two engines are required to drive the mill, one for each side. The third engine is for reserve, thus insuring continuous operation.

PLATE V.

Detroit Copper Mining Company, Morenci, Arizona.—The Gas plant is located between the Smelting and Concentrating Plant, with gas piped three-quarters of a mile from Smelter and one-quarter of a mile to Concentrating Mill. The Main Power Plant at Smelter consists of two 150 H.P. gas engines, each operating a 120 K.W. alternating Electrical Generator running in parallel. Induction motors are used in this department. The Concentrating Mill is operated by three 80 H.P. Gas Engines. There are a number of small gas engines of different makes about the works.

PLATE VI.

General view of Concentrating and Smelting Plant of the Moctezuma Copper Co., Nacosari, Sonora, Mexico.
All the power is furnished by Loomis Gas Plant with Gas Engines and Electrical Distribution.

Electrolytic Production of Metals, with Special Reference to Copper and Nickel.

By WM. KOEHLER, Cleveland, Ohio.

In considering this subject, we enter a field made attractive by the successful experiments of painstaking, original investigators, but hedged about with patents obtained by persons who seek to appropriate the results of these experiments which they had neither the patience nor the wisdom to make. We shall find that electro-metallurgy is based on facts known to generations earlier than our own, and by their age the common property of every scientist of to-day, and that the principles involved are so much matters of general knowledge that they are not the special properties of any man or association, that all are free to use them, and that any process, by whatever name it is known, is protected by patents only to the extent in which it is a combination of these well known principles with some patentable invention.

Electro-metallurgy, or, in other words, the electro deposition of metals from solutions, as at present practised, is not to be confounded with the production of metals by means of heat generated, and the electrolytic action dependent upon the reduction, in an electric furnace. It is more than that, and is naturally divisible into two branches: first, the electrolytic refining of crude metals, and, second, the direct production of metals from solution.

Before entering directly upon the subject under discussion, it may be well to give a few moments to electrolysis in general. By electrolysis we mean those chemical reactions which take place when a suitable electric current passes through a chemical combination, which is technically termed an electrolyte. In producing electrolysis, conductors of two grades or classes are necessary. Conductors of the first class are wires or sheets of conducting material, such as are used in the mechanical arts, their object being simply the conveying of the electric current from a point of higher to a point of lower potential difference. A conductor of the second class is always a chemical combination, existing either in solution or in a state of fusion. In electrolysis, conductors of the first class work in pairs. The electric current is not complete when a conductor of the first class enters a conductor of the second class, and to complete the circuit another conductor of the first class must also enter the conductor of the second class, usually at a point opposite that at which the first entered. This pair of conductors of the first class, when in contact with the electrolyte or conductor of the second class are known technically as electrodes, and it is virtually at these points of contact that electrolysis manifests itself. The electrodes are distinguished with relation to the direction of the electric current, as the anode and cathode respectively, the current entering the electrolyte at the anode and leaving it at the cathode. On account of the potential difference produced by the electric current at the electrodes, substantially different masses of the electrolyte (directly proportional to the quantity of current passing) are set in motion. These moving masses, composing the electrolyte, are termed ions, and, for further distinction, those moving toward the anode are called anions; those moving toward the cathode, cathions. At the electrodes proper, in an electrolyte, the ions undergo a chemical change, and this change is known as electrolysis.

The results of this change, according to conditions under which electrolysis takes place, can become of a very complex nature. Under primary conditions the results are comparatively simple. For example, the electrolysis of copper sulphate or sodic chloride solution produces in the first case copper, sulphuric anhydride and oxygen, while, in the second case, sodium (or sodium hydroxide and hydrogen,) and chlorine gas are produced according to the following equation :—

$$\begin{array}{lllllll} Cu\,S\,O_4 \text{ gives} & Cu & + & S\,O_4 & & & \\ & S\,O_4 & + & H_2O & = & H_2\,S\,O_4 & + O. \\ Na\,Cl \text{ gives} & Na & + & Cl & & & \\ & Na & + & H_2O & = & Na\,O\,H & + H. \end{array}$$

A given quantity of the electric current passing through different electrolytes will always set free the same number of valences or transfer them into different combinations. This can most readily be shown by allowing the same current to successively pass through different electrolytes. Results are shown in the following table :—

	Electrolyte	Electrodes	Cathions liberated	Compared to 1 milligram Hydrogen	Atomic Weight	Error
1.	Dilute Sulphuric Acid 1 to 12 H_2SO_4	+ Platinum — Platinum	6.002 mg. Hydrogen	1 mg. Hydrogen	Hydrogen 1	
2.	Potassium Silver Cyanide $KAg Cu_2$	+ Silver — Platinum	650 mg. Silver	$\frac{650}{6.002}$ = 108.2 mg. Silver	Silver 107 6	+ 0, 6%
3.	Cuprious Chloride $Cu_2 Cl_2$	+ Copper — Platinum or Carbon	380 mg. Copper	$\frac{380}{6.002}$ = 63.6 mg. Copper	Copper 63 3	+ 0, 4%
4.	Cupric Chloride $Cu Cl_2$	+ Copper Platinum — Carbon	Reduction of 190 mg. Copper	$\frac{190}{6.002}$ = 31.8 mg. Copper	Copper 63.3	+ 0, 4%
5.	Copper Sulphate $Cu SO_4$	+ Copper — Platinum	190 mg. Copper.	$\frac{190}{6.002}$ = 31.8 mg. Copper	Copper 63.3	0, 4%
6.	Stannic Chloride $Sn. Cl_4$	+ Platinum or Tin — Platinum or Carbon	170 mg. Tin.	$\frac{170}{6.002}$ = 28.3 mg. Tin.	Tin 117.8	— 4 %

The figures, representing the quantities of cathions liberated, give when compared to one unit weight of hydrogen, the amount of metal represented by one of their valences, while a single valence represents its atomic weight. In the solutions 2 and 4, the silver and copper atoms monivalent, in 3 and 5 the copper atoms are bivalent, while in 6 the tin atoms are quadrivalent.

From the foregoing it will also be seen that the quantity of cathions or anions liberated are proportional to the strength of the current and the time through which it is acting. According to researches of F. and

W. Kohlrausch, 0.3281 mg. copper are liberated from the solution of an oxide salt of copper by one coulomb.

0,6578 mgs. of Copper from cuprous salt.
0,3050 mgs. of Nickel from nickel oxide solution.
0,2394 mgs. of Sodium from salt solution.
0,3682 mgs. of Chlorine from chloride solution.

This list can easily be extended and the values of all elements calculated. The results are known as the electro chemical equivalents. A coulomb being an ampere second, and knowing the potential difference necessary to overcome polarization and bring about dissociation of an electrolyte, the power necessary to deposit a certain quantity of metal from an electrolyte can easily be calculcated. For example, estimating a horse power at 730 watts, or volt amperes, and figuring the potential difference of an electrolyte at one volt, a horse power will contain 730 available amperes. From the above we have the deposition of 0.3289 mg. copper through one coulomb, which, in one hour would be (0.3289 mg. x 3600 seconds) 1.18 grms. copper per hour. 1.18 x 730 equals 861 grms. per hour per horse power, or 20 kilos, about 44 pounds, per horse power day.

As the subject of this paper is electrolytic production of metals, the methods by which matte and crude metal are obtained can only be briefly discussed, For their production various metallurgical operations are resorted to. The ores are subjected to roasting and smelting operations, thereby increasing the metallic values of the products and eliminating some impurities,. When the metal content is sufficiently high they are subjected to what is known as the Bartlett-Thompson separation smelting, by this means producing crude copper and nickel. The crude metals are then electrolytically deposited in general from sulphate or chloride solutions on pure metallic cathodes. (Process by Titus Ulke.)

In the production of copper and nickel, we will first take up the subject of refining. For this purpose a high grade matte, or, better still, crude metal of about 95 per cent. fineness is necessary. The possibility of refining copper by this means was made known by Cruikshanks' researches, dating back to 1800. Of greater importance to refining in general is the process patented by Elkington in February, 1870. This process is the basis of all refining processes in present use, and the inventor claims the recovery of copper, together with the separation of other metals associated therewith. To this end copper ores undergo smelting operations until crude metal is obtained, which is then cast into plates. With the aid of electric current, these are dissolved in a suitable electrolyte and the copper deposited upon other plates. The precious metals contained in the crude metal fall during electrolysis to the bottom of the electrolytic vats. The inventor prefers working ores which contain sufficient silver to effect the good qualities of a pure copper. The impure, or blister copper, is tapped from the melting furnace into cast iron molds, about 600 mm. long, 200 mm. wide, and 25 mm. thick. In one end of such a plate a large and heavy T shaped headpiece of copper is cast into the same. The object of the T shaped headpiece is to provide means for the suspension of the plate and at the same time secure electrical contact. These plates are then suspended, together with the cathode plate, in earthenware vessels arranged in terrace form. This terracing is to facilitate the circulation of the electrolyte, which is a solution of copper sulphate, containing a small amount of free sulphuric acid. The vessels, or electrolytic baths, are connected with each other by lead pipes. The solution from the lowest vessel flows into a sump, from which it is pumped to the vessel at the head of the system, and is again allowed to circulate through the system. The variations of this process and the manner in which the refining of metals is now carried on, are wholly mechanical, and in no way is the original process changed or new principles introduced, although there are innumerable improvement patents in existence. The pioneers in the work of developing the electrolytic refining of copper are Siemens and Halske, of Berlin, through whose efforts the success of the process has been largely secured.

It may here be noted that the method described in the treatment of copper is applicable to the production of other metals: gold, silver, lead, zinc, nickel, etc. The Wallace Farmer patents, a description of which will be given later, have special application to this extension of the process of all metals, especially to nickel. In fact, the production of fine nickel from crude nickel anodes, using an electrolyte of nickel ammonium sulphate, is at present being carried out on the lines indicated for copper production, and the success attending refining has led to much experimental work on lines tending toward direct production of metals from ores or furnace products. This brings us to the second phase of electrolysis; namely, the direct production of fine metal.

Many experiments were made to solve this problem by using mattes or furnace products directly as anode material in a suitable electrolyte identically as in copper refining. It must be born in mind that, in copper or metal refining it is very necessary for economic working to have a pure anode material. Even then the electrolyte will become so fouled by the accumulation of impurities that it becomes necessary to regenerate it. The question may naturally be asked heie, if impurities accumulate with comparatively pure anode material, what will be the ratio of this accumulation, and what will be the effect in using an anode material containing from 10 to 95 per cent of impurities? Upon the answer to this question hinges the direct economic production of metal through electrolysis. A number of processes tend to answer this question, and we will speak of them in the order of their priority or date. First of these is the Marchese Process, (D.R.P. No. 22429 May 2nd, 1882.) This process was given a thorough trial by the Societa Anomima Italiana of Genoa. This company built a 125 horse-power plant for a practical test, and after spending large sums of money came to the conclusion that the same was a failure. The method of working was as follows:—

1st. The smelting of copper-bearing ores to matte of about 30 per cent copper and 40 per cent. iron was accomplished by well-known methods.

2nd. This matte was cast in plates (800 x 800 x 30 mm.) by means of iron frames or molds, a strip of copper being at the same time cast into the matte to serve as connection. Later this strip of copper was supplemented by a copper wire gauze extending through the whole form. This was done in order to prevent a too rapid disintegration of the anode plate, and also to equalise the distribution of the electric current throughout the whole mass composing the anode.

3rd. The cathodes, thin copper plates (700 x 700 by 0.3 mm.) were suspended by copper strips from wooden rails extending over the bath.

4th. The electrical connection between the anodes and cathodes of a single bath and twelve baths were known as a multiple series. All the cathodes of one bath were connected to one conductor, while all the anodes were connected with the positive conductor. The connection of the first to the second bath, and of the second to the third, and so on throughout the series, were made between the cathodes of the preceding bath and the anodes of the following bath.

5th. The baths were lead lined wooden vats (2000 x 900 x 1000 mm. deep). Twelve of these vats set in terrace form were connected to one machine.

6th. The electrolyte was composed of a solution of copper and iron sulphate, which was obtained by roasting ore and leaching the roasted product with dilute sulphuric acid. The circulation of the electrolyte through the series of baths was accomplished by means of lead pipes connecting the individual baths, the overflow from each entering at the bottom of the succeeding bath. (The diagram giving outline of process is appended).

This process proved a failure from a financial standpoint and was speedily abandoned. The prominent reasons for this failure were the uneven disintegration of the anodes, polarization arising from the encrusting of the anodes with impurities and consequently a very high rise in voltage, and further an accumulation of impurities in the electrolyte.

Nothwithstanding the failure of the Marchese Process, certain experiments carried on in connection therewith developed valuable and interesting facts. The action of the electric currents upon iron salts, during electrolysis, was found to result in the production of ferric sulphate from ferrous sulphate. This fact was made the basis of a patent issued to Body in 1886. Although Body's process and apparatus were not limited to copper alone, but were made the issue or the extraction and recovery by electrolysis of metals in general. This process is in reality the forerunner of what are at present the two principal processes for the recovery of metals from their solution; namely, that of Siemens and Halske, and that of Hoepfner.

Body's electrolytic vat consists of a square box made of Portland cement and covered with an acid and waterproof paint. Parallel to the four sides and some distance therefrom, are four tile plates so joined as to form a second box. The bottom of the outside box is composed of a carbon plate and is connected as an anode to the terminal of an electrical generator. The four tile plates composing the inner box are half the height of the outer box. Within the gap formed by the inner box and the bottom of the outer box, is stretched a felt cloth or some form of a diaphragm. In the space between the two vessels the copper cathodes are suspended. The electrolyte, composed of a solution of a ferric salt in salt or sodium chloride, enters the bottom of the inner vessel. Upon the carbon plate is placed raw ore. The solvent action of the electrolyte, together with the action of the electric current, dissolves the soluble part of the ore. The electrolyte, after filling the inner vessel, overflows into the outer, and here the copper, which it has taken up, is deposited. The electrolyte is drawn off at the bottom of the outer vessel.

According to Body's specifications, as the electrolyte flows through a bath, the following reactions take place:

1st. The metals contained in the ore are brought into solution by the reduction of a ferric sulphate or chloride solution to ferrous sulphate or ferrous chloride.

2nd. The dissolved metals are deposited upon the cathode.

3rd. The nascent chlorine generated at the anode reconverts the ferrous salts into ferric salts, and the excess of chlorine dissolves more metal from the ore lying in contact with, or existing as part of the anode.

Body's process was improved by Siemens and Halske. The improvement consisted in having the reactions between ferric salts and the metal in the ores take place outside of the electrolytic vats, and independent of the electrolysis. Figuratively speaking, they stored up the work at the anodes in the electrolytic baths for immediate use outside of the baths. In their patent specifications they claim the following method of procedure:

Sulphide ores (copper bearing pyrites, etc.) are roasted at a low temperature in such a manner that the iron contained therein is mostly oxydized, while a part of the copper should be present as copper sulphate, another part as oxide, but by far the greater part as sulphide. The roasted ore is then leached with the solution flowing from the electrolytic decomposition vats. When this solution had dissolved as much copper as is possible and all the iron salts have been converted back again into the ferrous condition, the same is then returned to the electrolytic vats for copper extraction and reconversion of the ferrous salts to ferric salts. The solution is then returned to be used for further extractive purposes. This cycle continues until the solution becomes so fouled with impurities that it becomes necessary to purify the same. The chemical processes involved in leaching and electrolysis are represented in the following equations:

1.—$H_2 SO_4 + 2 Cu SO_4 + 4 Fe SO_4 = 2 Cu + 2 Fe_2 (SO_4)_3 + H_2 SO_4$.

2.—$x H_2SO_4 + Cu_2 S + 2 Fe_2 (SO_4)_3 = 2 Cu SO_4 + 4 Fe SO_4 + S + x H_2SO_4$.

3.—$Cu O + H_2 SO_4 = Cu SO_4 + H_2O$.

4.—$3 Cu O + Fe_2 (SO_4)_3 = 3 Cu SO_4 + Fe_2 O_3$.

5.—$Cu O + 2 Fe SO_4 + H_2 O = Cu SO_4 + (Fe_2 O_3 + SO_3) + H_2$.

If we compare reactions 1 and 2, we will immediately see that, provided all the copper in the ore exists as copper sulphide (Cu_2S), the solution after lixiviation contains exactly as much copper sulphate, iron sulphate, and sulphuric acid (reaction No. 2) as the solution before electrolysis has taken place (reaction No. 1). In other words, the electrolyte is completely regenerated, and can be used as such.

From reactions 3, 4, and 5 it will be seen that if the ore contains copper oxide, the solution will contain more copper, less iron, and less sulphuric acid.

It is hardly necessary to state that copper matte may be used instead of roasted ore. In this case, more iron will be brought into solution, and it becomes a difficult technical proposition to obtain solutions of the identical chemical composition. It may here be noted that in the electrolysis of the above solution, provided a good and rapid circulation exists, hardly any polarization is found to take place, and the potential difference of a bath remains constant at about 0.7 volts for the same current density, as when refining with matte or soluble anodes requiring about 1.5 volts for the decomposition of the anodes and the deposition of copper.

The electrolytic bath used by Siemens and Halske consisted of a shallow wooden vat, containing a false bottom. Upon this bottom is placed the anode, which is in turn connected with the terminal of the dynamo through an insulated cable. The anode is composed of gas retort or artificial carbon, either in plates, rods, or broken pieces. If the broken pieces are used, they receive a bedding composed of perforated lead plates. On, and covering the anode is placed a diaphragm or filter composed of felt or some other suitable substance. The space voer the filter or diaphragm, known as the cathode chamber, contains the cathode in the form of a revolving cylinder, being a cylinder of wood covered with a thin sheet of pure metallic copper, which in turn, through brushes and the like, is connected to the other machine terminal. The cathode cylinder can be revolved slowly by means of suitable gearing or power transmission. The copper containing electrolyte flows into the cathode chambers in such quantities that the cathode cylinders are at all times covered by it. By rotation of these cathodes, the cathode solution is kept in constant motion or circulation. The electrolyte passes through the filter or diaphragm and fills the anode chamber, whence it is drawn off from this space formed through the false bottom. The inflow is kept constant with the outflow, thereby securing perfect circulation. The electric current enters the bath through the anodes and leaves it through the cathodes. At the cathodes the electrolyte gives up about two-thirds of its copper contents, while at the anode an equivalent quantity of sulphuric acid (SO_3+O) is liberated. The electrolyte, partially freed from its copper, flows through the filter into the anode chamber, where the ferrous sulphate, formed in the leaching of the ore, is reconverted in ferric sulphate by the sulphurous anhydride liberated at the anode. The ferric sulphate solution, on account of its higher specific gravity, sinks to the bottom of the vat and is there withdrawn, to be again used for leaching purposes. The potential difference of a bath is claimed to be

0.7 volts at 16 amperes per square meter of cathode surface. Within the last four or five years, extensive mechanical improvements have been made in conjunction with this process.

With the above process it is possible to bring into solution copper and nickel bearing materials on identically the same line as copper alone, enabling to produce copper and nickel from ores and furnace products (mattes, etc), containing both. Since copper is deposited at a different potential difference from that required to deposit nickel, it becomes possible to separate the copper from the nickel contained in the electrolyte, producing thereby a solution of nickel, iron sulphate, from which nickel can be separated either as a salt by displacement, or produced electrically in the metallic condition. It has been found that copper chloride acts similarly to ferric sulphate or chloride, in many chemical reactions—it undergoing oxidation and reduction, and a change of valence very similar to that observed in iron salts. This property of copper salts was introduced as an improvement over the Siemens and Halske process, and we have in this the fundamental principal of the Hoepfner electrolytic process. As in the Siemens and Halske process, we have the extraction of ores or metal bearing products with cupric chloride. The cupric chloride reduces to culprous chloride the same as ferric sulphate or chloride to the ferrous condition. While the cupric chloride is being reduced, an equivalent amount of metal from the product to be leached is dissolved. The process as carried out in practice is as follows: Ore, mattes, or other furnace products, are pulverized. This finely-ground product is treated with a hot solution of chloride, associated with salt, or saline chloride solution. The cupric chloride solution should contain from 60 to 75 grms. of copper per liter. The leaching is performed either in suitably constructed revolving drums or cylinders, or by means of a jet of superheated steam acting upon the pulverized ore product and leaching solution in specially constructed vessels. (This improvement was devised and introduced by the writer while in Europe in 1896.) By this means the cupric chloride solution is converted into cuprous chloride, dissolving an equivalent amount of copper from the material to be leached. If the cupric chloride solution contains 60 grams copper per liter before leaching, after leaching it will contain theoretically 120 grams of copper per liter. This ratio is very nearly attained in practice. If the ores or mattes contain silver, gold, nickel, cobalt, etc., the same will go, in equivalent amounts into solution, producing a complex chloride solution. This solution, after arriving at normal temperature, is ready for electrolysis. By submitting this solution to electrolysis, using copper electrodes, it is possible to drive all the silver, gold, and precious metals out of solution. (Improvement devised and introduced by the writer in 1895). According to Dr. Hoepfner, to establish between electrolysis and lixiviation of ores a process constituting a true cycle, it is necessary to have the original lixiviating liquid produced by electrolysis and the original electrolyte reproduced by chemical process.

For the successful carrying out of this scheme the arrangement of the baths, the chemical composition and the circulation of the electrolyte become of the highest importance. In carrying out his process (D.R.P. 53782, March 1888) he employs baths or a system of baths divided by diaphragms into two compartments. One compartment contains anodes which cannot be dissolved by electrolysis or nascent chlorine and the other compartment cathodes of pure sheet copper.

A solution of a halogen salt and cuprous chloride circulates by itself past the anodes and a similar solution flows past the cathodes. At the cathode metallic copper separates, and at the rate of 2.36 grms. for each ampere hour, or twice as much as is deposited by unit current when a solution of an oxide salt is used, viz., copper sulphate.

At the anodes free chlorine would be produced if no cuprous chloride were present at this point, and a voltage of 1.8 volts would be necessary at the poles of the bath.

The chlorine, however, combines in the nascent state at once with the cuprous chloride which should be present to form cupric chloride. By this means a depolarization is produced which experience has shown amounts to about one volt. The electrolysis therefore practically proceeds with a potential difference of only 0.8 volts per bath.

Cuprous chloride ($Cu_2 Cl_2$) develops in its formation 65.75 calories. Now as 45 calories of heat thus developed correspond to one volt of electromotive dissociating power, $65.75 \div 45 = 1.46$ volts is that electromotive force in volts which is necessary for decomposing cuprous chloride into 2 copper and 2 chlorine atoms. $Cu_2 Cl_2 = 2 Cu + 2 Cl$.

In order to overcome this resistance in practice the tension must increase to about 1.8 volts, as with 1.46 volts the dissociating and combining power only just balance each other, so that a quantitative decomposition cannot as yet take place. When, however, chlorine in a nascent state oxidizes cuprous chloride to cupric chloride the following reaction occurs :—$Cu_2 Cl_2 + Cl_2 = 2 Cu Cl_2$. As cupric chloride ($Cu Cl_2$) represents 125.4 calories, 125.42 - 65.75 or 59.67 calories become free and help the work of the depositing current. Theoretically, therefore, according to Hoepfner, electrolysis commences when applying only $65.75 - 59.67 = 6.08$ calories, or 0.13 volts.

The liquor at the cathodes, while successively flowing past a number of cathodes, gradually loses all its copper and leaves the electrolytic bath to be later on brought back into the process for completing the cycle. The liquor at the anode retains its full copper contents, but in the state of cupric chloride instead of cuprous chloride. At the electrodes the following reactions take place :—$Cu_2 Cl_2$ gives 2 Cu at cathode, while by electrolytic displacement the chlorine travels to the anode and combines with the cuprous chloride to form cupric chloride ($Cu_2 Cl_2 + {}_2Cl = 2 Cu Cl_2$).

The solution of the cupric chloride coming from the anodes is then employed for extracting copper, etc., from ores, mattes, and the like. In copper ores containing sulphide of copper the following reaction takes place :—($Cu Cl_2 + Cu S = S + Cu_2 Cl_2$.) (${}_2Cu Cl_2 + Cu_2 S = S + 2 Cu_2 Cl_2$.) This shows that the cuprous chloride formed has taken up as much copper as had previously been precipitated by electrolysis as metallic copper. As compared with the quantity of copper the concentration of the liquor is now twice as great as originally; in order, therefore, to establish the original concentration the cathode liquor which has been electrolytically deprived of its copper and flowing from the cathode cells is added thereto. It will be seen that the above constitutes a continuous process forming a complete cycle. The cycle is distorted by the gradual dissolution of iron, arsenic, antimony and the like impurities contained in the ores or mattes which become dissolved in place of copper. This defect, however, is overcome by the removal of such impurities, more especially the iron, by the purely chemical method through the use of oxide of copper before conveying the cathode liquor to the baths.

Simultaneously with the iron, arsenic, antimony and bismuth disappear. The advantages of this process according to Hoepfner are: 1st. Twice as much copper is produced from chloride solution as from sulphate with the same expenditure of energy. 2nd. The halogen salts of alkalies and earth alkaline metals (especially calcic chloride) possess such a dissolving capacity for cuprous chloride that in case of solutions free from iron, concentrations can be effected which cannot even be remotely obtained with sulphate solutions. From this it follows that the slighter volume of liquid used in the Hoepfner process enables a smaller plant to produce the same quantity of copper as a much larger plant using sulphate solutions.

An acid solution of cupric chloride in calcium chloride is a very powerful solvent of many metals. If the solution contains free chlorine, gold, silver and allied metals are readily brought into solution, and through proper means can be readily recovered from such solutions independently. In properly constructed divided baths, having a perfect circulation of the anode and the cathode portions of the electrolyte, the writer has obtained from cuprous chloride solutions a quantity of copper comparing very favorably with the best electrolytic copper produced from sulphate solution. The voltage necessary did not exceed one volt per bath. Therefore one horse-power day, at the rate of 700 volt amperes to the horse power, produces 39.6 kilos. or 87 pounds of pure copper to the horse-power. This is double what can be obtained from sulphate solutions.

Cohen cites a very interesting experiment in the electrolysis of cuprous chloride without diaphragms. He noticed that in the electrolysis of chloride solutions at a low current density the solution of cupric chloride, regenerated at the anode, sinks to the bottom of the vessel containing it, on account of its increase in specific gravity, and there forms a definite rising stratum. If the copper cathode be of sufficient length to reach this stratum copper will be dissolved from the same. By employing a very deep bath this difficulty is overcome. His method was as follows:—A deep vessel, having a sump in the bottom thereof, a long carbon anode extending into the sump, a siphon removing the solution from the sump, a short copper cathode reaching about half-way down the bath and an inflow to supply perfectly reduced cuprous chloride solution. Cohen claims that with this apparatus a current density of 20 amperes per square meter cathode surface, and a potential difference of one-half volt per bath, he has obtained copper equal in all respects to the best copper produced by any known process. According to Cohen's claim, it would be possible figuring 700, instead of 730, volt amperes to the horse-power, to produce 79.2 kilos, equivalent to about 174 pounds of pure copper to the horse-power day. Theoretically the above is possible, but the writer thinks that practically it would be very difficult to attain any such results.

If copper nickel ores or mattes are used in the Hoepfner process after removing the copper, a solution coming from the cathode compartments of the bath will be obtained containing all the nickel, cobalt, etc., in the original electrolyte. This solution upon purification by the removal of iron, cobalt, etc., electrolyzed in proper baths, will yield nickel and free chlorine gas. The chlorine gas coming from the nickel electrolysis is in the Hoepfner process reabsorbed by a cuprous chloride solution to be further used in extracting more metal from ores and mattes, or it may be condensed into liquid, or absorbed by lime to produce bleach. The electrolysis of nickel chloride reverts back to a simple chloride solution ($Ni\,Cl_2 = Ni + Cl_2$), and for every 59 equivalents of nickel deposited there will be 71 equivalents of chlorine gas set free. The electrolysis of a nickel chloride solution is a simple and elegant technical proposition. Practically about six kilos or thirteen pounds of nickel are produced by one horse-power day. This yield is accompanied by the liberation of about 15 pounds of chlorine gas, yielding 45 pounds of 35 per cent. bleach. Sulphate and chloride solutions are of such a nature that one can almost say that what is possible with the sulphate solution is also possible with the chloride solution. It is in fact just as easy to refine from a chloride solution as from a sulphate. It is therefore possible to produce copper and nickel or any other metal from a chloride solution at the same time using a soluble anode. The electrolysis of a salt or sodium chloride solution in the presence of a soluble copper and nickel anode producing thereby a solution of copper and nickel chlorides and alkali (caustic soda), was introdnced by the writer as a part of the chloride process for producing metals (1898), that is solutions of metallic chlorides from copper, nickel ores, mattes, etc.

The electrolysis of a salt solution having as an ultimate object the production of caustic together with metallic chloride was made the basis of a patent issued to Faure, Eng. Patent No. 1742, in 1872, and again Trickett & Noad, Eng. Patent No. 7754, 1888. (For further particulars see *Electrolytic Alkali Industry*, George Lunge, Vol. 3.)

Little was known regarding the production of electrolytic nickel prior to 1840. At that time an English patent was granted claiming the recovery of nickel from the solution of the double cyanides. This patent had little value. But of greater importance are the researches of Böttger, who established the conditions upon which the production of pure nickel from nickel ammonium sulphates or chlorides depend. This suggestion toward the production of pure nickel was made the object of a patent by Andree, Nov. 1st, 1877. According to Andree, nickel ores or mattes or nickel-cobalt-copper combinations, either as sulphides or arsenides are connected with the positive terminal of an electric generator and suspended as anodes in dilute sulphuric acid. Upon the cathodes only pure copper would be deposited, while the nickel going into solution remained in solution as long as the electrolyte remains acid. Towards the end of the operation, carbon anodes replace the matte anodes and all the copper is forced out of solution, leaving an electrolyte of nickel sulphate with iron sulphate. To electrolyze this solution the same is displaced or made alkaline with ammonia, the precipitated iron separated by filtration and the resulting nickel ammonium sulphate solution electrolyzed producing thereby pure nickel. About ten years later, in April, 1888, Farmer applied for a patent upon an apparatus having for its object the production of sheet metal and the refining of crude nickel. Farmer uses a revolving drum placed in a vat containing an electrolyte of nickel ammonium sulphate, chloride or nitrate. The anode of the bath is composed of a semi-cylinder of impure nickel placed below the drum with its curvature in the direction of the drum or cathode. The cylindrical cathode revolves, thereby agitating the electrolyte.

while at the same time the nickel is deposited by means of the electric current passing through the same. It is difficult to electrolytically separate from crude nickel the metals which contam, inate it. A patent was issued to Basse & Selve in 1891 having for its object the separation of nickel from iron, cobalt, zinc, etc. To accomplish this a neutral or weak acid solution, containing nickel, cobalt, iron, zinc, etc., is treated with a sufficient quantity of an organic substance to prevent the precipitation of nickel, iron, etc., through alkalies. Concentrated caustic is added to slight excess, and the resulting solution electrolyzed. At a current density of 0.3 to 1.0 amperes per square decimeter of cathode service, iron, cobalt and zinc separate at the cathode, the nickel remaining in solution or partly separates as hydroxide. If the current density is large and the solution strongly alkaline, nickel will also separate as hydroxide at the cathode. In order to obtain the nickel from the purified solution the solution is treated with carbonic acid or ammonium carbonate to convert all free alkalies into alkali carbonates. The solution is then again submitted to electrolysis. The organic compounds used for the above purpose are tartaric, citric, acetic acids, glycerine, dextrose, etc. The writer has obtained very good results in this direction by the use of creosote sulphonic acids, made by treating phenoles, obtained from coal tar with sulphuric acid.

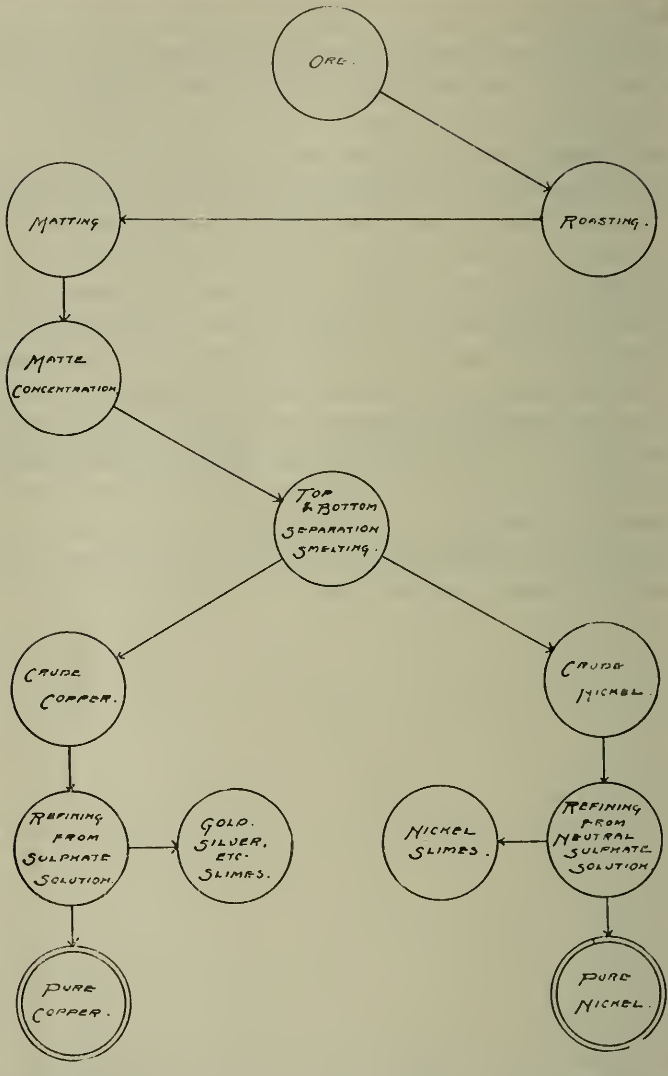
The much patented double decomposition arising when a solution of sodium chloride is electrolyzed in the presence of soluble anodes, carrying metals capable of forming chlorides, has again been made the basis of a patent granted to Frasch in 1901. The Frasch process was supposed to be an improvement on the Hoepfner process and was expected to supercede it and completely revolutionize all methods involved in the electrolytic production of metals. Much was claimed for the process by the inventor, but little has been realized, as the result of its work at Hamilton, Ontario, show. Sufficient critical comment upon the Frasch process has appeared within the past year to make further details regarding it unnecessary here. It is the writer's opinion that the patent for the Frasch process was granted as the result of the exertion of a shrewd patent solicitor rather than the public recognition of an invention containing new and original ideas on the subject of electro-metallurgy.

Hoepfner's process, or rather the legitimate electrolysis of chloride solutions, is a commercial success, as is evident from the fact that, 1st, the Papenburg Works in Europe continue to operate the same; 2nd, the Canadian Copper Co. are daily producing a ton or more of metal from chloride solutions, and, 3rd, zinc production from zinc chloride, which is technically a much more difficult problem than nickel from nickel chloride, is successfully carried on at present at the Brunner-Mond works in England. It stands to reason, therefore, that the failure of the Frasch process, judging from results at Hamilton, must be explained in other ways than in the technical difficulties surrounding the electrolytic decomposition of a chloride solution.

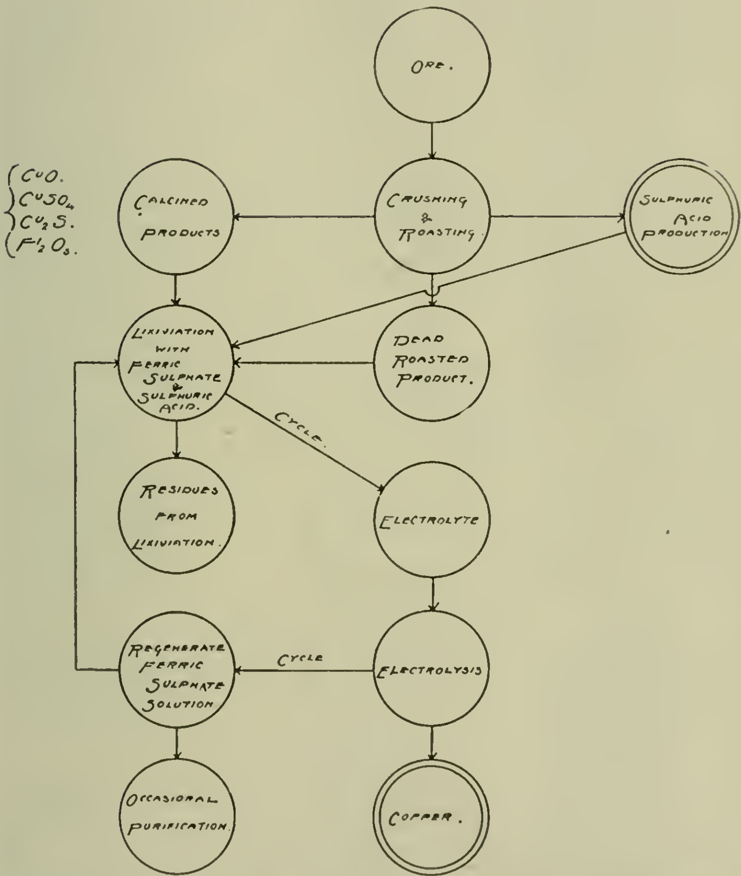
In the production of metals by the Hoepfner or by the Siemens & Halske process the question of diaphragms is an important one. The reactions occurring at the cathodes are always of a reducing nature, while those at the anodes are always of an oxydizing nature. The result is that the electrolyte surrounding the anodes is of a different chemical nature from that surrounding the cathodes and it becomes necessary, therefore, to keep the electrolytes separated by a substance having the property of allowing the individual ions to pass, but at the same time preventing the anode and cathode solutions from mechanically mixing. In the earlier experiments felt, cotton cloth, jute, parchment paper, etc., etc., were largely used. Hoepfner uses nitrated cotton-ducking to advantage. In recent times porous tiling and the like (porous cup material as used in two liquid or primary elements) has come extensively into use. The writer is informed that the Canadian Copper Company is using this substance at the present time in the construction of its baths. The Pukall porous cups and diaphragms manufactured by the Royal Berlin Porcelain Company of Europe, are coming into extensive use. Asbestos cloth, mineral wool, spun glass, sand, cements, etc., etc., in almost every conceivable form and combination, have been patented for the above purpose. Although there are innumerable patents, good, bad and indifferent, affecting the manufacture and use of diaphragms, very few of them give satisfactory results.

From what has been said it will be seen that the electrolytical production of nickel and copper as at present carried on reverts back to two fundamental methods, namely: 1st. The production from sulphate solutions; and, 2nd: The production from chloride solution, and any variations of method claiming to introduce new and original ideas or novelties are more of a mechanical than a chemical nature. It was the intention of the writer to furnish a list of patents on this subject, but the number is legion, and it was thought better not to cumber this paper with information which can be had from the Patent Office. In fact, the chemical and mechanical part of electrolysis has been so many times patented that doubt is thrown upon the merit and validity of each and every patent of this nature now upon the market. The question continually arises: Which of these patents are good, and to whom should the producers of metals pay royalties? So uncertain is the answer to these questions that resort is more and more made to the courts, and pending their decision capital is tied up and production stopped, and a new element added to the uncertainties of metallurgical and mining operations which should be as positive in operation as they are scientific in method.

Appended are outline schemes showing the more prominent features of the different processes in use.



A scheme for the Production of Copper and Nickel (according to information received by writer) as proposed by Mr. Titus Ulke, for the working of Canadian Pyrrhotite Nickel Ores at the Sault Ste. Marie, Canada. From the above diagram it will be noticed the process is a refining process and uses crude metal as anode material, necessitating roasting and smelting operations together with separation smelting to the stage of obtaining a crude metal of about 90 to 95% metal contents.



Outline scheme for the Electrolytic Production of Copper. Siemens & Halske (Ferric Sulphate) Process.

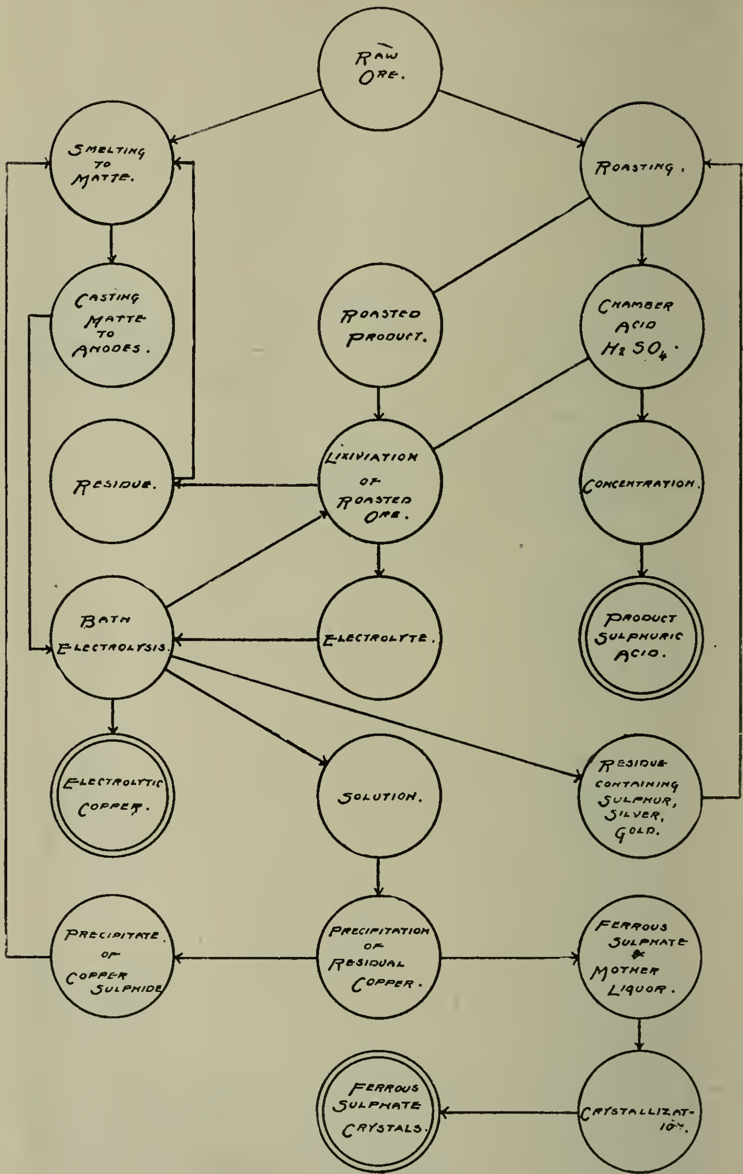


Diagram of the Marchese Process.

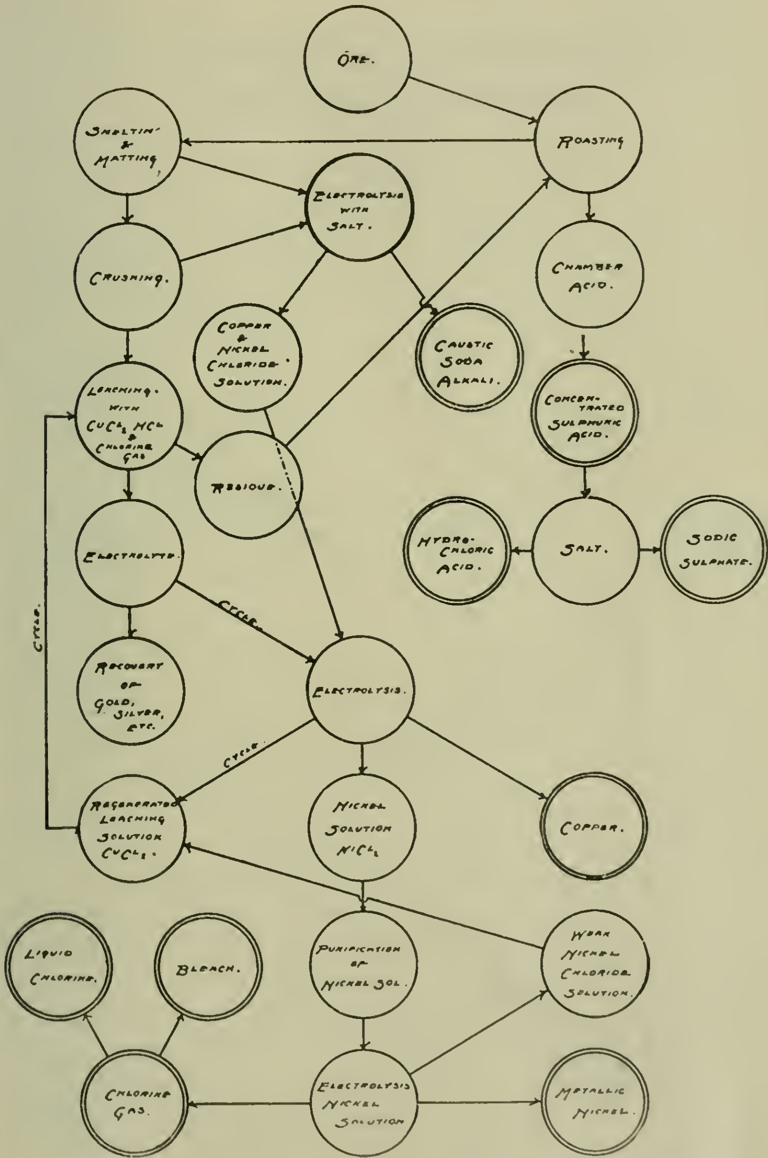
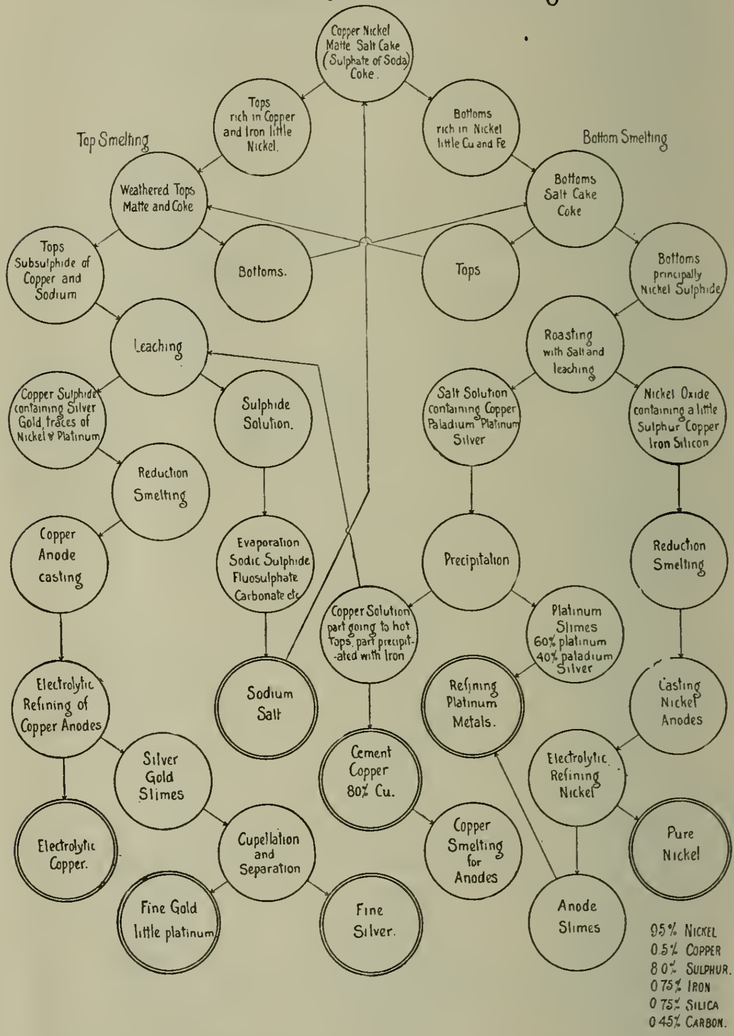


Diagram for working Chloride Solutions viz. Hoepfner Process, together with additions and improvements introduced by writer, viz. : Production of caustic (Salt Electrolysis) Liquid Chlorine, utilization of sulphur for Sulphuric Acid, Salt Cake and Muriatic Acid ; also Nascent Chlorine for leaching purposes.

Bartlett Thompson Separation Smelting also known as Top and Bottom Smelting.



A Method of Mining Low Grade Ores in the Boundary Creek District.

By Frederic Keffer, M.E., Anaconda, B.C.

It is usually the case in new districts presenting a variety of new conditions, that a good deal of preliminary work must be done to determine the best methods of mining and treating ores. This has been true in the Boundary District, the ores of which, as a rule, are of very low grade, occurring in deposits of great extent without well defined walls.

It is the purpose of this paper to describe the methods of mining at the Mother Lode mine in Deadwood Camp, near Greenwood, and the reasons which have led up to their adoption.

The ore deposit here outcrops at intervals for a distance of about 2,000 feet, the width in explored portion averaging perhaps 140 feet, although the absence of any defined walls prevents exact measures being given. The dip is about 70 degrees easterly, and pitch toward the south at an angle yet undetermined. Only the ground to the north of the shaft, which is located centrally, has been explored as yet. At the beginning of stoping operations, the ore body had been developed by a northerly drift from shaft on the 200 level, the drift extending to apparent end of ore. The deposit was crosscut at intervals of about 100 feet. Similar work was also done on 300 level. A winze to surface, about 500 feet north of shaft, afforded good ventilation.

It was the original intention to sort all the ore from the mine, filling the stopes with the waste, and with other rock blasted from walls or elsewhere obtained. To this end a system of belt conveyors was arranged whereby the ore from shaft was dumped into a No. 5 Gates crusher, thence passing over a 3 foot wide picking belt to the ore bins. The waste was dropped into side pockets falling upon another belt system, whereby it was conveyed to a bin at top of winze, whence it was to be dropped into the stopes.

It may be said here that the term " waste " is, generally speaking, merely comparative, for the whole of the ore body (with exception noted below) contains copper, gold and silver in varying degree, and waste is merely rock with lesser quantities of these metals. The sorting and conveying belts worked to a nicety, but the smelter had been in operation but a short time when it became apparent that its capacity for these self-fluxing ores was much greater than had been thought possible, and consequently smelting costs were lower than had been figured. A direct result of this was that the definition of "waste" was altered, and its quantity greatly diminished. And further, that the cost of sorting out this diminished waste was approximately equal to the cost of smelting it; for even the poorest of the rock contains some values to offset in part the smelting charges. These conditions necessitated the abandonment of the filling plan for stopes. Also the sorting of ores was suspended, save for certain ores from 300 level, where the waste happens to be totally barren and easily sorted out.

The filling system having been dropped, it was then planned to timber the stopes in the ordinary fashion, but this plan was abandoned on account of high cost of timber compared with ore contents.

A third alternative was next adopted in one stope—that of timbering the whole of the floor of stope heavily, only the excess of ore from above being dropped through shutes conveniently placed. This plan was going nicely until the roof of stope was some 20 feet over timbers, when a mass of ore became detached from roof, which mass weighed some hundreds of tons. Everything in its path was crushed and the stope wrecked. Luckily no one was hurt.

A further, and final plan, was then adopted. The ore body was divided into stopes 30 to 40 feet wide, the length of stopes being the distance across the ore body. The crosscuts already existing were used, and others cut where needed under the centre of each stope. From these crosscuts, upraises were made 30 feet apart. These were made 10 to 12 feet high, and were then connected by second and parallel crosscuts. From these latter crosscuts the stopes were opened out the proposed width, and then carried vertically upward, the short upraises being cribbed and furnished with gates for loading. Between the stopes, pillars 20 to 25 feet in thickness were left, these being frequently pierced to allow intercommunication and ventilation.

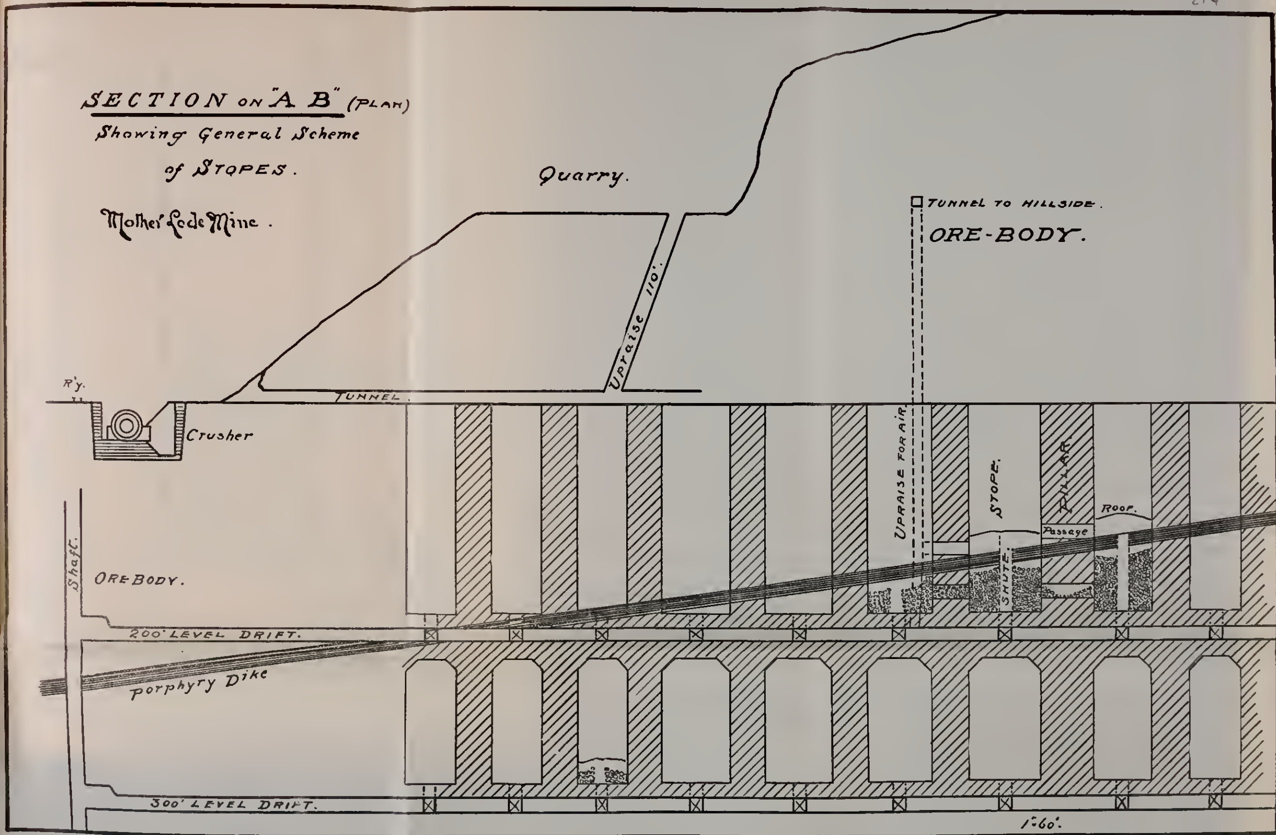


PLATE I.—Illustrating paper by Mr. Frederic Keffer, M.E., on "A Method of Mining Low Grade Ores in the Boundary Creek District."

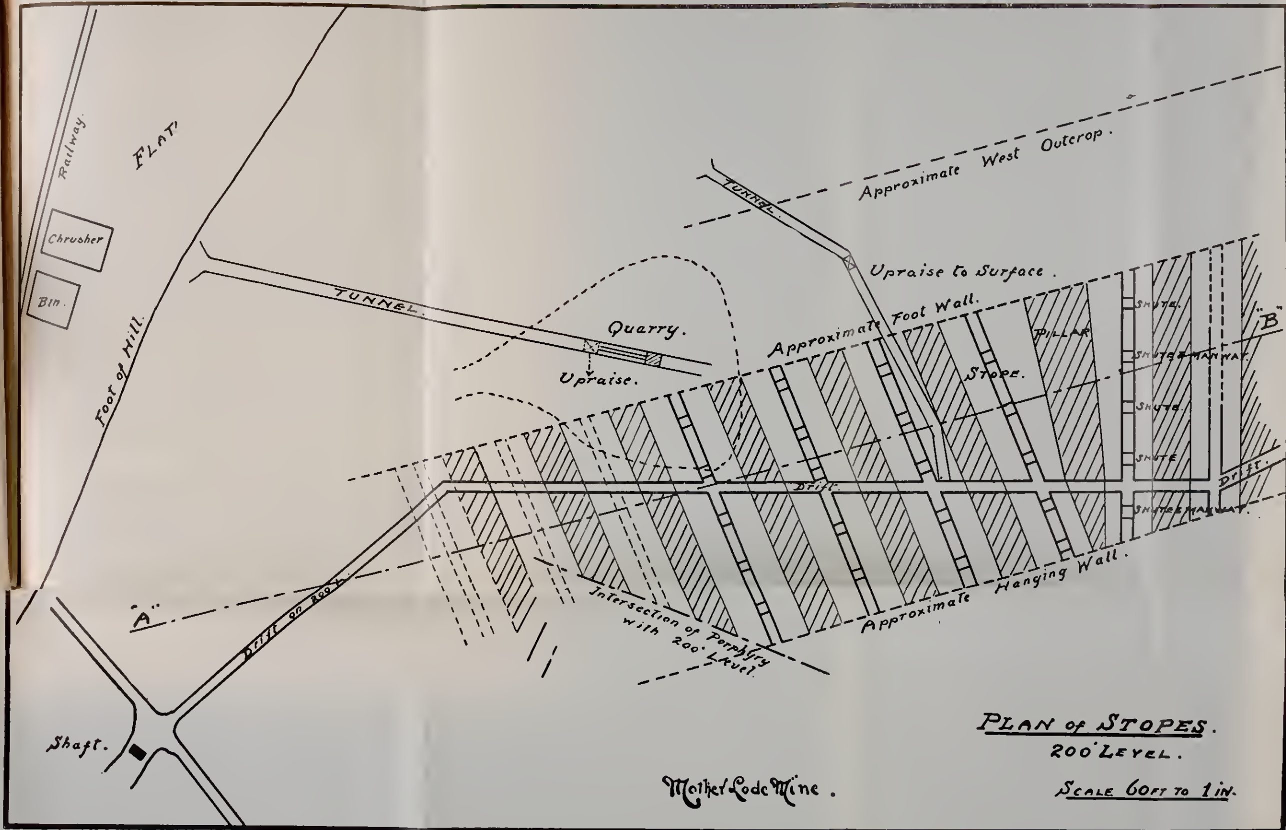


Plate II.—Illustrating paper by Mr. Frederic Keffer, M.E., on "A Method of Mining Low Grade Ores in the Boundary Creek District."

In the stope where the wreck occurred a very heavily timbered passage corresponding to a crosscut was built, shutes being placed at 30 ft. intervals.

The empty space was filled with porphyry blasted from a blanket dyke, which extends through all the ground yet explored. The accompanying plans and sections illustrate the general arrangement of the workings.

These stopes will be carried up to a point 160 feet above the 200 level, where they will meet with the surface workings to be described. After this occurs, the ore remaining in stopes above the porphyry will be sent through the shutes, and as much of the pillars removed at same time as safety may dictate.

The ore below porphyry may be removed at will, as this dyke is very thick and solid and will stand any pressure. In this method of working, nearly 50 per cent. of broken ore must be left in the stopes for a considerable period, but to offset this, the interest on capital so tied up is but a fraction of the cost of timbering these great stopes. Moreover, the system is as safe as mining can be made, the roof of stopes always being near the men, and there can be no wrecks occasioned by a cave. Further, there being no danger from timbers giving way, tremendous blasts can be employed and the ore broken down in great quantities at a time. One drill will frequently break down 75 to 80 tons in 24 hours.

On the 300 level, the pillars come directly below those on the 200, but in future levels the distance will be increased from 100 feet to nearly 175 to allow of less rock being left between levels, and less development having to be done.

SURFACE MINING.

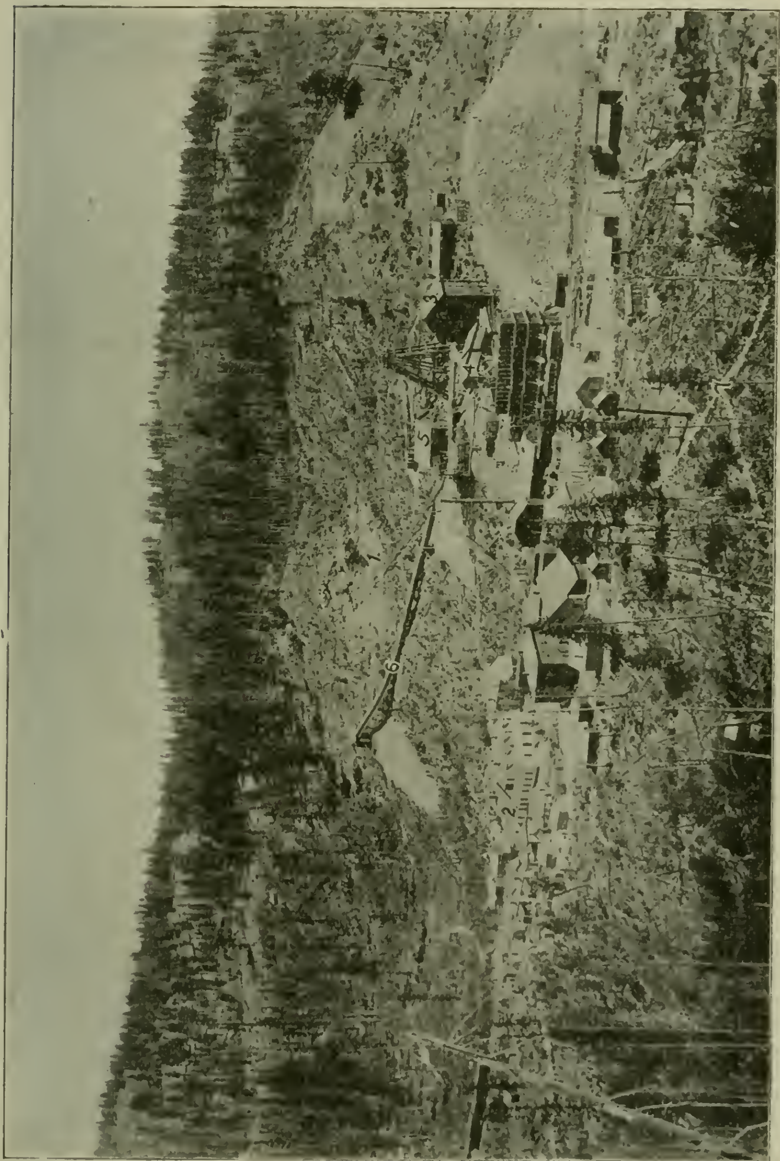
To supplement the output from underground, a great amount of ore is now obtained by quarrying. In the hill which rises some 260 feet over surrounding flat, a quarry (or "Glory Hole" as it is locally styled) is in operation, this quarry being 110 feet above flat and 50 feet above collar of shaft. Ore is at present run down a gravity tram to Gates crusher, and thence over conveying belts to bins on the flat. This No. 5 crusher, experience has shown, to be far too small to admit of economical work, the ore having to be reduced to 10 inch size in order to pass into crusher. This reduction has mainly to be effected by "bulldozing" with high percent dynamite, the rock being too hard for hammer breaking. To obviate this difficulty, and to permit of cheaper handling, a tunnel has been driven into hill from level of flat. This connects by a 12 x 12 upraise with the quarry. In a pit on flat next the railway an immense Farrell crusher, with jaw opening 2 x 3 feet, is now being installed.

Ore will be dropped down the upraise, and there loaded into cars having a capacity of 4 tons. Trains of these will be drawn by mules to the crusher pit, where they will be dumped, by compressed air, over a grizzly leading to crusher. The screenings and crushed ore will be elevated to a bin beside the railway.

As quarrying proceeds, other raises will be made, and the level of quarry floor at the same time be lowered until the flat level is reached and the tops of stopes encountered, when these latter may be emptied. The present Gates crusher will take care of all ore from shaft as at present, its capacity being from 400 to 500 tons per 24 hours when fed with ore properly broken.

A photograph accompanying this paper shows the general arrangement of works, and the appearance of quarry when it was first begun.

SURFACE WORKS B.C. COPPER CO., ANACONDA, B.C.



1. Quarry—as it was in July. 2. Site Large Crusher and Bin. 3. Gates Crusher House. 4. Sorting Belt House.
5. Hoist House. 6. Waste Conveyor. Compressor is in ravine to front of picture (7).

The Old and New Iron Industry Compared.

By John Birkinbine, Philadelphia.

The activity prevailing in the iron and steel industry, especially the developments contemplated and in progress in the Dominion of Canada, will probably command attention at the Annual Meetings of the Canadian Mining Institute, and the following is presented as a contribution to such discussion and as a slight recognition of the compliment conferred upon the writer by his election to honorary membership.

The known deposits of iron ore in British Columbia, on the north shores of the Great Lake region, in Central Ontario, in Quebec, New Brunswick, Nova Scotia, Labrador, and in the adjacent islands, including Newfoundland, have invited the prospector and explorer, while facilities offered in the Dominion have suggested the possibility of the ores from some of these being assembled where fuel is cheaply obtainable and markets for the products can be developed. Descriptions of some of these deposits or of works to treat the ores are included in the Institute's transactions and the history of iron manufacture in Canada from the establishment of the St. Maurice forges has been presented by those posted as to details or familiar with local conditions. The development of the iron and steel industry within the United States also forms an equally interesting story, although it covers a lapse of time less than three centuries, and a brief resume of this is offered.

This paper is suggestive rather than historical, hence mere mention will be made of the early effort in the United States where an iron industry was attempted along the Atlantic Coast from 1630 to about 1740, primarily by utilization of bog ores and local brown hematites. The production was not of importance, measured by quantity, and practically all of the plants were either forges, or blast furnaces and forges combined in which the pig metal was cast, and also the wrought material fabricated.

About the middle of the 18th century the distribution of blast furnaces extended over a somewhat greater area and in addition to the brown hematites, magnetic ores were employed, but the ore was either reduced directly to blooms in Catalan forges or the pig metal was fabricated in forges after it came from the blast furnace. All of the furnaces and forges up to about 1840, were fed with charcoal and were operated with cold blast.

The control of the iron works was generally directed by the owner, who exercised absolute dominion over a considerable territory. Each plant produced its fuel from wood, cut and carbonized upon property connected with the furnace or adjacent thereto, mined ore from its own or convenient lands, or quarried limestone nearby, making these early iron works self-dependent. In addition to the supply of raw materials, each works maintained its store, smithery, and generally a mill to supply the employees and their families; little money was used, most of the labor being taken out "in trade" at the store or mill. Each aggregation of houses about these iron works, which sheltered the employees and their families as tenants of the owner, was a settlement independent of others, often reached by long and tedious wagon journeys. The transporting of the material to the furnace or forge and also the product from them was by animal power, first on the backs of mules, or later by large wagons each drawn by a number of animals. These wagons made extended journeys to points of consumption and brought back, with the necessary supplies required for the community, news from the outside world. The owner or "iron master" was practically "monarch of all he surveyed," owning the lands, farm, furnace, forge, mill, store, tenements, not infrequently the church and school house, or at least the ground they occupied, and while slavery prevailed in a portion of the United States, some were also owners of many of the employees. On his farm, feed for his horses and cattle and grain for his mill were raised. If he elected to serve, he was Justice of the Peace and Post-Master—otherwise trusty subordinates were named at his dictation. He was the political, and in some instances, the religious guide for his people, but often the manager did not intrude upon religious duties as upon political privileges, giving to his employees and their families unlimited proxies to represent him at the revival services at which a number "got religion" each year—at least a supply believed to be sufficient until the frogs croaked in the spring, after which it was often accepted as more or less of an incumbrance.

Long credits allowed on the sales of products or claimed on the purchase of materials, made the owner or manager of one of these older plants also a banker, whose fiscal work was mainly confined to short seasons recurring once or twice every year.

As to the blast furnaces, a massive stone stack about 30 feet high and about 30 feet square at the base enclosed the refractory lining whose greatest diameter seldom exceeded 9 feet. This furnace, operated by a water wheel propelling pistons in wooden cylinders or moving ponderous bellows, was kept in blast from 8 to 10 months of each year, producing an average of about 100 tons of pig iron per month, but was then blown out for re-lining. During this season of inactivity the miners and furnace men not needed in repair work were sent into the forest to chop wood for the next season's coaling or aided in stripping the overlay from ore banks. The raw materials for the furnace were produced by hand labor, hauled by wagons to the charging floor on the hillside or bank at the same height as the furnace top, and fed into the tunnel head by barrows, baskets or boxes. The metal produced and the resulting cinder were also handled by manual labor, and the labor item was prominent in the cost of metal produced.

This briefly details conditions prevailing up to about the year 1840

With the introduction of the hot blast, nearly contemporaneously with the application of mineral fuel in America, and closely following the construction of canals, and later the development of railroads, it became possible to utilize as avenues of transportation the canals and railroads. Some blast furnaces were moved from the immediate vicinity of the ore or fuel supply and the tendency was to locate new plants about business centres. The size of the furnace was increased and improvements in equipment introduced, but up to about 1880, there were a number of cold blast furnaces constructed and operated practically as described above. There are several cold blast charcoal furnaces still active in the United States, whose equipment, however, has been improved and labor saving introduced to a limited extent. These furnaces produce special grades of metal which command prices permitting of following the methods indicated, but the demand for quantity is slight.

With the proportions of the furnaces increased and improved steam machinery to operate them, the product was augmented and from a score of tons per week the output gradually increased to as much as 100 tons per week. About 1850, products from a furnace of 200 tons per week were occasionally reached as more powerful equipment was supplied. The forges being separated from the blast furnaces and rolling mills substituted, more of the product of the furnaces was carried to distant works where it was manipulated and fabricated into commercial forms.

In the next two decades interest in the chemistry of the blast furnace was excited, and about 1876 the technical side of iron smelting received liberal attention, the iron masters of the United States profiting largely from the Centennial Exposition in Philadelphia, where experts in all branches of iron metallurgy came together from various parts of the world and discussed the problems which each had to meet in his own locality. In the meantime the manufacture of steel by the pneumatic, or what is generally known as the Bessemer process, was advancing and the requirements for metal became greater, so that the product per furnace and the total for the United States was materially increased. The machinery to operate the blast furnace was constantly improved and this improvement extended to the mills where the pig metal was either puddled or converted, requiring a large output, to meet which the capacities of furnaces were augmented.

Up to 1870 the majority of the iron plants had been operated by individuals or partnerships, but incorporated companies entered the field, thus permitting of enlarged development with greater capital and division of responsibility. The fire-brick hot blast stoves, introduced about the time of the Centennial Exposition in Philadelphia, assisted to augment the output and decrease the fuel consumption per ton of iron, while chemical researches demonstrated the increased value of rich ores and the demands of the Bessemer plants made necessary the selection of many ores low in phosphorous.

About the year 1880 a daily output of an individual furnace which reached 100 tons was phenomenal. Since that time general advances in all lines technical, metallurgical and mechanical have been pronounced and a furnace which two decades ago produced 100 tons per day is not now notable if it exceeds 400 tons, although the dimensions of the stack may be the same. Various experiments were made to develop the blast furnace in height, in diameter of bosh and in diameter of crucible, but there has been no greatly augmented height nor has the diameter of bosh of many of the furnaces been extended much more than those of the largest furnaces of twenty years ago, although the record of some individual plants have reached 800 tons in one day, or as much as an up-to-date furnace would produce in a year prior to 1840. In the larger plants which are now in operation, equipped with powerful steam engines, ample boiler capacity, efficient hot blast stoves, appliances for handling the raw materials and also the product, an average exceeding 500 tons a day is not unusual for a considerable period. A blast furnace plant designed to produce 1,250 tons daily, may at present consist of two or three furnaces, and the question of preference is an open one. It is probable that, all things considered, better results will be obtained from dividing this quantity among three units than among two, that is, having three furnaces each producing about 400 tons per day rather two with a capacity of 600 tons per day. This, however, is not the place to discuss this detail.

A development such as that indicated in the foregoing hurried recital could not have been spasmodic but was gradual and within a half century marked advances have been fairly persistent, although some developments were quite sudden. Conscientious and careful study by engineers, mechanics, chemists and superintendents to obtain a large output and secure the greatest economy of operation has resulted in achieving the record described.

Under the older method detailed, it would be impracticable to assemble the large amounts of raw materials required, or to handle these, and the present product at one of our modern blast furnace plants. The number of men and animals necessary would interfere with each other, and the available space around a furnace plant would be insufficient for the work, if it were done according to the older and more expensive methods.

To obtain the amount of pig iron credited to the United States in 1901 (15,878,354 gross tons) it has been necessary to develop enormous mines, both of ore and coal, to equip them with the best of machinery for winning and handling the material, to build thousands of coke ovens, to construct hundreds of miles of railroads supplied with powerful locomotives and capacious cars in which the materials can be cheaply transported and from which they can be readily discharged; to erect enormous shipping docks where the ore is conveniently and economically handled into vessels and to prepare also extensive docks where the ore can be taken from vessels and transported rapidly and at small cost placed on stock piles or railroad cars.

These features have also resulted in the establishment of an important maritime trade on the Great Lakes, where powerful modern vessels of large capacity have been supplied in great number.

When the raw material reaches the modern blast furnace, it is received and distributed by means of mechanical appliances and bins costing large amounts of money, the tendency being to eliminate, as far as possible, in mining, in handling, in transportation and at the furnace, manual labor, by substituting mechanical appliances. The pack mule first gave place to the wagon and team, the wagon and team were supplanted by canal boats and these by railroad cars carrying five tons of material. Now cars holding 50 tons drawn by ponderous locomotives move the ore which is dug from mines by steam shovels or won by the use of air drills, supplemented by electrical or air motors. It is discharged by gravity from cars with drop bottoms, which either carry the material directly to the consumer or to docks where the material drops into pockets and from these is shot into vessels. Great "grabs" at the terminal docks lift this ore from the holds of vessels and mechanical appliances convey it to stock piles and cars, these latter transporting the ore to the bins or stock piles at the blast furnaces where other mechanical appliances move it or lift it to the furnace top, and much of the ore now used is not touched by hand from its native bed until it enters the throat of the blast furnace. This ore obtained from mines several hundred, and even exceeding 1,000 miles distant from the blast furnaces, is delivered to them at no greater cost than some of the near by ores fed to the older furnaces which were won entirely by manual labor. Similarly the advancements in coal mining have been in the use of compressed air and electricity or continuous rope haulages with cars which convey the fuel to the ovens into which it is automatically dumped. Some ovens are built so as to utilize a portion of the non-condensible gases, the condensible being converted into commercial products, and in addition to obtaining value from these it is possible in by-product ovens to utilize some coals which otherwise would be unfit for coking by reason of their low volatile contents. The metal, after it is smelted in the blast furnace, instead of being tapped as was formerly the case, and handled by manual labor, now runs into ladles carried on trucks which deliver it to mechanical casting machines, or it is charged direct into mixers or converters at the steel plant. It is at these plants that mechanical ingenuity and great economy in labor and material have reached a most commendable result. The converted metal cast into ingots of weights up to 5 tons (and in the construction of ordinance or armor plate of 20 tons or more) passes to hydraulic presses or to blooming mills and in many cases a practically continuous mill permits of the finished product being produced without the metal reaching a temperature below that which can be readily raised by temporary "wash" heats. The finished product from a number of these mills, whether it be rail, bar, shape or plate, is now produced and marketed at prices no greater than the old charcoal furnaces received for pig iron.

The perfection of the mechanical equipment is marvelous. The molten metal brought in ladle cars each holding 15 or 20 tons, is discharged into a tilting mixer or receiver with a capacity of 350 tons.

This feeds the converters or open hearth furnaces from which ingots are cast and quickly conveyed to soaking pits or gas furnaces. Powerful cranes place the ingots on the feed tables of blooming trains to be rolled and sheared to billets and these pass to other trains so that in a brief interval the finished rail, shape, bar or plate is produced.

It is probable that in a modern mill ten tons of finished product are obtained by the employment of no greater number of workers than were necessary in crudely fabricating one ton a half century ago.

With the increase of quantity and the improvements for handling and using the raw materials, augmented capital became necessary to develop and exploit large mines, to build railroads, to construct vessels with the requisite shipping and receiving docks, to erect furnaces, converting plants and mills of large capacity and equip them with the machinery and appurtenances to produce the quantity of material desired at the lowest practicable cost. As this augmentation became general, private or partnership control was, except in relatively few instances, supplanted by corporate ownership. At present corporate control is so combined as to encourage centralization of interest and management, the capital of some of the important iron and steel companies reaching figures scarcely appreciable to the average business man. When the stock of companies is rated by hundreds of millions, and in one case exceeds one thousand million dollars, the figures are hardly understood by most of those engaged in commercial enterprises. This centralization and consolidation is being watched with great interest; that it has merit can be demonstrated from a number of points of view; that there is danger in it is apparent from different aspects. But few combinations have been possible except by associating with successful and good paying enterprises, others which were at least doubtful and whose location, equipment or other causes, handicapped them in the race for pre-eminence. The stronger will have to carry the weak, and there may be times when this burden will be troublesome. A great business can undoubtedly earn great profits, but enormous capital also means proportionate interest charges which must be met.

While we may consider ourselves in an era of consolidation, the entire iron and steel business may not be so classed. The bulk of the iron and steel trade of the United States is undoubtedly controlled by a few corporations, but there are a number of relatively modest enterprises which are, and under proper management, will continue to be successful. Although the prices of products may be generally dictated by the stronger, the relatively weaker will prove important factors not only to the supply of the general public, but will be used to a greater or less extent to supplement deficiencies of the larger enterprises, and even a small producer with a moderate amount of product to dispose of may demoralize a market apparently strongly sustained.

In some of the later developments which have been made or are in contemplation, there is apparent neglect of the essential feature of convenience to a remunerative market. The industries which have been most profitable have developed from smaller ones to great ones. There are but few instances where large plants have become successful unless these have resulted either from an earlier development or of a combination of neighboring interests. Many of the modern plants occupy the sites of ancient industries, are successors of these, or are located in districts in which for a term of years labor has been educated and market facilities secured.

The danger which seems to threaten the iron and steel industry is the enthusiasm with which great projects are launched and for which great promises are made. With no desire to question the propriety of a number of the important projects contemplated or in course of erection, there is, to the observer, an apparent neglect in some instances of the question of practically continuous remunerative markets.

The iron and steel industry of the United States is no longer in its infancy, it has grown to maturity and individual plants now produce more metal in a year than the entire United States supplied less than half a century ago. Nor is the industry dependent upon local supplies of raw material; railroads with improved locomotives, large cars, substantial road-beds and bridges and advances in vessel construction both as to power and capacity, the facilities of shipping and receiving docks, where these are necessary, the equipment of important mines and the selection and handling of the material mined, all combine to admit of assembling raw materials from long distances or of shipping manufactured products to far away consumers. The mechanical appliances and methods introduced at the blast furnace, the converter, and the mill, make possible enormous outputs at small cost for labor, fuel and administration; and have materially reduced the requirements for skilled labor, while the transportation problem permits of the assembling of the raw materials and distribution of the product.

The modern blast furnace stack, although three times as high, occupies no more ground space than its ancient prototype, and the equipment of 4,000 H. P. boilers, cross compound blowing engines, supplying 1,000 cubic feet per second, at pressures of 20 pounds or more, delivered through 10 or more tuyeres into the blast furnaces at temperatures of 1,200 degrees Fahr. seem strange developments from the weary water wheel forcing from its bellows or tubs a weak blast through a single open tuyere. The 3,000,000 or 4,000,000 gallons of water demanded daily for steam and cooling purposes by a modern blast furnace would have gone far, under a liberal head, to have been the motive force operating the older furnaces.

The advances in quantity of product, in the control of its character, in the low consumption of fuel, have all been made possible by a study of the chemistry of the blast furnace, which exposes to the student the secrets of the smelting process, and the modern furnace is as much a tribute to the work of the chemist as it is an example of the highest skill of the mechanical engineer. It is not alone to the blast furnace that such credit is due, for the Bessemer steel converter with its startling reactions, the massive open hearth steel furnaces, the handling of large ingots, the rapid passing of these into commercial shapes, equally pay tribute to the genius of the metallurgist and the mechanic.

Notes on the Economic Minerals of Vancouver Island, B.C.

By W. F. Best, Victoria, B.C.

Vancouver Island, which is nearly as large as England, has a climate identical with that of the British Isles, and a geographical position as favourable for Australasian and Oriental trade, as England has for trade with Europe and America.

The island, which has been known as a mineral producing district for only a few years, is now attracting the attention of many mining people, both in Canada and the United States. In no portion of the British Dominions are there more promising indications of extensive and varied ore deposits than on Vancouver Island, and nowhere are there better facilities for profitable development of mines.

On account of the mild climate and absence of frost, it is possible to carry on mining operations throughout the entire year, while the numerous large streams, flowing from the mountains in the interior of the island, furnish an abundance of water-power.

Numerous excellent harbours and deep inlets indent the coast-line, and afford an opportunity for the exploration of the country near the sea coast.

The interior of the island is at present almost unknown, as the dense forests and tangled masses of vegetation form a barrier which even the intrepid prospector cannot penetrate.

Until trails and roads are opened by the Government, it will be utterly impossible to gain any adequate idea of the mineral resources, which, according to geological conditions, must exist in and near the mountain ranges of the centre of the island.

Wherever prospectors have been able to follow up the rivers, or in other ways to reach the vicinity of the interior mountains, they have been rewarded by important discoveries of valuable ore.

Among the ore deposits thus located those of the Mount Sicker district are probably the most important thus far discovered.

In the vicinity of the Mount Sicker claims that have been developed to the shipping stage a flourishing town is growing up, which at no distant day may rival the mainland city of Rossland.

Smelting works for the reduction of the ores of the Mount Sicker district are now under construction at Osborne Bay, a seaport some ten miles distant from the mines, and a second town, with hotels, stores, wharves, and dwellings, is in course of construction in the vicinity of the smelting works.

The ore of the Mount Sicker district is "chalcopyrite," containing copper, gold, and silver, the average value per ton being more than $20.00. At the 280 feet level in one of the Mount Sicker mines the ore is much richer than at the surface, and some remarkably high assays have been obtained.

Extensive ore reserves are "in sight," and at least 300 tons per day will be shipped to the smelter, as soon as the railway to Osborne Bay is completed.

At several points on the west coast of the island, along the inlet known as the Alberni canal, three or four very promising copper properties are in course of development, and many shipments of ore have already been made to the Tacoma smelter.

Other promising copper "prospects" have been found at Barclay Sound, and near Quatsimo Sound, at the north end of the island.

It is hardly necessary to make special reference to the coal mines of Vancouver Island, as they are comparatively well known. It may be mentioned, however, that for several years past the average output of these collieries has been about 1,500,000 tons per annum.

The coal measures of Vancouver Island occupy the eastern side of the island, and dip towards the Strait of Georgia, which separates the island from the mainland of British Columbia.

After copper and coal the most important economic mineral of the island is iron.

This metal exists in the form of "magnetite," containing from 60 to 68 per cent. metallic iron.

The largest known deposits are at Sechart, Sarita River, and Copper Island, although there is reason to believe that much more extensive deposits exist in the interior, as the sands of many of the streams consist chiefly of magnetic iron.

As far as tested the " magnetite " of Vancouver Island is remarkably free from phosphoric acid and sulphur, and is in every way suitable for the manufacture of " pig " iron and steel.

Vancouver Island " magnetite " is at present being exported to supply an experimental furnace situated in United States territory near Port Towsend.

It is most essential that at this stage of the industry an export duty should be placed on the ore, so that permanent plant and iron furnaces will be erected on Vancouver Island, instead of in United States territory.

To simply ship raw material from the island in order to build up a huge industry in the State of Washington is not at all desirable, from a Vancouver Island point of view.

The sooner this matter receives the attention of our legislators, the sooner will the revenue of the country increase from a most important industry.

Extensive deposits of " hæmatite," and also of clay ironstone, exist on the island, and as there are inexhaustible deposits of limestone, and abundant fuel close at hand, it would appear that Vancouver Island is an ideal location for iron works.

As for a market for iron and steel, there are all the countries bordering on the Pacific Ocean, countries that would consume the product of a dozen ordinary iron and steel works.

The principal discoveries of gold bearing quartz have thus far been made in the vicinity of San Juan river and its branches, on the west coast of the island, about 50 miles from the city of Victoria.

Recent assays of ore from a claim in that vicinity yielded 4 oz. (four ounces) gold per ton of ore.

While this cannot be taken as the average yield of the lode, yet the new district is certainly worthy of careful exploration.

In the same district a large and continuous vein of " stibnite " has lately been located, yielding 65 per cent. antimony, while a few miles distant a deposit of "galena" has been traced for several miles, on the surface.

An entirely new and very promising mineral district in the interior of the Island was reported by prospectors last summer, but on account of its inaccessible situation it will be some time before it can be profitably explored.

In that district large ledges of low grade "free milling" gold bearing quartz were found, but on account of their provisions running short the prospectors were obliged to leave the district, and hurry to the seacoast.

At Wreck Bay, and other places on the island coast, deposits of fine gold have been found associated with magnetic iron sand.

Some $12,000.00 was taken from one claim with rather crude appliances, which should encourage others to test similar black sand beaches.

It is probable that the beach gold has been derived either from lodes a few miles up streams, or from ancient river channels that had their terminations on the coast, in pre-historic times.

Thus far no systematic attempt has been made to ascertain the source of this beach gold.

The association of copper with some of the magnetite outcroppings on the island has led many persons to believe that the extensive magnetite deposits of Vancouver Island are simply the "capping" of large copper deposits at lower levels.

Should future investigation prove this theory to be correct, the possibilities of Vancouver Island as a copper producing country will certainly be remarkable.

Some very promising outcroppings of "cinnabar," containing an admixture of "native" quicksilver, have been found within 100 miles of the city of Victoria, but thus far very little has been done to test the extent or value of the ore-body.

Native arsenic, accompanied by gold, has also been found in well defined veins, but arsenic has apparently no charms for the people of Vancouver Island.

Lack of capital has retarded the development of many promising "prospects" on Vancouver Island, and there is nothing more needed on the island at the present time than a "Development Company," with sufficient capital to bring some of these prospects into the condition of shipping mines.

Americans, who investigate many reported discoveries in Canada, are beginning to turn their eyes towards the undeveloped mineral and other natural resources of Vancouver Island.

It is unfortunate that Eastern Canadian and British capital is not available for the development of Vancouver Island mining property, that in many instances would yield excellent returns on money expended.

More especially is it surprising that Great Britain, who sees her grip weakening upon the World's trade and manufactures, should not seek for reliable information respecting the mineral and other resources of that part of her Canadian domain bordering upon the Pacific

The fact is that at present most of the developed mines of British Columbia are in the possession of United States citizens, while England quietly slumbers and permits her most active and enterprising trade rival to gain a foothold in Canada which may mean much to the British Empire at a later date.

The expenditure of a fraction of the amount lavished upon the South African war, would have been sufficient to secure the development of deposits of economic minerals on Vancouver Island that would yield vast profits to the Motherland, and build up a prosperous British community in a position most favourable for commanding Oriental trade and maintaining British supremacy on the Pacific.

Eastern Ontario: A Region of Varied Mining Industries.

By WILLET G. MILLER, Kingston, Ont.

Numerous papers and reports have been written on the mines and mineral deposits of Eastern Ontario, or that part of the Province which we shall consider as lying east and south of the boundary line between the districts of Nipissing and Algoma. This region embraces all the older settled part of the Province, together with a considerable portion of the newer, or what is now called New Ontario. Although most of us are familiar with one or more special mining industries of this region it probably has not occurred to some of us that those industries are so varied in character. It is the purpose of the writer in this paper to draw attention to the great variety of the mineral deposits which are now being worked in the eastern part of the Province.

It will be seen from this paper, I think, that Eastern Ontario at the present time is producing as great a variety of mineral substances as almost any other part of the world of equal area. We have the variety and we hope and believe that in time the volume and value of our mineral products will compare favorably with those of most other countries of equal extent of territory.

While this paper deals with the mining industries of a part of the premier Province of the Dominion. it may not be out of place to point to the fact that Canada as a whole has a record as a mineral producing country to be proud of. As regards population we must be considered one of the smaller nations of the world. Compared with that of the mother country our population is small. Compared with that of the other English-speaking American nation, our population is almost insignificant, being considerably less than that of their greatest State.

Yet, in spite of this small showing of our population among those of the great nations of the world, we find that Canada stands third in the production of that metal which is and always has been the most sought after by mankind. The United States and Australasia alone lead us in the production of gold. Only seven or eight years ago we stood eleventh on the list of producers of this metal. Judging from this alone, we find that we are making good progress.

Then again Canada is unrivalled as a producer of that widely used mineral, asbestos.

This Dominion is one of the two countries which are practically the only producers of nickel.

In the production of another mineral, mica, which is of great importance in this age of electricity, Canada is one of the three chief producers.

There are also other inorganic or mineral materials, in which as regards value of output or cheapness of production, Canada compares favorably with any other country. But I must not dwell on these.

We hear a great deal about what our country is doing in the production of agricultural and dairy materials, and about our timber and fisheries in comparison with those of the rest of the world. We are glad to know that our cattle were adjudged to be the best on the two continents at the recent all-American exhibition held at Buffalo. Our horses are said to be among the best. Our timber is said to be unsurpassed as to quality and quantity, and our fisheries are acknowledged to be equal to those possessed by any country. We hear ltttle, however, of our relative standing among the nations as a producer of mineral products. The reason for this is, I suppose, owing to the fact that mining men are proverbially modest and are not so much given to advertising themselves as some other classes of their fellow citizens!

I think, however, it will be seen from the statements I have made concerning the place our country occupies as regards its mineral products, that mining men are doing as much for this Canada of ours in comparison to their numbers as any other class of her citizens.

Eastern Ontario is not only a region in which a great variety of mining operations are being carried on, but the region to which the name applies is unique in respect to one or two industries in all America and almost in the world.

In the account of these industries I shall refer briefly to the character óf the deposits now being worked, as well as to the products obtained. In conclusion I shall mention the uses made of some of these products.

NICKEL AND COPPER.

Beginning at the western edge, the boundary between the districts of Nipissing and Algoma, of the region under review, we have the Sudbury nickel mines. These deposits, which have been worked during the last twelve or fourteen years, have been frequently described. The ore consists essentially of phyrrhotite and chalcopyrite, in somewhat irregularly formed deposits associated with basic rocks which are typically hypersthene gabbro. The ore bodies lie at or near the contact of this rock with granite. It has generally been claimed that the ore bodies are of igneous origin., *i.e.*, that the phyrrhotite and chalcopyrite have separated from a molten mass of rock as it began to cool, and were deposited at or near the contact of the granite. This theory of origin is based largely on hypothesis. It is based on the supposition that the granite in contact with the gabbro in which the ore bodies occur is older in age than the gabbro. This does not seem to have been proved. The writer's observations lead him to believe that the granite in contact with the gabbro is never the older of the two rocks. In many cases the granite is clearly younger than the gabbro. That the ore bodies have been the scene of some secondary action is evident from the fact thut veins of pyrite and galena are occasionally found running through the massive pyrrhotite and chalcopyrite. If all the granite in association with the gabbro is the younger of the two rocks, or even of the same age as the gabbro, the ore bodies must be considered to be essentially of secondary and not wholly of igneous or primary origin. In all the other districts in our Archæan with which I am acquainted the granites are usually younger than the older of the diorites and gabbros.

In addition to the chalcopyrite and pyrrhotite, which are the more important minerals in the nickel deposits, other nickel-bearing minerals, such as pentlandite, gersdorfitte, and niccolite are at times met with. Some amounts, frequently merely traces, of gold and platinum, are found in the ore. On the waste heaps copper pyrites is seen to be more plentiful in the rock than phyrrhotite, the latter mineral making up the greater part of the more massive deposits. The analyses of a number of samples, from one property in each of five different townships in the nickel belt, were found to average nickel 2.48 per cent, and copper 0.86 per cent. Many of the deposits, however, run considerably higher than this in metallic contents.

Bessemer matte produced from some of these Sudbury ores was found to have the following composition :—

*Copper	per cent 43.36
Nickel	per cent 39.96
Iron	per cent 0.30
Sulphur	per cent 13.76
Silver	per ton, 7 ounces
Gold	per ton, 0.1 to 0.2 ounces
Platinum	per ton, 0.5 ounce

The deposits are found at different points over a strip or belt of country which is somewhat lenticular in form, its greatest diameter, from S.W. to N.E., being 50 to 60 miles in length, and its breadth in its widest part being something like 25 miles.

There is considerable demand in the Province for iron pyrites as a source of sulphur, but up to the present no method has been adopted for utilizing the sulphur contained in these copper-nickel ores. It may be of interest to see what the value of the sulphur roasted off these ores would be if it could be saved. Let us say that 1200 tons of ore are roasted on the average in the district daily. Pure pyrrhotite contains about 38 per cent in sulphur, but let us assume that the ore averages only 25 per cent. The sulphnr contained in the 1200 tons of ore would amount to 300 tons.

Since it takes about eight tons of ore to produce one ton of matte, the 1200 tons of ore will represent 150 of matte. Following the analysis just quoted, let us say that the matte contains 14 per cent sulphur, or the 150 tons of matte contain 21 tons of sulphur. Deduct this 21 tons from the 300 tons, and we find that 279 tons of sulphur, approximately, are driven off from the ore on the roast heaps and in the smelters daily.

Iron pyrites, containing 50 per cent. sulphur, sells at about $5.00 per ton. Or one ton of sulphur, contained in two tons of iron pyrites, is worth $10.00. On this basis the 279 tons of sulphur in the pyrrhotite wonld be worth $2790 if it could be saved, or the 300 tons, the amount

*Min. Ind., Vol. III, p. 460, and Bur. Min. Ont., Vol. IX, p. 218.

of sulphur contained in the 1,200 tons of ore, would be worth $3000. While the percentages made use of in this calculation are only approximately correct, they will serve to show roughly the amount of sulphur which is lost.

Of course the same loss of sulphur takes place at other metallurgical works in different parts of the world. It would seem, however, that there is a good field for experiment here with a view to saving the sulphur. Moreover, there is another object in not driving the sulphur into the air in such cases. It is a nuisance to the inhabitants, as it pollutes the air they breathe and destroys the vegetation over a considerable area, giving the country in the course of time so desolate an appearance that its effects are well compared to those produced by a recent lava flow, not a blade of vegetation to be seen.

In hand specimens the Sudbury ore is difficult to distinguish from those of some of the Rossland, British Columbia, ores. In one case the ore is valuable as a source of nickel and copper, while in the other gold and copper are the metals sought for. If a Sudbury prospector had been the first to discover the Rossland deposits, he would likely have been keenly disappointed if on analysis no nickel was found in them.

Other deposits of pyrrhotite occur in the more eastern part of the Province, but they are associated with rocks of a different character from those of Sudbury, and contain no commercial amounts of nickel.

IRON.

Proceeding eastward from Sudbury iron ores are met with in the district bounding Lake Temagami on the east and west. These ores have had very little work done on them up to the present, but judging both from the wide extent of country over which the iron-bearing rocks are found, and also from their character, the district should contain deposits of value. The iron-bearing formation here, I may say, is similar to that of the great mining districts of Michigan and Minnesota, the ore being associated with jasper and related material. During the coming summer, the Ontario government is to begin building a railway through the Temagami district This will greatly facilitate the prospecting of the iron ranges.

In the more southern and eastern parts of the region under review iron ore deposits are found over a large territory. These ores occur in deposits of different character from those just referred to, and have been worked at different times. In a paper published in last year's proceedings of this Institute I gave an account of the iron ore fields of the Province, and it is not necessary for me to review the matter further here.*

GOLD.

Eastern Ontario produces one other metal, gold, in addition to the three to which reference has been made.

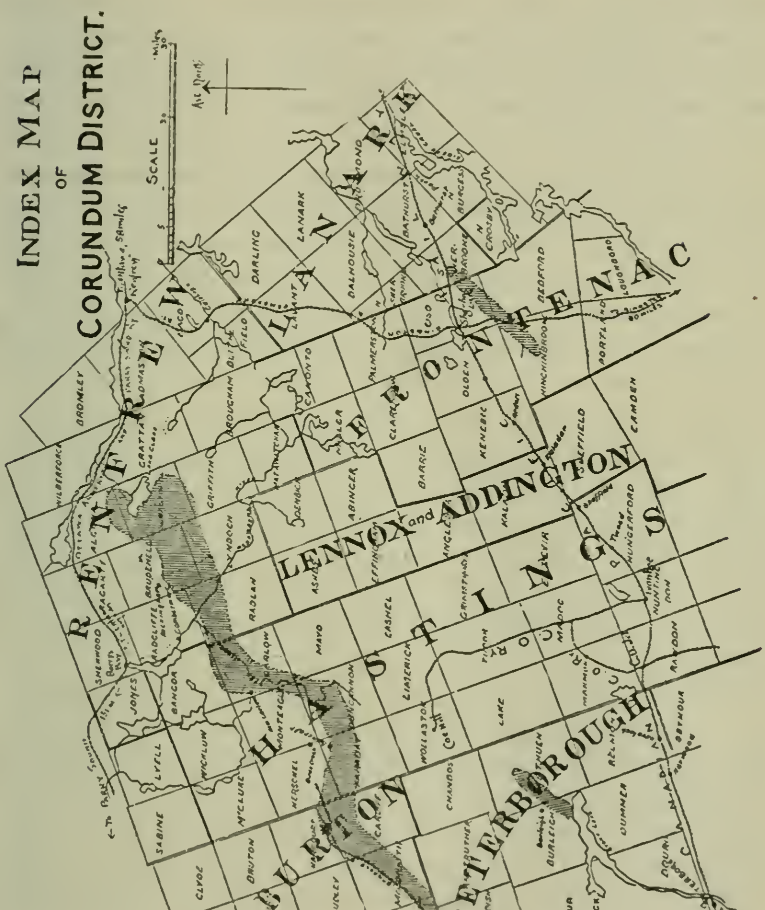
The Wahnapitae district, which lies to the east of Sudbury, has attracted much attention as a gold field. A few years ago a number of deposits were opened up and some very rich ore was produced. Systematic work has been done on one property during the last year with very satisfactory results.

The placers along the Vermilion river, in the region to the northward of Lake Wahnapitae, judging from official reports which have been made on them to the government, seem to be worthy of more attention than has been given to them.† The region in which these placers are situated is difficult of access, and mining operations have thus been impeded, as they appear to be suitable for working only by large plants, and are not "poor man's diggings." During last summer work was done, I believe, by one company.

The only part of Eastern Ontario, however, in which gold is being produced is what is generally called the Hastings district. A strip of country in this district stretches from the eastern edge of Peterborough county in a direction north of east across the northern part of the counties of Hastings, Lennox and Addington, and Frontenac. Historically the district is interesting on account of the fact that through it attention was first directed to the Province as a gold territory. Morals of a mining nature may also be drawn from its history in connection with the various schemes and attempts which have been made to pro-

*Iron Ore Fields of Ontario, also Iron Ores of Nipissing, Vol. X, Bur. Mines Ont.

†Reports Ont. Bur. Mines, Vol. VII, pp. 256 to 259, and Vol. X pp. 151 to 159.



The lower part of this Map shows the location of the Eastern Ontario gold belt which runs north of east from the Township of Belmont, in Peterborough County, across the Counties of Hastings, Lennox and Addington, and Frontenac.

Map by W. G. Miller, 1898.

duce the precious metal. It probably would have been much better for the Province if the precious metal had escaped observation for 20 or 25 years after its discovery was made, when mining methods were better understood and we had a population which had had experience in other fields.

In addition to glacial and recent deposits, there are four important types of rocks in connection with this gold belt. These are Silurian limestone, which overlies the Archæan uncomformably, being deposited on the eroded surface of the latter, together with granite, diorite, and crystalline limestone. The latter rock frequently possesses a highly schistose structure, and is spoken of as calc schist. Under the name diorite are grouped a variety of massive and schistose representatives.

The granite is the youngest of the crystalline or Archæan series, and is found cutting through both the diorite and the crystalline limestone. Of the latter two rocks the diorite in the eastern part of the belt is the younger, as dikes of it penetrate the limestone. Along the western portion of the belt the relations are not quite so clear, although it would appear that the same relation holds. It is possible, however, that some members of the diorite series are of different age from the others.

The gold deposits are in most cases associated with the diorite, and frequently occur near the contact of this rock with the granite. When occurring at or near the contact the ore is essentially composed of mispickel and quartz. A few deposits in the eastern part of the belt are found at or near the contact of diorite with crystalline limestone, and are also high in mispickel. The Belmont mine, which is situated well within a diorite area, contains pyrite in place of mispickel.

The ore bodies situated near the contact of diorite and granite are evidently of later age than the younger of these rocks, as they cut across both of them. The cavities in which the deposits are found appear to have originated first as narrow cracks through the shrinkage of the granite mass on cooling, and to have been afterwards enlarged through the agency of water.

The Belmont mine, in the township of the same name, which has been in operation some years, has a recently erected 30-stamp mill and a cyanide plant for the treatment of concentrates. The Deloro mine, in Marmora township, is running a 20-stamp mill, and has a bromo-cyanide plant for the treatment of its concentrates. This plant and the method of treating the ores, were described in two papers in last year's transactions of this Institute, and need not be further referred to here.* The Atlas Gold and Arsenic Company have a 10-stamp mill and are working properties adjacent to the Deloro and others more distant.

Details concerning the development work done at these mines, and the character of their plants, will be found in recent publications.†

ARSENIC.

The Deloro mine, in the township of Marmora, Hastings County, is unique in being the only mine in Canada which is a producer of arsenic. The arsenic occurs in the mispickel, and is associated with gold, as already stated. About 80 tons of white arsenic or arsenious acid are produced monthly by this mine, and by far the greater part of the product is shipped to the United States.

The arsenic plant presents an interesting sight to the visitor. In looking at the piles of the innocent appearing white powder one can hardly realise that it is anything but wheat flour.

Many of the workmen in the plant have their faces painted with ferric oxide, which acts as an antidote to the poisonous fumes. When I first visited the mill, I wondered why the manager showed such a preference for birth-marked men or where he succeeded in getting so many of them. It did not strike me at first that the coloring of their faces was artificial.

There are a number of other important mispickel properties in the district, among which are those controlled by Mr. W. A. Hungerford and associates and others in the vicinity of Deloro, and those belonging to Mr. Joseph James. The latter are situated near the village of Actinolite.

* "The Treatment of Auriferous Mispickel Ores," by Messrs. P. Kirkegaard and Sidney B. Wright. Vol. IV Canadian Mining Institute.

† Reports Ont. Bur. Mines.

The arsenic industry is only in its infancy in this district. Under favourable conditions it should be developed to such an extent that the American market will be controlled by this Province, and an important foreign trade in other parts of the world should be secured. The district is easy of access to the chief markets for arsenic in the United States, and is well situated as regards European trade.

Some of the numerous uses made of the compounds of arsenic will be referred to towards the end of this paper.

PYRITE.

Iron pyrites has been mined quite extensively during the past year, in the vicinity of Bannockburn station, on the Central Ontario Railway, in Madoc township. The work is carried on by an open cut. The associated rock is of a talcose nature, but the ore body, which has a considerable width, is pretty free from intermixed rock matter.

The deposit was first worked as a bog ore, the pyrites being decomposed at the surface. A short distance down, however, the bog ore was found to pass into pyrite.

No doubt there are many other workable deposits of this mineral in the Province. As, however, the mineral tends to weather more rapidly than the surrounding rocks, the deposits often occur in low ground and thus escape observation.

CORUNDUM.

Eastern Ontario is the largest producer of pure corundum in the world, and possesses what there is every reason to believe are the largest known deposits of this mineral. Before the opening of these mines it was impossible to buy corundum in any quantity on the market, although strenuous attempts had been made to obtain a supply in different countries. At the present time, I am told, Ontario corundum is alone used by Canadian manufacturers of abrasive goods, and a large market is being found for it in the United States. It is also gradually being introduced into Europe.

The only plant so far erected in the Province for the concentration of conundrum is located in the township of Raglan, Renfrew

County, the product being shipped *via* Barry's Bay, a station on the Canada Atlantic railway.

Corundum is found in the district as a constituent of igneous rocks which embrace the ordinary varieties of syenite, together with syenite pegmatite, nepheline syenite, and anorthosite. The localities in which the mineral occurs, together with details concerning its modes of occurrence, will be found in different reports published by the

Concentration Plant of the Canada Corundum Co., Raglan Township, Ont.

Provincial and Dominion Governments.* An account of the process employed in milling and concentrating the mineral is given in a paper by another writer presented at this meeting of the Institute.

MICA.

The south-eastern part of Ontario, together with some of the adjacent territory of Quebec, is well known as one of the world's chief producers of mica. It may be well to contradict a statement here, which I recently saw in a text-book on economic geology, to the

* Reports Geol. Survey, and Vols. VII and VIII Bur. Mines, Ont.

effect that all the mica of commerce is the variety known as muscovite. This mica is the product of the mines of India and North Carolina and some other countries, but the variety produced in Ontario and Quebec is phlogopite. On account of its color our mica is known in the trade as amber mica. It is claimed to be softer and better adapted to electrical purposes than muscovite. The clear white color of much of the latter, however, makes it a more suitable material for decorative purposes, such as for use in stove fronts, than the amber mica. The demand for the mineral in electrical works is, however, by far the more important.

Amber mica is found in irregular shaped deposits associated with calcite, pyroxene, apatite, and other minerals, some of which occur in very large crystals. These deposits are of secondary or aqueous origin, while white mica and other varieties of muscovite are obtained from dikes of pegmatite or coarse grained granite, which are of aqueo-igneous origin. Years ago, when phosphate or apatite was much sought after in the Province, the mica found associated with it was considered of little value, and much of it was thrown in the waste rock heaps. This was, of course, before the great electrical development which has taken place during the last few years. Recently many of these dumps have been worked over, and the mica has been carefully sorted out. During recent years, since the fall in the price of phosphate, the most of what little of this material has been produced is a by-product of the mica mines.

At the present time two very important mica mines are in operation in Frontenac County. One of these, operated by the Messrs. Kent and associates, of Kingston, is known as the Kent mine. The other is generally known as the Lacey mine, since the deposit now being worked is not many feet distant from this mine, which was operated a number of years, and was one of the greatest producers ever worked in Canada. The amount of mica in sight in the mine at the present time is said to be greater than any ever before uncovered in the country. Crystals of mica of very large size are obtained. In the old workings crystals six feet in diameter were met with. This mine is situated a few miles from Sydenham village.

The product from the Kent mine is shipped to Kingston, where it is prepared for the market. This company is reported to have lately begun to utilize the small pieces or scrap mica produced in their works. The scrap is split up into thin layers, and these are cemented together into large sheets which are said to answer well for use in connection with some parts of electrical machines where heat and friction are not great.

Another important use for scrap mica is in the manufacture of coverings for boilers. This invention was patented by some residents of Canada a few years ago. That it is of much commercial importance is seen from the fact that the company manufacturing the covering were given the highest award obtainable, a gold medal, at the recent Pan-American exhibition. India is said to produce one-half of the world's supply, and Canada and the United States about one-quarter each. The United States consumes more than one half, including all its own, the most of the Canadian, and a large fraction of that of India, the amount of Canadian and Indian mica imported each being about equal to the home product. The remaining Indian mica goes almost all to England, and is there partially re-shipped to Germany and France, the only other users of consequence.

TALC.

Eastern Ontario has, I believe, the only talc deposit in Canada which has been a producer. Within the last year or two this mineral has been mined in tne vicinity of the village of Madoc, and a considerable quantity of it has been shipped to the United States. The quality of the material has been reported to be good and the deposit appears to be of large size, little waste material being produced in mining. The deposit is associated with crystalline limestone.

GRAPHITE.

As long ago as the Centennial Exhibition of 1876 the Province of Quebec made a good display of graphite and articles produced from this mineral. But for some reason, probably owing chiefly to trade prejudices, Canada was not able for many years afterwards to develop a graphite industry of any importance. Within the last three or four years, however, a graphite deposit of large size has been developed in

Renfrew county, a few miles from Calabogie station. Up to the present time the mineral has been marketed only in the crude state. That the mineral is of high quality is evident from the fact that as much as five dollars per ton is said to have been paid for drawing it from the mine to the railway station in summer. Nothing but a substance of the first grade would stand such an initial expense in competition with that of older mines in other countries. A large plant for refining the mineral is now being erected at the mine, and the property will be worked under much more favorable conditions.

FELDSPAR.

This is the youngest and hence may be called the baby mining industry of Eastern Ontario. Some 4,000 tons of feldspar were mined last winter, a short time after the deposit was opened up. This quantity was all sold in the United States during the season of lake navigation. At the present time the owners are engaged in mining some 7,000 tons to fill contracts that have been made, and expect that within the next few months they will have sold double this amount.

Attempts have been made over and over again to develop a feldspar industry in Ontario, but without success till last year. Success would not have been achieved even now had the problem not been in the hands of thoroughly trained business men. The item of freight is a very important one, as the margin of profit is not large in any case.

Considerable difficulty was met with in trying to market the material, owing to the fact that many of the large users of feldspar were found to be working deposits of their own and tried to discourage the mining of the mineral in this country.

The deposit which is now being worked in Ontario is situated near Bedford station, on the Kingston and Pembroke railway, and is of very large size. The feldspar occurs in large masses remarkably free from quartz and other minerals. That it is of a superior quality is evident from the fact that orders have been received from some of the largest pottery companies in the United States, now that they have found that other companies are using the Ontario material and that it cannot be kept out of the market.

The same difficulties in gaining a market in Great Britain have been met with as were encountered in the United States, but it is believed that in the near future an important trade will be established with the United Kingdom.

The following are analyses of specimens from different parts of the deposit :—

	(1)	(2)
$Si\ O_2$	65.40	66.23
$Al_2\ O_3$	18.80	18.77
$Fe_2\ O_3$	Trace	Trace
$Ca\ O$	....	0.31
$Mg\ O$	....	....
$K_2\ O$	13.9	12.09
$Na_2\ O$	1.95	3.11
Loss	0.60	....
	100.65	100.51

ACTINOLITE.

While feldspar may be called the newest of the mining industries of Eastern Ontario, the mining and grinding of actinolite can be put down as the oldest, since this industry has been going on continuously since 1883. Of course in making this statement I leave out of consideration the production of lime and other materials which are produced in small amounts in numerous places for local consumption. Moreover, I refer only to those substances which are derived from deposits in crystalline rocks.

At what is now the village of Actinolite, formerly Bridgewater, in Hastings County, actinolite, together with other minerals, is mined and ground for use as a roofing material. During the last twenty years large quantities of it have been shipped to the United States, and the composition made of it has been used on some of the largest buildings in Chicago and other leading cities.

CEMENT.

Another industry of a mineral character and of great and growing importance in building operations and engineering works is that of Portland cement. Ten years ago this industry was in its infancy, and there were strong prejudices against the use of material of domestic production. During the last two or three years a number of large factories have been erected. The cement produced in the Province is now known to be of as good quality as is to be obtained anywhere.

As, however, the materials used in the production of cement are not derived directly from our crystalline rocks, I shall not refer further to it, it being necessary, in order to keep this paper within reasonable limits, to restrict it to substances produced in areas underlain by our older or Archæan system. For the same reason I shall pass over our clay industry, which is destined to become a very important one, and has up to the present been comparatively neglected. Most of our building stones also come from our newer rocks.

Then there are the important mineral industries, petroleum, natural gas, salt, and others, to which time will not permit of more than a mere reference.

I think, however, that I have shown that Eastern Ontario has as great a variety of mining industries as probably any other area of the earth's surface of equal extent, although I have omitted reference to some of the least important industries.

I have not referred to the uses of the minerals which I have mentioned, wsth the exception of one or two. In concluding I may be permitted to notice them briefly.

The metal nickel, the production of which has probably made the Province more widely known than that of any other substance, has many uses. It may be called the metal of defence, since it is being adopted so rapidly as a constituent of steel for use in armour plate by the navies of the world. As a constituent of steel required for ordinary purposes it has a wide field of usefulness. Then there are its uses in plating and in coinage. It seems to me that since Canada is such an important producer of the metal we should have a distinctively nickel coin.

It is necessary for me to refer but briefly to the uses of copper, whch our Province produces along with nickel and from other deposits. In pre-historic times, before the advent of the iron age, copper was the metal chiefly used in the production of tools and articles of every-day use. In later ages it occupied a much less important place in the industries than iron. In recent years, however, as in the early ages of human history, copper has become an indispensable metal. In our present state of development we could not do without iron, and the same may almost be said concerning copper. We are now in what is

Concentration and Refining Plant in course of erection at the Black Donald Graphite Mine, near Calabogie.

sometimes called the age of electricity, and if our supplies of copper were suddenly cut off we can hardly conceive of the state we would be left in, at least until some substitute were found for the metal.

Of the other metal to which I have referred in this paper, it may be said that it has apparently been the metal most eagerly sought after by the race of man throughout all ages, alike by barbarians and those in higher states of civilization. Much has been written of its uses and abuses. However, I think it can be said that, with all the ill uses to which it has been put, it has proved a greater factor in bringing about the settlement of waste places and in promoting civilization than any other substance, organic or inorganic. Gold-bearing deposits have been the lodestone which attracted population to the wildernesses of Western America, Australia, and Africa during the century just closed. In spite of all endeavors of statesmen and the often quoted missionaries these vast regions would even now have had very sparse populations had it not been for the great promoters of civilization, the men with the pick and shovel in search of gold.

The manufacture of sulphuric acid, which is used in the production of many substances, makes a steady demand for iron pyrites, and I have shown that Eastern Ontario is now a producer of this mineral.

The uses of white arsenic or arsenious oxide, of which Hastings County is becoming so important a producer, are numerous. It is the base of different paints, and is also a constituent of certain varieties of glass. In agriculture it is used extensively as an insectide. In medicine it also finds important application. There is reason to believe that in the future the demand for the material will greatly increase, especially in connection with agriculture.

Just a few words as to the uses of the non-metallic products of Eastern Ontario to which I have referred.

I have stated that we are the greatest producers of pure corundum. This mineral is of great importance in the arts, as it is used in grinding into shape and polishing various parts of machinery of all kinds. At times it is used in the loose or granular form, but most frequently the grains are cemented together in the form of wheels. Some of these wheels can be used only in the dry state, while others are used with water. In the former the binding material is usually soluble glass, while in the latter it is some material which has been fused by subjecting it to a high temperature.

The consumption of mica has greatly increased during late years. This is owing to the fact that the mineral is used very extensively at the present time as an insulator in electrical machines. In addition to this use there is also more or less demand for it in the stove and lamp trade. Mica flour, or as it is commonly called, ground mica, has also recently become an important article of commerce. In this form it is used for coating wall papers, to which it gives a brilliant and lasting lustre. Only scrap or refuse mica is used for grinding. This use of scrap, together with its use in the production of large sheets by cementing flakes together, has made a demand for this material, which was formerly a waste product.

Talc, in the form of flour, is an important substance in the paper industry. It is used as a filler or to give body to paper.

Graphite is used as a refractory material in furnace linings and in crucibles. It is, moreover, a constituent of stove polish, and in addition to other uses, there is a growing trade in paints whose chief constituent is graphite.

Of the many kinds of feldspar the chief one used in the arts is the potash variety or orthoclase. It is usually a light pink in color, and forms the chief constituent of the glaze in pottery and in the body of different kinds of so called earthenware.

Actinolite, as already stated, finds a considerable application as a roofing material.

Of the uses of building materials, cement, clay, and stone, it is not necessary to refer.

The uses of other mineral substances, such as salt, petroleum, and natural gas, of which the southern part of the Province is an important producer, do not need to be mentioned.

Before concluding this paper it may be well, in order to show the standing Ontario has among other American countries as a producer of minerals, to refer to the awards she received on her mineral exhibit at the recent all American exhibition held at Buffalo. These awards were practically all given in connection with exhibits composed of minerals and mineral products from the eastern part of the Province, the region to which this paper relates.

The following is a press account which appeared shortly after the awards were made :

"The official list of awards obtained by the Ontario mineral exhibit, made by the Bureau of Mines at the Pan-American Exposition, shows that the exhibit was not surpassed by any in the Mines Building, if, indeed, there were any which equalled it. Three gold medals, the highest honor conferred at the Exposition, were awarded the exhibit, while, with the exception of Mexico, which also received three, and Chili, which got two, no other State, foreign country, or individual obtained more than one.

"One ot the gold medals was for the excellence of the exhibit as a whole, viewed as a collection of "the economic ores and minerals, maps, and photographs illustrative of the mineral resources of Ontario," and one was for the "installation" of the exhibit, a term which includes the general plan and arrangement of the exhibit, the effectiveness of the display, and the decorations. The Ontario exhibit was the only one in the Mines Building to receive this award, notwithstanding that equally elaborate and much more expensive schemes of installation were adopted by several other of the exhibiting States and countries. Maryland was the only State of the Union to be adjudged a gold medal for a similar collection of economic minerals, the remaining exhibitors who shared the honor being the Governments of Bolivia, Brazil, Chili, and Mexico. The third gold medal granted in the Ontario section was to the Mica Boiler Covering Company, of Toronto and Montreal, on their mica covering to prevent the radiation of heat from boilers and steam pipes. The judges made the awards after a scrutiny of the results of the tests of mica for this purpose in comparison with magnesia and asbestos.

"The next highest form of award was the silver medal, and of these no less than seven fell to the lot of Ontario, one to the Bureau of Mines itself, and the others to individual companies, whose displays formed part of the collection. The very interesting and complete assemblage of gold and arsenic ores and products made by the Canadian Gold Fields, Limited, of Deloro, Hastings County, was unique of its kind in the building, and was very properly granted a silver medal. The magnificent collection of copper-nickel ores and products shown by the Bureau of Mines, to which the Canadian

Copper Company and the Orford Copper Company were the chief contributors—and which was probably the most imposing exhibit of the kind ever made, some of the specimens of ore weighing as much as five tons—also won the silver medal. The Orford Copper Company's exhibits of refined nickel and copper from Sudbury matte, as well as

Faulted Corundum Crystal in Felspar.—Craig Mine, Raglan Township, Ont.

nickel goods and nickel-steel, were very instructive, and the whole display was well calculated to draw attention to the nickel resources of Ontario. Other silver medals were awarded to the Canadian Corundum Company for a comprehensive display of corundum ores and products, which well set out in its wealth of material the abundance of the newly opened stores of this useful substance possessed by the Province; to the Hamilton Steel and Iron Company for iron and steel shapes, angles, bars, etc., with iron ores; to the Lake Superior Power Company, Sault St. Marie, for pig iron, ores, charts, and an electrically illuminated and very effective map of Northern Ontario; to the Milton Pressed Brick and Terra Cotta Company, Milton, for an exhibit of pressed brick and terra cotta, which took the form of an arch specially designed and manufactured, forming part of the scheme of installation; and to the Ontario Graphite Company, of Ottawa, for the handsome exhibit of graphite, comprising blocks of unusually large size, and forming the shaft on which rested the emblematic statue of Canada, made by Mr. J. L. Banks, of Toronto, the centre round which the whole Ontario collection was grouped.

" Of bronze medals, the next highest form of award, six fell to Ontario's lot. One of these went to the Nickel-Copper Company, of Hamilton, for an exhibit of ores and products illustrative of the various operations in the reduction of nickel and copper by the Frasch process, an interesting and significant display; one to the Bureau of Mines, for an exhibit of raw mica, including muscovite, phlogopite, and biotite; one to the Imperial Oil Company, of Sarnia, for a display of Ontario petroleum and its products; a fourth to the Peat Development Syndicate, Toronto, for an exhibit of peat and its products, drawing attention to an industry which promises to become one of great importance to Ontario in the near future; a fifth to the Stewart Granite works, of Hamilton, for carved and polished syenite, a handsome block from a quarry near Gananoque; and a sixth to the Caledonia Springs Natural Mineral Water Company, for mineral waters.

" On the honorable mention list were five of the exhibitors in the Ontario section. Dr. R. A. Pyne, M.P.P., Toronto, received this award for graphite and products, the output of a mine near Oliver's Ferry, on the Rideau Canal; James Richardson and Son, Kingston, for felspar, shown in immense blocks of fine quality; the Crown Corundum Company, of Toronto, for corundum ores , the Queenston Quarry Company, St David's, for cut limestone blocks for building purposes ; and the Canada Iron Furnace Company, of Midland, for iron ores and pig iron.

" In addition to full recognition of the merits of the Ontario collection as a whole, the awards received covered almost every mineral product of importance in the display. Gold, arsenic, nickel (two awards), copper, iron, including ores and manufactures (three awards), corundum (two awards), pressed brick and terra cotta, graphite (two awards), mica (two awards), petroleum, peat, building stones (two awards), felspar, and mineral water were singled out for awards of varying degree. In all, three gold medals, seven silver medals, six bronze medals, and five honorable mentions were adjudged the exhibit, a total of twenty-one awards. Owing to the method of making and announcing the awards, it is hardly possible to institute comparisons with other exhibits, but an inspection of the list leads to the conclusion that Ontario has done very well indeed. Certainly no State of the Union fared better and probably none as well. There was no Canadian representative on the Board of Commissioners who made the awards."

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The Iron-Bearing Rocks of the Nastapokan Islands.

By G. R. Mickle, M.E., Toronto.

The location of the Nastapokan Islands will be seen from the accompanying map (Fig. 1). They extend from Richmond Gulf northwards in a chain about 100 miles long, and consist of fourteen large islands having areas ranging from about 1 square mile up to probably 25 or 30 sq. miles. Besides these large islands there are many small ones, some being mere rocks projecting out of the water.

From about Cape Johnes northwards, the coast and islands are built up of a set of rocks consisting mainly of sandstones, varying in size of grain, and generally having a light gray or white color; along with the sandstones and subordinate to them in quantity are some slates and shales and limestone or dolomite, and in places chert and jasper. The sandstones are overlain by basalt. The beds of sandstone lie almost horizontal, dipping only slightly to the west. These rocks have been named the Manitounick series by the Geological Survey. The following illustrations will give an idea of their appearance. (Figs. 2 and 3.)

On most of the Nastapokan Islands there is no basalt, and the structure of the islands will be understood by referring to the two imaginary sections given. In Fig. 4, starting from the left hand or west side, and going eastwards, one would first go up a gentle slope, then there would probably be a fresh water lake, and after that a rise towards the east covered with moss, and a steep bluff on the east shore. There are in places indentations on the east coast of the islands, forming safe harbors. Fig. 5 shows an imaginary section through one of the high prominent bluffs on the east coast. Figs. 6 and 7 convey an idea of the general physical features of the islands. In places on the Nastapokas there is a very large development of jasper rock, the beds being sometimes 40 ft. thick, and even up to about 100 ft. Fig. 8 shows a bed about 40 ft. thick.

Besides the jasper, two types of iron-bearing rocks exist on the

Plate I.—Illustrating paper by Mr. G. R. Mickle, M.E., on "The Iron-Bearing Rocks of the Nastapoken Islands."

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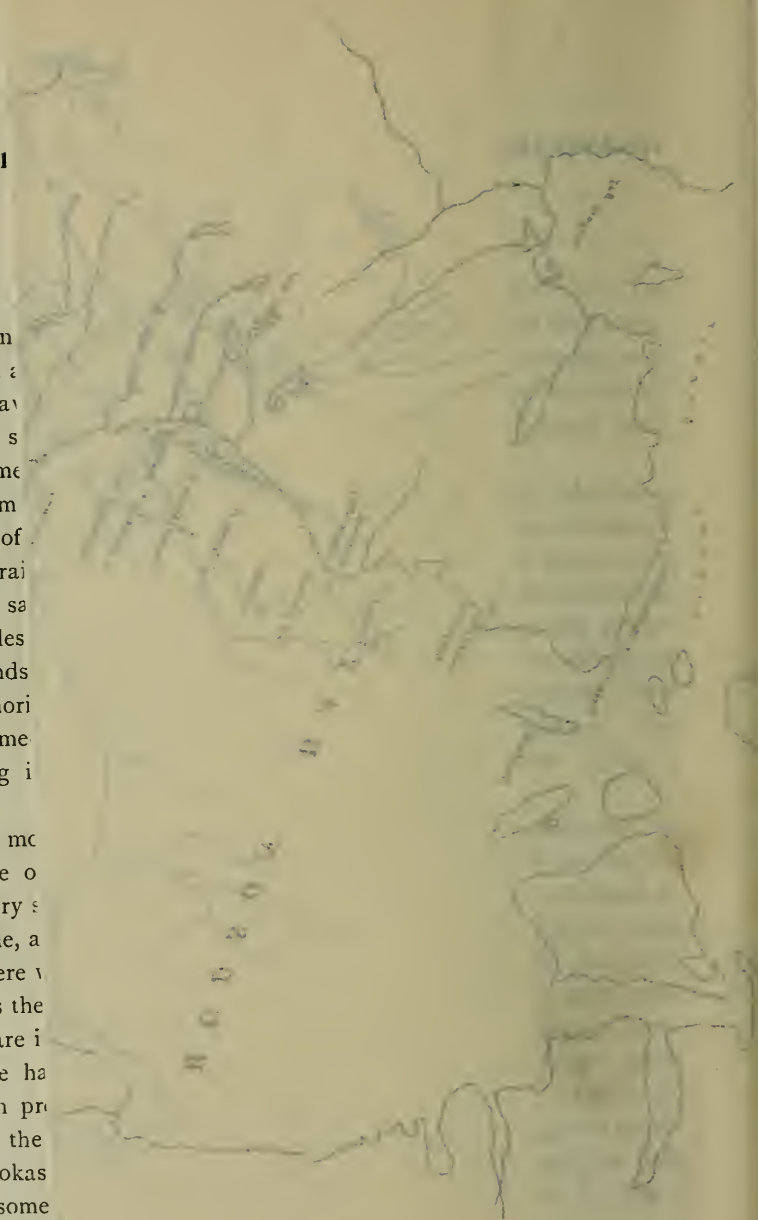

Nastapokas, viz.: a hard stratified hematite-magnetite siliceous ore, and manganiferous iron carbonate; both of these appear to occur as local enrichments or concentrations of metal in the rock in certain layers, the metal gradually diminishing in quantity in all directions horizontally, and therefore merging into barren rock again without having any well-defined boundaries or walls. In the case of the hematite-magnetite rock, it was sometimes jaspilite, and sometimes sandstone that was enriched. These concentrations of iron in the rock sometimes covered large areas, such as about quarter mile by half a mile, in one place, or 500 ft. by 600 ft. in another. In the largest areas discovered about three-quarters was rock, and in the best from one-third to one-half rock. In the case of the best, the hematite and magnetite was interbanded with jasper, in places the jasper almost disappeared, but nowhere did this state continue long, the rock replacing the ore again within the distance of 10 to 40 ft. For example, in one spot which showed, as nearly as could be judged, the jasper and ore in their average relative proportions, out of a total width of 72 in. the jasper bands aggregated 38 in. In this place the area might be taken as 600 x 900 ft. and thickness 6–7 ft. Fig. 10 shows the hematite.

The manganese-iron carbonate ores occurred in a similar manner to the oxide ores already described, sandstone being replaced in parts by the metallic carbonates, forming thus a low-grade ore. The sandstone occurs always in bands of varying thickness followed by alternate layers of the carbonate ore. In one of the largest exposures of ore (see Fig. 11) taking measurements over a 62 ft. face, the sandstone bands aggregated 40 per cent. of the whole; as the carbonate streaks in themselves are not pure, the percentage of metal in the whole mass would be further reduced. This type of ore also showed the same lack of continuity as the oxide ores, the metallic portion gradually vanishing and being replaced by barren sandstone. The concentration or enrichment usually extended only two or three hundred feet. This class of ore, weathering as it does on all exposed surfaces to a rusty brown color is very conspicuous, and in the distance the loose fragments formed by the shattering action of the frost and weather on rocks of this nature present a very alluring aspect and give the impression of immense beds of iron one.

Fig. 11 shows bed of carbonate ore, interbanded with sandstone, the light streaks being sandstone; Fig. 12, the shattered carbonate ore.

The following analyses were obtained from what appeared to be the best bed of ore of the carbonate type, as not only was the sandstone less prominent, there being no pure sandstone bands mixed in with the ore, but from the striking color to which it weathered—almost black—it seemed possible that the percentage of manganese might be fairly high. A more minute examination showed that there were certain streaks consisting of the carbonate and siliceous matter intermixed; these will account for the high percentage of silica obtained. The thickness of the bed varied from 6–7 ft. and extended about 300 ft.; after this decreased in size and finally went down to nothing.

	No. 1.	No. 2.	No. 3.	No. 4.
Manganese	3.47	3.35	3.97	3.41
Iron	33.35	30.82	33.76	34.07
Silica	23.05	23.20	22.94	21.98
Phosphorous	.024	.031	.091	.018

The peculiar dark color to which these rocks weather is deceptive. This color is further increased by heating strongly. Numerous tests made by heating this ore in an open wood fire showed that even with the small percentage of manganese present it turns almost black. Other samples which showed less than 1 per cent. manganese on analysis were still darkened more than the iron carbonate would be by heating.

Unfortunately, even allowing the best prices quoted for the manganese and iron, these rocks are too low grade to work, being ruined by the high silica contents.

From the description given of the iron rocks on the Nastapokas it seems evident, I think, that the iron was laid down contemporaneously with the enclosing rocks. There is no evidence of any veins or dykes or any serious disturbance of the original horizontal layers, and therefore the conditions which have been found elsewhere necessary to the formation of rich ore are lacking here.

Manitounick Series, Manitounick Sound.

General View, Nastapokas.

Nastopokan Islands taken from 12th Island, looking North.

Imaginary Section through High Bluff on East Coast of Nastapokan.

Imaginary Section through one of the Nastapokas.

Typical Scene East Coast of Hudson Bay.

Stratified Hematite-Magnetite Ore.

Jasper at Nastapokas.

Jasper at Nastapokan Islands.

Iron-Manganese Ore, showing Stratified Masses.

Manganese Iron Ores, showing Banded Structure.

The Harris System of Pumping by Compressed Air, as applied at the Deloro Mine.

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By J. P. KIRKGAARD, Deloro, Ont.

The raising of *water* from mine workings is often a serious problem, and always a heavy cost on mining, even under favourable conditions; this subject, therefore, is a matter deserving of serious consideration.

At the Deloro Mines, Hastings County, Ontario, a shaft was being sunk which had an inflow of water amounting from 400,000 to 500,000 gallons per 24 hours. To deal with this amount of water by the then existant plant of " direct-acting steam pumps " was both slow and costly.

The greater part of this water flowed into the mine through and along the footwall, at the south end of the ore chute, and from thence to the lower workings, where the shaft was to be sunk.

The writer conceived the idea of impounding most of this water, making a permanent pumping station on the third level, and thus practically leaving the lower workings dry. An old shaft at the south end of the ore chute, being admirably situated to suit this purpose, was selected.

The bottom of this old shaft was 47 feet below the second level and full of water, and 35 feet above the third level, which latter had already been driven under and past this shaft.

The work preparatory to the installation of this pumping system was as follows :—

A chamber 30 x 15 x 12 feet was blasted out on the third level immediately under the bottom of the old shaft, and all necessary preparations made for constructing a dam to prevent the water from flowing into the third level. This being done an upraise was made to the bottom of the old shaft, thus unwatering the shaft.

While this work was in progress investigations were made of the several types and varieties of pumping engines. The direct-acting pump was out of the question. Plunger pumps driven by compound-condensing engines seemed the best in this line of pumps, but the situation was such that, should anything happen to the pumps or engine, they would be drowned before repairs could be effected.

The next thing presenting itself as suitable was the "Harris" system of lifting water by direct air pressure.

Not only did this system promise great economy over previous installations, but its construction was such that no machinery was required in the mine, other than two tanks and some pipes connecting them with the machinery on surface: and with this system there could be no drowning, no matter what happened to the surface equipment.

The objections against its adoption were these, viz., its greater first cost compared to other systems, and secondly it was an untried system as applied to a comparatively high lift mining installation. However, against these, its simplicity so appealed to the writer that it was finally adopted.

The two tanks, 4' x 20', were placed in the "sump" or "chamber" on the third level, the pipes connected to surface and the dam built.

The reservoir thus made, (that is the chamber at the bottom of the shaft 30' x 15' x 12', and the shaft itself, being 82 feet below the second level, and 9' x 15' in cross section) altogether gave a storage capacity of 130,000 gallons approximately, thus permitting the engines at surface, if so desired, a period of from 6 to 7 hours rest, without any fear of the water finding its way to the lower workings.

This arrangement has proved very satisfactory and has been a strong factor in reducing the cost of operations, not only in shaft sinking, but also in stoping; these places now being dry, comparatively speaking.

It had also reduced the cost of raising water from 25 to 30% on former cost—part of the economy being in fuel, but mainly in labor and repairs.

Formerly it was necessary to have a pump man constantly attending the pumps: now this service is entirely dispensed with. It will be apparent from what has been said, that this system is only applicable as a "stationary pump," but as such, it is, in the writer's opinion, very satisfactory.

The "Harris" system of air-lift, is composed of two tanks in the mine, which are connected by two air pipes to an automatic switch located in the engine-house at surface, the switch in turn, being connected with an air compressor.

The principle of the system is simplicity itself, although not easy of explanation.

A "cross compound" "steam and air" of the Rand type, class B, compressor is placed at a suitable location at the surface, and two tanks, 4′ x 20′ each, are placed in the mine—the air compressor and tanks are connected by two air pipes, and between the air compressor and the tanks at a suitable point near the compressor a switch is located.

This switch serves the purposes of changing the inflowing air from one tank to the other at regular intervals; these intervals are termed "cycles."

The duration of the cycle may be varied from 2½ to 6 minutes, to conform to the amount of the water to be raised; these variations are governed through the amount of air forced into the system.

If there is only a limited amount of water to be raised, (and there is no object in maintaining a constant supply) provided that the sump, or reservoir is of sufficient capacity, the engine may be stopped for a time and again started by simply turning steam on the compressor, the switch at once resuming its functions, no attention being required at the tanks in the mine.

As regards the air, the system is "closed" or return pipe system, *i.e.*, the same air is used over and over again, returning to the compressor at the end of each cycle for compression, ranging in pressure from that required to do the work, to that which equals the pressure due to the head of water around and above the tanks.

The greater the head above the tanks the greater the economy.

In this feature is the chief economy. The tanks are so connected that they receive air and water alternately, when one receives air and delivers water, the other receives water and delivers air.

It will thus be seen that the air is not brought up to working pressure from the atmospheric pressure, as would be the case in the ordinary air compression.

Attention should be drawn to the fact that the only moving parts in the mine are the inlet and outlet valves at the tanks.

These valves only move once for each cycle, and as near as can be ascertained by listening to them, they open quickly but close gradually, hence the wear is slight. In this case they have never caused any trouble.

In the particular plant under review 96 pounds air pressure is required to force the water through an 8-inch pipe to the mill tank, a vertical lift of 208 feet. The "lift" is kept running steadily night and day in order to supply the requisite water for mill purposes, also for condensation purposes in the compressor house for the condenser of the air lift, and also another pertaining to a 20-drill compressor.

As before stated, the air is forced into the system at 96 pounds pressure, and after the completion of the cycle it returns through the switch into the low pressure air cylinder at a pressure of 65 pounds, immediately after switching, and gradually decreases in pressure through the cycle to zero, or the pressure of the atmosphere: on reaching this point and the compressor still running and having no other source of supply, (it should be noted that there is a small loss of air through leakage and the working of the switch, as this latter is exhausted into the atmosphere, this loss is made up by a supply of air through a small check valve on a ⅜" pipe, fixed to the low pressure inflow pipe) it follows, therefore, that all the air in the system is extracted, and finally a partial vacuum is created within the tank and pipe line of that side of the system; this vacuum continues to increase until it reaches a point where the atmospheric pressure on the surface of the water overcomes the weight of the inlet valve on the suction pipe connected to the tank, and the water rushes in filling the tank. The vacuum will vary with the height of the water; if below the tank, switching will take place at about 11 inches, if above the tank at 4 to 5 inches or less.

The switch in general appearance resembles a direct acting steam pump, having what corresponds to both steam and water ends. At what would be the steam end, there is a vertical cylinder serving the purpose of the valve, in this works a piston. The space above the piston is directly connected with the air inlet of the compressor, but the space

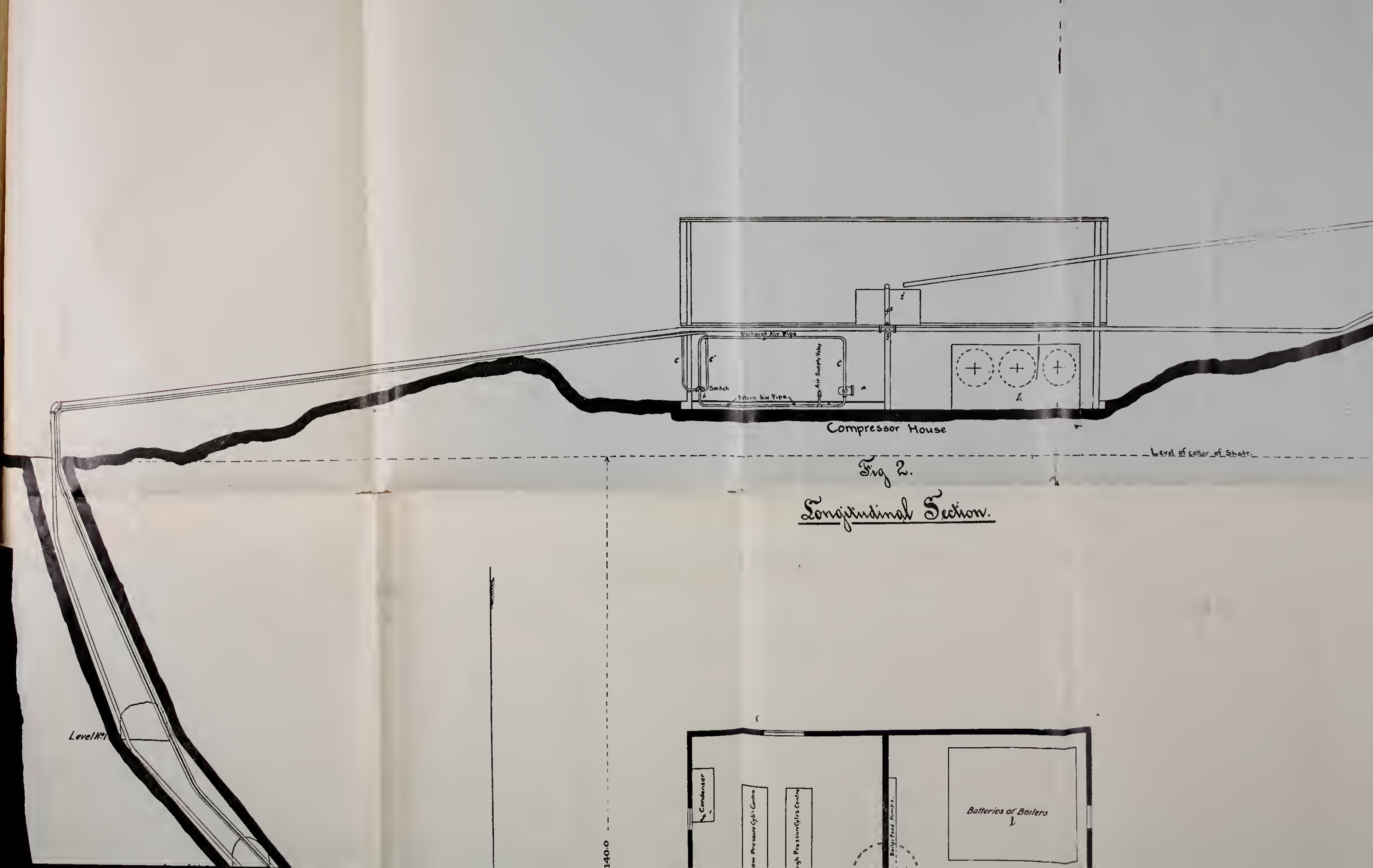

Fig 2.

Longitudinal Section.

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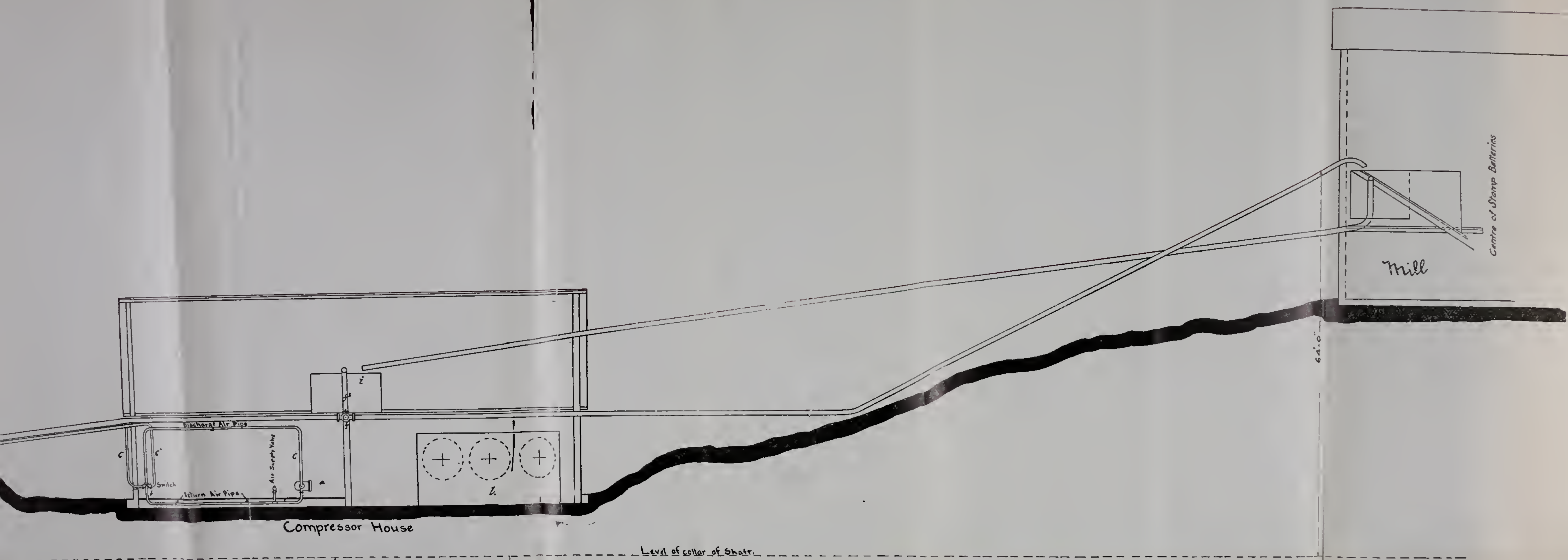

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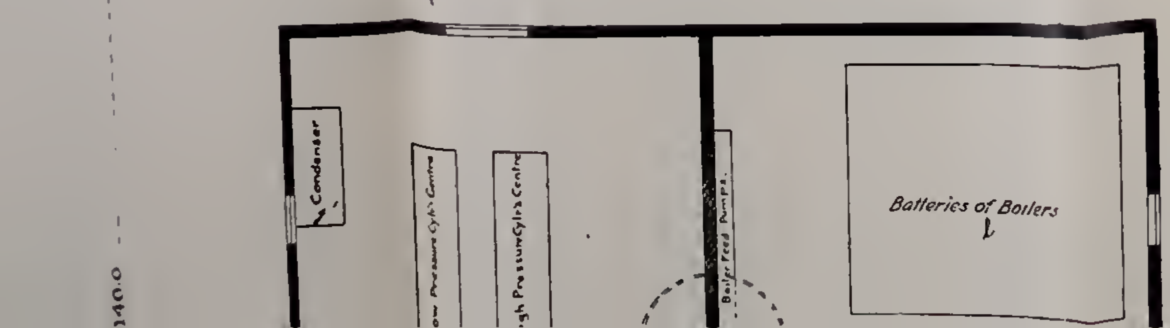

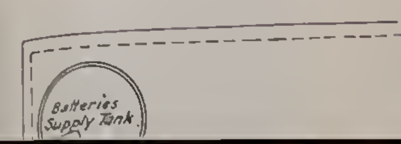

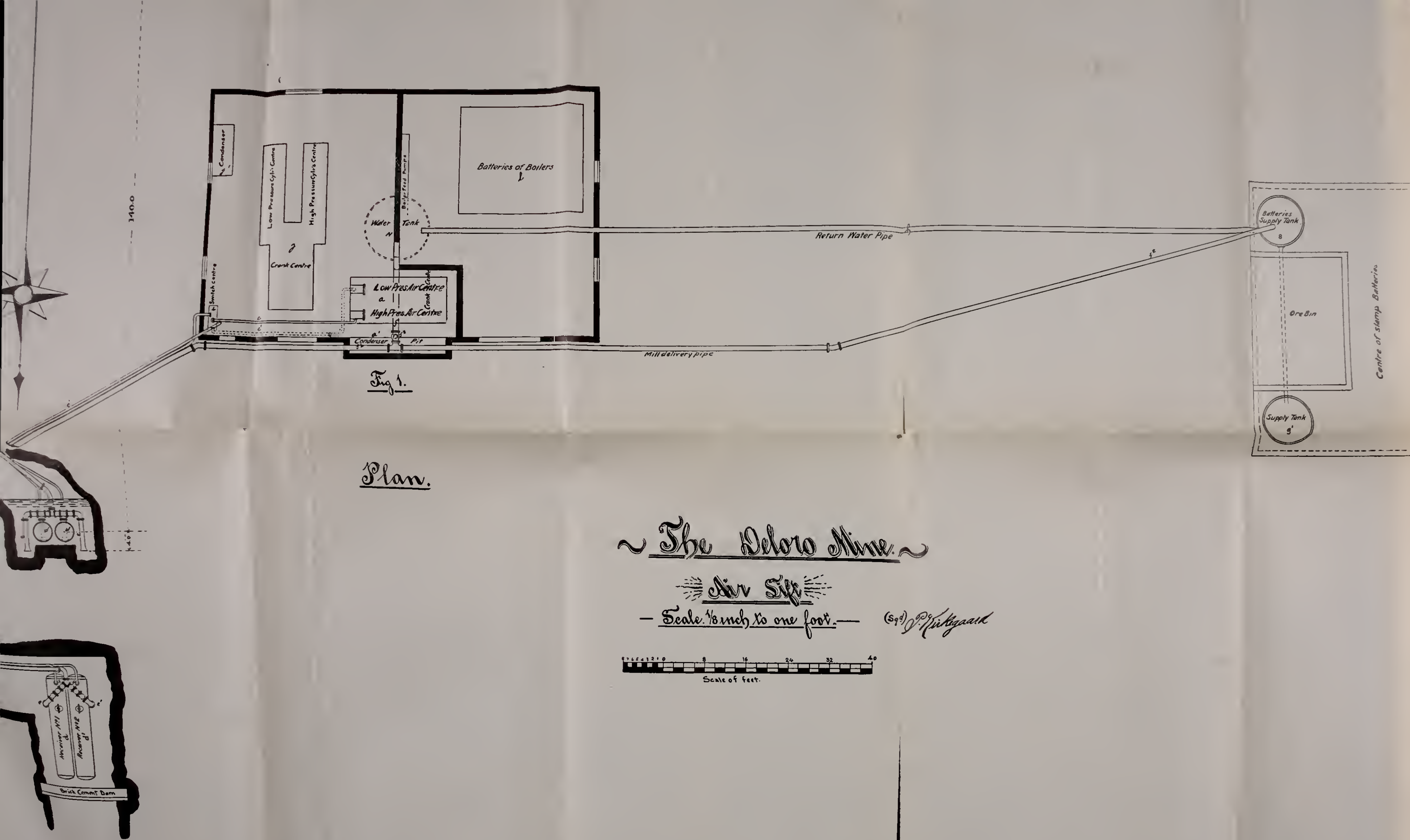

Plate I.—Illustrating paper by Mr. P. Kirkgaard on the "Harris System of Pumping by Compressed Air."

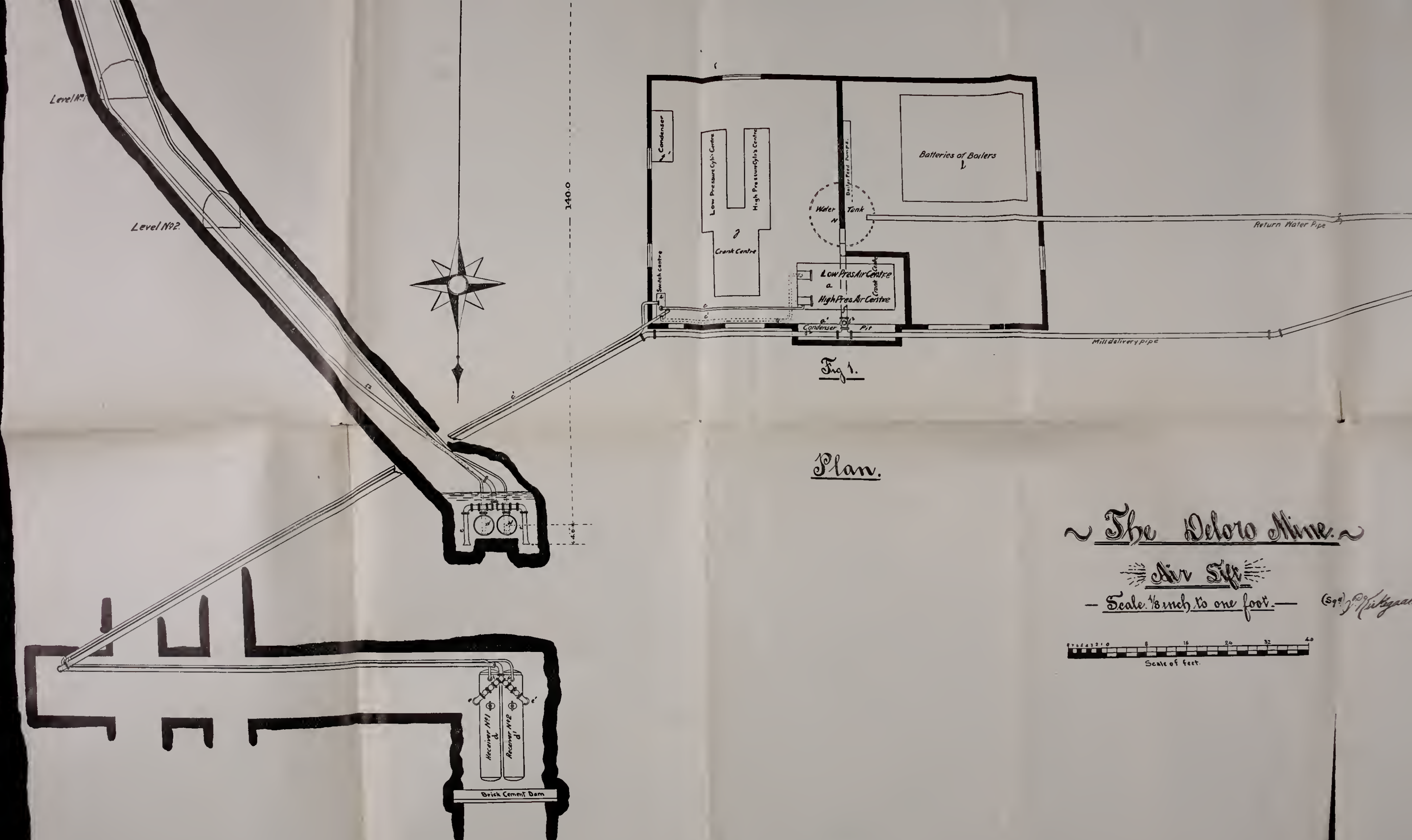

Plate I.—Illustrating paper by Mr. P. Kirkgaard on the "Harris System of Pumping by Compressed Air."

under this piston is open to the atmosphere; it therefore follows that as the low pressure cylinder exhausts the air out of the tank and the pipe connecting it with the switch, creating a vacuum, a vacuum is necessarily thus produced above the little piston; when this point is reached, the atmospheric pressure pushes the piston upwards and this in turn, being suitably connected with a rotary valve on a ¼ inch pipe connected with the high pressure air pipe, opens this valve, admitting the air which acts upon another piston similar to the steam piston in an ordinary pump. This latter piston is directly connected with a plunger, corresponding to the water-end of a pump, but this latter acts as a valve, opening or closing the passages leading to the pipes connecting compressor and tanks with the switch.

The drawings that accompany this brief description give a general view of the arrangement of the "Harris System of Air Lift" as applied to the raising of water at the Deloro Mine.

Fig. 1 is a plan; Fig. 2, a section; Fig. 3, an elevation of the tanks and dam; Fig. 4, an elevation showing the position of the tanks in the mine.

Referring to the drawings, '*a* is a cross-compound steam and air Rand drill compressor, type B, steam, 10-16-16, air, 14-8-16; *a'* is a condenser; '*b* is the switch located in the engine room; *c c'* are 3″ air pipes leading from compressor to switch, and from switch to tanks, in the mine; *d d'* are the tanks, each 4′ x 20′ with an approximate capacity of 1,800 gallons each; *e e'* are the suction pipes; *f f'* the valves on the delivery pipes; f^2 the 8″ delivery pipe; this, as also the air pipes, *c c'* are securely clamped between timbers, at intervals up through the shaft, and from the collar of the shaft are laid together until they reach the compressor building, here the air pipes are connected with the switch, while the water pipe is secured under the eave of the house, running the full length of the building, 75 feet, and from thence up the hill on trestles, until it reaches the mill at the level of the ore floor, a total vertical height of 65 feet, above the collar of the shaft; here the pipe empties into a tank, *g*, 6 feet diameter, by 8 feet deep, this tank is in turn connected with another tank, *g'*, at the opposite corner of the mill, these are the supply tanks for the mill; *h* is an 8″ over-flow pipe connected through the bottom of the tank, *g*, and leading back to the circulating tank, *i*, in the compressor building.

This was done to obviate any waste of water, which might otherwise occur if the mill at any time needed less water than the regular supply.

On the delivery pipe, f', at f^2 a 6″ branch is fixed, leading to the circulating tank *i*; on this 6″ pipe is a valve, f^3, for the purpose of regulating the amount of water needed for the compressor condensers.

For about four to six months in the year all the water raised by the air-lift from the mine is needed at the mill, and during this time the condensers, as also the boilers at the compressor, are supplied by an auxiliary pump located on the river; (*j* is a 20-drill cross-compound steam, single acting air, Rand compressor, furnishing air for all underground work, j' the condenser); *l* a battery of three, 100 h.p. each, return tubular boilers.

Fig. 4 shows the position of the tanks in the mine; it will be noticed that these are located at the bottom of a shaft ending on the third level. As already explained, nearly all the water of the mine is confined to this place, the fourth level is almost dry, as is also a winze lately sunk to the fifth level, it is also pointed out that work is being pushed to pass under the bottom of the water shaft, leaving 50 feet of the ore in place.

When this air-lift was put in, it was thought quite probable that the water would break through to the fourth level, it was therefore specified that the lift should be capable of lifting 500,000 U.S. gallons per 24 hours from the fourth level, this would add about 70 feet more to the vertical lift. The makers of the plant have given a guarantee that the plant will perform the above duty, should it be necessary to move the tanks down.*

The writer would like to give more detailed data covering the efficiency of the plant, but owing to the fact that the steam used for the lift is drawn from the same boilers that are supplying the larger compressor, and this latter running constantly, there has been no oppor-

*This plant has been in operation continuously for over a year, raising from 300,000 gl., the minimum, to 650,000 gl., the maximum, per 24 hours.

tunity to make a test other than a series of "cards" taken at intervals of 15 seconds, throughout the cycles, both from the steam and air cylinders.

These cards are very interesting, showing the variation throughout the whole cycle—there are no two cards alike, but the very fact of this variation makes them of little value—no information of value can be deducted from them.

A table showing these variations is hereto attached.

INDICATOR CARDS, TAKEN JUNE 8TH, 1901.

HARRIS AIR-LIFT CROSS-COMPOUND AIR COMPRESSOR ENGINES.

No Card.	Time in Cycle.	Gauge reading H P Steam	Gauge reading L P Steam.	Gauge reading H P Air.	Gauge reading L P Air.	Revolutions per minute.	End of Cylinder.	Card taken by	Remarks.
1	Start switch.	90	25	110	20	124	Both.	Swallow	
2	15 seconds.	90	28	105	110	120	"	and	
3	30 "	90	30	110	105	140	"	Donaldson	
4	45 "	90	30	95	95	148	"	"	
5	1 minute.	89	30	95	80	120	"	"	
6	1 "	90	31	93	80	144	"	"	
7	1¼ "	89	30	93	60	144	"	"	
8	1¼ "	90	30	92	75	120	"	"	
9	1½ "	90	28	91	55	148	"	"	
10	1½ "	90	28	92	45	144	"	"	
11	1½ "	90	27	90	40	148	"	"	
12	1¾ "	90	26	92	45	128	"	"	
13	1¾ "	91	25	91	42	132	"	"	
14	2 "	89	25	91	40	124	"	"	
15	2¼ "	89	22	91	34	148	"	"	
16	2¼ "	90	23	92	35	124	"	"	
17	2½ "	89	23	90	30	148	"	"	
18	2½ "	91	23	91	35	136	"	"	
19	2½ "	90	22	92	33	140	"	"	
20	2¾ "	89	22	92	30	140	"	"	
21	3 "	90	22	91	32	144	"	"	
22	3¼ "	91	22	91	30	136	"	"	
23	End of Cycle	90	21	92	30	132	"	"	

COMPOSITE CARDS.

No. Cards.	Time from.	Steam. HP	Steam. LP	Air. HP	Air. LP	Rev.	End of Cylinder.	Remarks.
24	0 to	90	20	110	20	140	Crank	High and low pressure cylinders.
	30 sec.	90	30	90	100	140		
25	1½ min. to	90	28	92	50	131		——
	2 min.	90	23	92	35	131		*Composite Card Explained.*– Pencil kept in contact with card during the 30 seconds
26	2½ min. to	90	22	92	30	127		
	3 min.	90	22	92	30	127		
27	0 to	90	20	110	20	132	Head	
	½ min.	90	30	100	100	132		
28	1½ min. to	90	27	93	50	143		
	2 min.	90	23	92	35	143		
29	2½ min. to	90	22	92	34	134		
	3 min.	90	22	92	30	134		

AIR CYLINDERS.

No. Cards.	Time from.	Steam. HP	Steam. LP	Air. HP	Air. LP	Rev.
30	Switch .	90	20	60	20	136
31	½ min.	90	30	100	105	136
32	1 "	90	31	90	82	148
33	1½ "	90	29	93	60	140
34	2 "	90	25	92	40	152
35	2½ "	90	22	92	35	144
36	3 "	90	22	92	32	120
37	3½ "	90	21	92	30	142

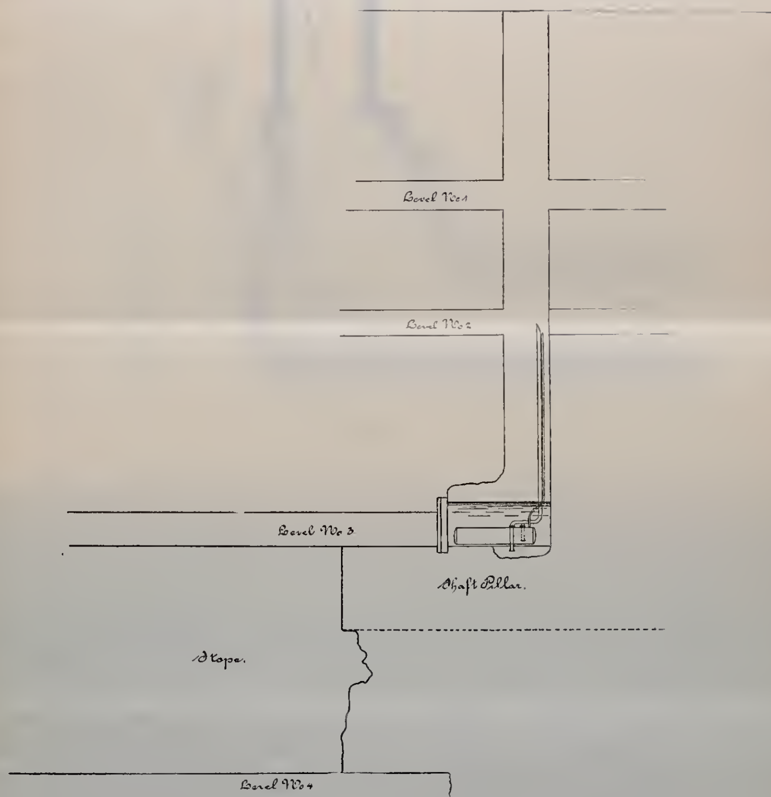

Fig 4

PLATE II.—Illustrating paper by Mr. P. Kirkgaard on the "Harris System of Pumping by Compressed Air."

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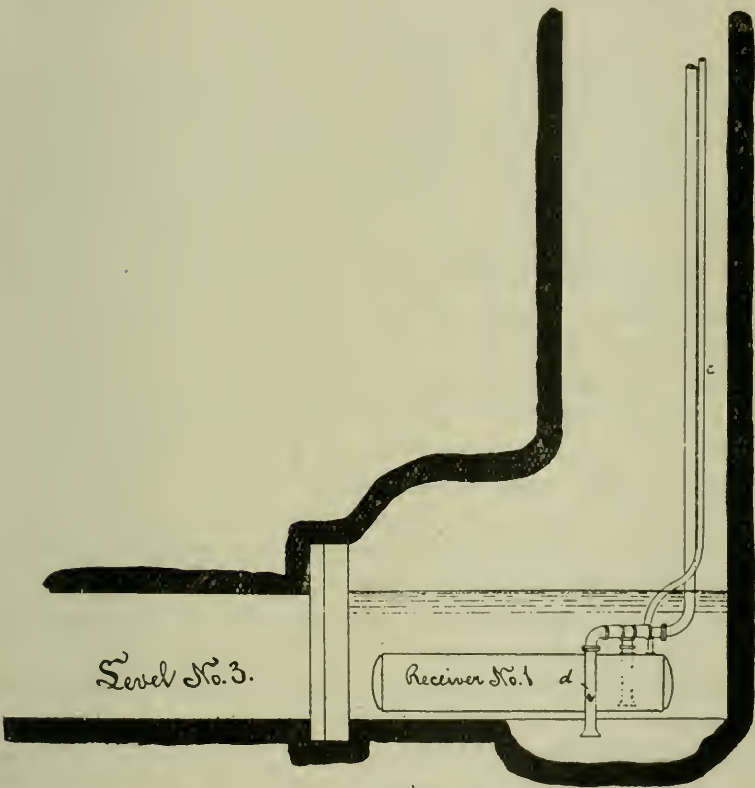
No. Cards.	T fı
24	3(
25	1 ½
	2
26	2 ½
	3
27	½
28	1 ½
	2
29	2 ½
	3

30	S\
31	½
32	1
33	1 ½
34	2
35	2,
36	3
37	3



Elevation

Fig. 3.

Scale. 1/8 inch = 1 foot.

Notes on the Milling of Gold in Republic, Wash.

By F. Cirkel, M.E., Montreal.

A casual inspection of the ore of the Republic Mining Camp would give the impression that it is of a poor quality as far as the contents in precious metals is concerned ; the quartz is of a peculiar milk white appearance, devoid of all sulphides or any other metals generally associated with gold ; in most of the gold, even in panning, we hardly detect any visible gold, except by microscopical examination, and yet this "hungry-looking quartz,"—as it is generally termed in western miners' language—contains gold and silver values sometimes up to several thousand dollars per ton. When the Republic Mining Co., owners of the Republic mine, were confronted with the problem of gold extraction from their ore, it was readily acknowledged that the difficulties of finding a suitable process were great, so much so, that it took two years before a definite plan as to the character of the mill was decided upon. Experiments showed at once that the cyanide method generally in vogue would not answer the purpose—it being found that many alterations in the old method had to be made, if to be of any use at all. It was found that the cyanide solution did not thoroughly percolate through the pulp ground to 40 mesh fineness, thus leaving a large percentage of the gold undissolved ; in order to liberate all the gold it was necessary to pulverize the ore to very fine mesh, and this difficulty discarded at once the use of stamps alone. The experiments, however, showed conclusively that if the ore were pulverized, the so-called agitating cyaniding process was apparently the only solution of the difficulty. It was the Pelatin-Clerici process which was adopted by the Republic people, and which treated under special patents the ore as outlined above, and it was decided to build a mill for a daily capacity of 30 tons. The main feature of this method of treatment is to dissolve precious metals from ores and precipitate same from their solution in one single operation. The apparatus most extensively used so far is a tank provided with an amalgamated copper bottom, a metallic stirrer and electrical connections. The ores to be treated by this process may be pulverized by any dry or wet system ; pulp from stamp batteries may be run into Pelatin-Clerici tanks ; dry pulverized ores, concentrates, tailings, slimes, may be added to the solution in the tanks. The process is an electrical one ; to the pulp are added common salt and the chemicals which from actual tests have proved the best solvents of the precious metals ; an electical current is passed through the pulp, while it is continuously stirred, dissolution and precipitation proceed at the same time. Coarse gold will go down by gravity and amalgamate at the bottom ; all metals are saved in the shape of amalgam. Clean-ups are made from time to time, and a product is obtained which requires retorting and melting into bars.

A mill for the employment of this process was constructed in 1897. It was started in May, 1898 ; as mentioned above, it treated only 30 tons per day, but its achievements during the short period of its existence were greater by far than any of its more ambitious and costly successors.

However, this was not due to the excellent working of the process, but to the enormous richness of the ore treated. The percentage of saving was from 55 to 80 per cent. only, and the cost of treatment per ton about $8. It was found that the electrical process did not work as anticipated. The process seemed to work most satisfactorily after a clean-up, and after the electrodes in the tanks had been freed of their coating. In some cases savings of only 50 per cent. of the gold were made, and this enormous loss, in connection with the high cost of treatment, made the whole process a very unprofitable one. The question of seeking a better and more economical means of treatment was again taken up, not only by the Republic people, but also by the Mountain Lion Gold Mining Co., which in 1898 had developed its mines to such an extent as to make the erection of a mill a necessity. The Mountain Lion ore showed about the same characteristics as the Republic ore, with the exception that some of the gold was in a coarse condition. Experiments with this ore were carried on on a large scale, independent from that of the Republic mine, and several experts who tested the ore, came to the conclusion that the Mountain Lion ore especially could best be treated by the combined stamp-mill amalgamation process, with subsequent pulverizing and cyaniding. It is remarkable to note that experiments carried on independently from one another all led to the belief that the process above referred to appeared to be the most suitable. The reasons for recommending the above mode of treatment were, that a portion of the Mountain Lion ore is in the condition of coarse bright particles which are practically insoluble in cyanide solution, but too fine for amalgamation; it was also determined that only a partial extraction of the gold could be effected from coarsely crushed quartz, even when roasted, but that by fine crushing a high percentage of the gold could be recovered. It would be beyond the scope of this paper to enumerate all the experiments made with this ore before a definite plan was decided upon; it suffices to say that the "Gold and Silver Extraction Co., of America," undertook the responsibility for the treatment of the Mountain Lion ore at a royalty of 10 cents per ton, at the same time guaranteeing an extraction of at least 85 per cent. of gold and of at least 60 per cent. of silver. The mill was constructed in 1899, and although the process employed did not give the satisfaction anticipated, I believe it is of interest to give here a brief description of the same, for the reason that it is the only mill of its kind ever erected in the gold mining camps of the western Pacific States. The ore is raised out of the mine through a vertical shaft in a self-dumping skip and dropped into a grizzly, the coarser passing through a 9 x 15 inch Blake rock crusher, and thence with the finer material into a 200 ton ore bin From that it is delivered into self side dumping cars, and passing down an automatic tramway, is dumped into ore bins at the top and east end of the mill. It is automatically handled from the moment it leaves the mine until the tailings are sluiced out of the mill. From the bins the ore goes to 4 stamp batteries, each having five 200-pound stamps, which drop seven inches, crushing the ore 30-mesh fine. From the stamps the pulp passes over amalgamated copper plates, thence to four Huntingdon mills, in which it is re-ground from 80 to 100 mesh fine. It is then raised by bucket elevators to the settling tanks, in which it is freed from the major part of the water. The pulp from the settlers is transferred to agitating tanks, in which it receives an eight-hour treatment with an excess of cyanide solution, and then allowed to settle. All the clear solution is decanted off, and a second solution of cyanide, weaker than the first, added to the pulp in the agitators for a second contact. After this the charge is sluiced off to big percolating or filter tanks, and here allowed to settle. The clear liquor is then drawn off, and the remaining solution is drawn through the pulp by means of a vacuum pump. This completes the percolation. The charge is then washed to free it from the cyanide, and the tailings sluiced out. The solution which contains the dissolved gold, coming from the agitators and the filtering tanks, passes through boxes with zinc shavings, and in these the gold is precipitated in the form of black slimes.

The solution, freed from its gold contents, is pumped into the large storage tanks, where, after being strengthened by the addition of fresh cyanide, it is ready for treatment of a fresh charge of ore. It requires from 36 to 48 hours from the time the ore goes into the stamps to complete the operation of saving the gold.

There are 4 storage, 6 filtering, 5 agitating, 2 vacuum, and 2 sump tanks, all made of steel. The storage tanks are 16 feet in diameter, 10 feet deep, with a holding capacity of 65 tons each. The settling tanks are funnel shaped and suspended with the small end downwards. They are 12 feet in diameter at the top, 12 feet deep. The agitating tanks, which are each capable of holding 30 tons of ore and solution, are 10 feet deep and 11½ feet in diameter. They are provided with blades of the propeller type, which, revolving 16 times per minute around a vertical shaft, stir the ore and cyanide solution and keep them in continual motion, facilitating the attack of the cyanide on the ore and consequently the solution of the precious metals. The filter tanks are 24 feet in diameter and 4½ feet deep, with a holding capacity of 60 tons each. The zinc boxes have each nine compartments 27 inches long, 16 inches wide, and 20 inches deep.

The mill is equipped with machinery for both the mine and mill power, consisting of two 100 horse-power and one 80 horse-power Fraser and Chalmers' boilers, a 125 horse power Bates Corliss steam engine, which furnishes power for the mill.

The mill was started on the 15th of March, 1900, and for the first two clean-ups gave by amalgamation and cyanide a total saving of nearly 70 per cent. gold and 37 per cent. of the silver, and by actual bullion recovery only 64 per cent. gold and 35 per cent. silver. The causes for the low percentage recovered in bullion were apparently due to bad agitation and coarseness of the pulp treated, and after repeated experiments it was found that owing to the coarseness of the pulp, agitation of the whole was not practicable ; the fines and coarse, after leaving the plates, were separated, the fines agitated and the coarse treated by percolation. For several months the mill was run on this improved plan, with a number of other changes, and below is a compendium of the results obtained :—

	Treated.	Assay Value		Gross Value.	Assay Value.		Slag.	Total.	Per cent Saving.
	Tons.	Gold.	Silver		Am'lg'm	Cyanide			
May	2135	12.39	1.87	30445.10	7042.40	5231.75	269.66	12543.81	41.2
June	2225	10 20	1.73	26544.25	4195.71	5901.55	269.66	10366.92	39.0
July	2202	8.50	1 38	21755.76	4449.64	8101 84	359.40	12910.88	59.3
August	1806	7.49	1.47	16181.76	3773.94	5988 25	256.20	10018.39	61.9
September	1711	8.11	1.44	16340.15	3314.57	4275.67	145 42	145.42	47.3
October	1880	7.95	1.55	17860.05	3918.74	6265.30	239.57	239.57	58.3

Milling Cost, per ton $3.73	Average Saving of 54.9 per cent.

We see from the above table of mill statistics that the average saving during a six months' run was only 54.9 per cent of gold and 26.9 per cent of silver, instead of 85 per cent. gold extraction and 60 per cent silver extraction as guaranteed by the Gold and Silver Extraction Co., of America, and which percentage of extraction the metallurgical experts confidently predicted would be verified and continued by actual mill operations. In consequence of this disappointing result, the mill was closed on November 1, 1900. Further metallurgical tests were made with the ore, and though the results showed some encouragement as to the probable improvement in the extraction should further modifications of the plant and process be made, still, after the experience already suffered and the failure of previous metallurgical experts to verify their predictions, it was not deemed advisable to incur any further expenditure for further mill modification, especially in view of the fact that at that time it was in the bounds of certainty a railroad would soon be constructed to the town of Republic. This would give an opportunity of selling the ore to smelters, located on the line, which were desirous of obtaining a large amount of silicious ore, hitherto obtainable only in limited quantities.

The Mountain Lion mill was erected at an expenditure of about $60,000, and although the same may not yet be considered failure, still the fact remains that it is not always a wise policy to launch out an enterprise of such a nature on too large a scale at once.

Had the management erected a small trial plant, which was more than once recommended, it is quite evident that at least two-thirds of this money could have been saved for the benefit of the shareholders.

In the year 1900 another company started the erection of a custom mill in the town of Republic, and, like the Mountain Lion, was a failure as far as the extraction of the values are concerned. No data were obtainable regarding the operation of this mill, but it appears from information received that the results obtained were similar to those in the Mountain Lion mill. At the same time, when the Mountain Lion mill was in course of construction, the Republic Consolidated Gold Mining Co. was not idle in trying to improve their method of treatment in their mill. The services of Mr. Daniel C. Jackling, a metallurgist of very high standing in the U.S., were obtained. This gentleman undertook the solution of the very difficult problem of treating Republic ore ; the achievements obtained by his process are highly creditable for the technical ability and ingenuity of this gentleman. The Republic Consolidated Gold Mining Co. erected a new mill in place of the old one in 1900, and a complete description of the same will be very interesting, both on account of the immense benefit it promises to be to the Republic district, as well as from the fact that it is the largest, most modern, and fully equipped hydrometallurgical plant in the Western States.

The reduction plant of the Republic Power and Cyaniding Company, or as it is locally known, the "Republic mill," has a daily capacity of 200 tons of ore in 24 hours, although the rough crushing and sampling department will readily handle this tonnage in 12 hours.

The mill was designed and erected in 1900 for the purpose of treating the low and medium grade ores of the "Republic mine," belonging to the Republic Consolidated Gold Mining Co.; but its capacity was made large enough to admit of its receiving about 100 tons per day from other mines in the vicinity, the expectation at the time of its construction being that the Republic mine could maintain an output of 100 tons per day.

The plant began receiving ore in October, 1900, and continued to run, at part capacity only, until July, 1901, when it had to be shut down on account of an insufficient ore supply. Developments in the Republic mine had not advanced rapidly enough to keep pace with the production, and it was no longer possible for it to furnish enough ore to supply the mill with more than a small fraction of the tonnage required for an economical running capacity. Contracts had not been made with the other mines of the district for any fixed quantity of ore, nor could such contracts be made at the time, for an immediate and adequate supply, for several reasons. The other mines were nearly all idle, and had made no special preparation to produce tonnage, and such preparation contemplated equipping most of them with machinery, ore bins, &c., before any large and regular shipments could be made at a reasonable expense. There were no transportation facilities for delivering ore to the mill, excepting by wagons, which was too expensive at all times from some of the properties, and utterly impossible very frequently, from any of them, save at great cost, on account of bad roads. If a satisfactory tonnage could have been secured from the mines, the mill would have stood in constant peril of being idle at any time during bad weather unless large quantities of ore could have been purchased and stored against such emergencies, and this the milling company was not prepared to undertake.

Another serious factor was that of a controversy between the Milling Company and the various mining companies as to what was a proper treatment rate. This consideration had resolved itself into practically a dead-lock, from which neither side saw its way clear to recede. The mine could not name the lowest rate possible unless it could be guaranteed a full daily supply of ore, to run the plant at its fullest and most economical capacity; and the mines would not agree to deliver any definite tonnage unless the lowest possible rates were made, regardless as to whether the aggregate of ore deliveries was sufficient to fill the requirements. Probably the most potent factor in bringing about such a condition was that both the Republic Consolidated Co. and the Milling Co., which is really a branch organization, had for some time been involved in serious financial difficulties to the end that they were unable to make full and prompt settlement for ores received, a condition sufficiently grave in itself to preclude the possibility of successfully operating a custom plant.

The mill did, however, receive lots of ore from most of the properties of the district, varying in quantity from a few tons to several hundred tons from each mine, the total of such shipments being ample in quantity and variety, when combined with the ores from the Republic mine, to run the plant at somewhat less than half capacity for the entire period of the operation; and the results of the run demonstrated in a very conclusive way that the mill and the methods employed in it were well suited to the treatment of most of the ores of the district, both from a standpoint of saving, and treatment costs. The average percentage of recovery of all values was as high as ordinarily maintain in hydrometallurgical plants on a like grade of ore, and notwithstanding the adverse conditions existing with regard to costs of labor and supplies, the costs, when running only on about two-thirds of the full capacity, were about as low as those of other districts and much lower than some, where similar conditions maintain. The railways now building to the district will make it possible to very materially reduce the running expenses of the works when they are again started, and the actual costs of treatment will then compare favourably with those of the large plants of Utah and Colorado, using wet methods of extraction.

DESCRIPTION OF THE PLANT.

The sampling mill was located below, and near, the entrance of the lowest tunnel of the Republic mine, for convenience in delivering ore both from this and the other mines, but as there was no suitable site for the main mill at the same or a lower elevation, it had to be located on the hillside above the sampling mill, and some 300 feet from it. This arrangement necessitates hoisting the ore from the sampler to the main storage bins of the mill, which is done by a self-dumping skip, running on an incline, which connects the lower portion of the sampler with the top of the main storage bins. This skip is operated by a small hoisting engine set in the sampling mill, in such a position that the man operating it can also load the skip from a bin under which the skipway terminates. As before stated, the sampling mill has a capacity of 200 tons in 10 to 12 hours, and, at the present capacity of the works, is only required to run on day shift. The receiving storage bins will hold 1000 tons of unsampled ore, and the crushed ore storage bins 500 tons—1,500 tons in all. From the receiving bins the ore is delivered by car to a No. 5, style D, Gates crusher, passing which it is elevated to a revolving trommel, through which the fines smaller than ¾ inch pass direct to a sett of 15 × 36 in. Gates high-grade rolls. The rejections from the trommel return to a style H Gates' crusher, located alongside, and on the same level as the D crusher. The re-crushed material from the H crusher drops into the boot of the same elevator that handles the material from the large crusher, and is again elevated to the same trommel, circulating thus, until it is all fine enough to pass through the screens to the rolls. Under the first rolls, the first sample is cut out by a Brunton sampler, the rejections going by elevator and chutes to either of the six storage bins. The first sample, one tenth of the whole, is elevated to a small set of rolls and further crushed, after which it passes in succession through two more automatic samplers and distributors, the final sample going to a small sample bin in the adjacent sampling room, and the rejections to the storage bins. All material is crushed to about one half inch before the first sample cut is made, and this sample is crushed to ¼ inch before the final sample is cut out. The third sampler cuts out about 1 per cent. of the original weight of ore, and this sample is further reduced by hand sampling, after the necessary additional crushing and grinding. The sampling mill machinery reduces all the ore to ½ inch or finer. This is done to avoid the necessity of any "roughing" rolls in the main mill, as well as to reduce the ore to as fine a condition as possible before drying, and thus avoid dust losses.

The process employed in the mill is: dry grinding to 60 mesh, roasting "dead," and cyaniding, by direct percolation, the values being precipated from solutions by means of zinc dust. From the main storage bin, of 500 tons capacity, into which the ore is delivered from the sampler, it is fed automatically to two 60 in. by 26 ft. cylindrical dryers. Each dryer served a series of fine crushing machinery, consisting of 1 set of 15 by 36 inch and one set of 15 x 26 inch Gates rolls, and three 30 inch Griffin mills; 4 sets of rolls and six Griffin mills in all. The large rolls set above the small ones, and the Griffin mills on the same level as the small rolls. Passing the upper set of rolls, the material discharges over an inclined screen to the lower rolls, and thence to an elevator which delivers it to six 8 ft. Jeffrey Columbian separators. The fines, both from the separators and the inclined screens, between the rolls, go, by elevator and belt conveyor, direct to the finished ore storage bin in the roasting or adjacent department. The rejections from the reporators go to the Griffin mills, and from these discharge again into the same elevators that serve the rolls, and the material is again passed over the screens, and so on, till it is all fine enough to pass them.

The Griffin mill discharges are supplied with a coarse screen cloth, and no attempt made to finish at one grinding all the ore going to them, but the aim is rather to avoid making an excess of slimes by discharging quickly from them and screening out what material is finished, returning the unfinished portions for further grinding. The shaking screens or separators are supplied with 40 mesh, No. 32 brass wire cloth, set at an angle of about 40 degrees from the horizontal, and deliver a product, 96 per cent. of which passes a 60 mesh screen; 55 per cent being finer than 200 mesh. The fine crushing department is kept free from dust by means of exhaust fans connecting with the chief sources of dust, and discharging into a series of settling chambers, where the dust is collected and saved. The roasting section contains three straight line furnaces, which are fed automatically from the finished ore storage bin at 400 tons capacity. The furnaces each have a roasting hearth 100 ft. long by 12 ft. wide, and an upper deck or hearth of the same dimensions used as a cooling hearth. The hot ore is elevated at the discharge end of the furnace to the cooling hearth and returned by the furnace mechanism to the feed end, where it arrives cooled and ready to go to the leaching tanks. The ore is sprayed with water just before discharging from the cooling hearth, this moistening serving to avoid dusting in subsequent handling, as well as to make a less compact charge, when loaded into the tanks. From the discharge of the cooling hearths of the furnaces the ore is elevated and conveyed to a 300 ton bin above the leaching tanks, in the adjoining section. The leaching tanks are 16 in number, each 22 feet square, 6½ feet deep, and holding about 110 tons of ore. These are loaded by means of basket, or side dumping cars, running on two tracks over each row of tanks. The false bottoms are made of a wooden frame, constructed of 1 x 4 pine slats set on edge, in such a way as to form cells 4 x 36 inches, which are filled with gravel, the top being surfaced with fine sand and the whole covered with two thicknesses of 16 oz. burlap. Iron strips tacked on top of the burlap at each longitudinal 1 x 4, or 4 inches apart, protect the cloth from damage in shovelling out tailings. The tanks are discharged by shovelling into cars on tracks beneath the tanks, four doors being provided in the bottom of each tank for this purpose. On a staging, above a portion of the leaching tank, are located three steel collution and and standardizing tanks, 14 ft. diameter, 10 ft. deep.

The first solution applied to the ore contains 0 50 per cent potassium cyanide, and is put on from the bottom of the tanks. When the ore becomes thoroughly saturated in this way, it is allowed to stand only while any irregularities in the surface are remedied by filling in or levelling off, and percolation is started at once, and continued until the charge is finished, solution being continuously run on at the top of the charge. When sufficient strong solution has been used, weak solution, 0.35 per cent, is started, and this is followed by wash water, when an assay of the solution draining from the tank, and preliminary tailings samples, show that the treatment of the charge has been sufficiently extended. The total time of leaching averages about seven days, this time being nearly equally divided between the three solutions; and the total time of loading, leaching, draining, and discharging a tank averages nine days. It is usually necessary to use vacuum, to assist leaching after the first two days, but this is not always required. When sufficient lime is not present in the ore to keep the solutions to the required standard of alkalinity, caustic soda is used for that purpose. Next below the leaching section comes the precipitating and refining department, containing two gold solution tanks 10 feet deep, 14 feet in diameter; two precipitating tanks, 8 ft. deep, 10 ft. in diameter, and one sump tank 5 feet deep, 24 ft. diameter, all of steel. This section also contains two cycloidal pumps for handling solutions, one triplex plunger pump for vacuum for the leaching tanks, and four 24 in. 36-section filter presses for collecting the slimes resulting from precipitation. All the solutions from the leaching tanks, whether strong, weak, or wash, run together into the gold solution tanks, and after being precipitated, become the weak solution for succeeding charges of ore, or are re-standardized to strong solution, by the addition of the required quantity of cyanide in lumps. Precipitation is effected by sifting the necessary amount of zinc dust into a tank of solution, while it is being agitated, by means of an air pipe, introduced from the top of the tank. After the necessary zinc is all added, agitation is continued for a few minutes only, and the suspended slimes allowed to partially subside. The solution is then drawn off through the filter presses, and is rarely found to contain more than a few cents per ton in gold. Clean-ups are made monthly by cleaning out the precipitating tanks and filter presses and treating the resultant slimes, in a lead-lined tank, with sulphuric acid, to dissolve out the excess of zinc. The enriched slime is again filter-pressed, washed and dried, and smelted into bars in the usual way. The bullion recovered is about 900 fine in combined gold and silver. The cyanide consumed averaged for the entire run of about nine months 1.18 pounds per ton of ore, and the zinc dust required for precipitation was 0.98 pounds per ton of ore, or 0.80 pound per ounce of combined gold and silver precipitated. No trouble whatever is experienced in any part of the process, provided the ores receive a very thorough roast. Otherwise, the solutions will become vitiated, and disastrous results will ensue, both in the way of extractions and precipitations.

The actual bullion returns for the entire period of operation on ores averaging 0.75 oz. gold and 2.3 oz. silver was 91.3 per cent. of the gold and a trifle in excess of 85 per cent. general extraction of combined gold and silver. After treating these ores with cyanide, there remains about 30 cents per ton, or two per cent. of the original value, in coarse gold particles that can be saved by simply sluicing the tailings over amalgamated copper plates. This was only done on a limited scale when the plant was running, for lack of equipment, but with this saving added, the net saving of gold values can be made to exceed 93 per cent. in this plant. The silver extraction is low, in conformity with the invariable result of roasting silver ores before cynading, but on higher grade silver ores, especially from mines other than the Republic, and notably when the ores contained considerable quantities of calcite, the percentage of silver saving was much better, and on the average silver contents of the district, which was shown by custom shipments to be 5 oz. silver to 1 oz. of gold (exclusive, only, of the high grade silver ore of the Quilp and Blacktail, none of which was received), the silver extraction can probably be maintained at ·35 to 40 per cent.

The plant is operated by steam throughout, each department having its individual engine, so that the temporary stopping of one part of the works does not interfere with any other department. All the engines take steam from one central boiler plant of 500 h p. capacity. The large engines driving the sampler and fine crushing sections are of the Corless type, the others all being plain slide valve. Wood is necessarily used as fuel for all purposes, and is brought to the works by a V flume 5 miles long.

The plant is supplied with well-equipped machine shop, laboratory, and warehouse, and is thoroughly modern in every respect, the mill and sampler being entirely automatic, excepting as the ores are fed to the crushers in the sampler, and loaded into and unloaded from the leaching tanks. The extreme dimensions of the sampler are 106 x 63 ft., and those of the main plant 315 x 280 ft., and both are built on a gently sloping ground, their design being a compromise between the all gravity, and level site, types of automatic plants. The flues and dust chambers for the furnaces and dust exhausting systems aggregate 435 ft. of brick flue, having a cross sectional area of 65 square feet, and terminating in a steel stack 8 ft. in diameter and 112 feet high. The plant is so designed and arranged that its capacity can readily be increased to any desired extent, the sampling mill now having about double the present required capacity. All the buildings are frame with corrugated iron roofs, and are heated by exhaust steam throughout.

Notes on Oil Furnaces for Assaying and Melting.

By Charles Brent, M.E., Rat Portage.

In view of the fact that the use of oil fuel in many departments of metallurgy has been greatly extended during the past two years, a few practical notes on the use of oil as applied to the furnaces necessary in the assay office and melting room may be found of interest to some of the members of the Institute.

The furnaces described in this paper were designed by the writer mostly for use in my own laboratory and are the result of a good deal of practical experiment in the use of oil for fuel, carried on for the past twelve years. Petroleum, either as gasoline, refined oil or fuel oil, can be used in any of the furnaces and it will be found to possess many advantages over any other class of fuel wherever steam or compressed air can be obtained, or even the comparatively light pressures from an ordinary blower. It will be found in most cases more economical than either charcoal, coke, coal or gas, and wherever ordinary precaution is used the risk from fire or explosion will be reduced to the vanishing point.

The saving of time and labor in the use of oil fuel as compared with solid fuel must be known to be properly appreciated, and the ease of manipulation and the freedom from dust and ashes and outside heat will recommend this fuel very strongly to anyone who tries it.

The furnaces described and illustrated in this paper can be constructed by any ordinary mechanic, and will cost less than half the money ordinarily expended for furnaces of like capacity for solid fuel.

They occupy a quarter of the space usually taken up by furnaces of the old type, and can be placed in any convenient part of the laboratory to which air or steam and oil can be piped.

The construction of all the furnaces is the same in that they are all constructed of sheet steel, of suitable weight, according to the size of the furnace. The shells are lined with a plastic mass, composed of 4 parts of old assay crucibles ground to about 20 mesh and 1 part of good finely-ground fireclay. This mixture should be worked up with a small quantity of water and put in as stiff as it can be handled. After a day or two drying, a light wood fire is put in the furnace until the lining is thoroughly hard.

A little caution must be used the first time oil fuel is applied, but if the furnace is thoroughly dried the heat may be pushed at once to the extreme limit required.

On cooling, the lining will be found pitted together by the small quantity of slag from the broken crucibles and will usually be free from cracks. Should any develop they should be filled with a thin mixture of the lining material. This lining burns as hard as porcelain, and as there are no ashes from solid fuel to slag the walls, it will be found practically indestructible. (The writer has a small furnace in his laboratory in which thousands of assays have been made, and the lining is today as good as the day it was first put in.)

The combination furnace shown in Fig. 1, Plate I, was designed to hold six Battersea crucibles, size E or F, and a size J or H Battersea muffle. In the diagram A is the crucible chamber with an opening below and in front to admit the jet of oil and steam or air. A convenient cover for the chamber is an ordinary soapstone foot-warmer, bored and fitted with an iron ring for convenience of handling Behind and above the crucible chamber is the muffle chamber, C, containing the muffle B. The walls of this chamber hug the muffle at the sides, the top and the end within ¾ of an inch and the opening for the escape of the products of combustion is placed in the middle of the muffle. A small door lined with a sheet of asbestos closes the opening to the muffle and a small shelf beneath this adds to the convenient working of the furnace.

This furnace can, with the right quantity of oil and air at 80 lbs. pressure, be raised to the temperature for fusion for assays in less than ten minutes, and the muffle will be found at a suitable temperature for cupellation in fifteen minutes. Work can be carried on simultaneously in both crucible chamber and muffle, as the jet sweeps between the crucibles and strikes at once into the muffle chamber. This furnace will make a set of fusions in 20 minutes, and by the use of a second jet of compressed air, E, into the mouth of the muffle a set of cupellations on 10 gramme buttons can be made in from 7 to 10 minutes. The fuel burned will be less than three-quarters of a gallon of oil, which, after the furnace has been burning a few minutes, can be cut down to burn with a practically invisible flame. The saving in crucibles and muffles in this furnace over a furnace of similar capacity for solid fuel, will be found a very strong point in its favor. (The writer has in use in his laboratory a muffle that has been heated at least five hundred times, and it is as good as new.)

The furnaces designated as Figs. 2 and 3 (Plate I) were designed to be worked together in an assay office handling ordinarily one hundred assays and upwards per day.

Fig. 2 is a crucible furnace designed to take in 12 size E or F crucibles in the chamber H, which is covered with three soapstone covers, B. The jet is admitted through an opening at the bottom and in front and the products of combustion escape through openings between the covers B, which are arranged to slide apart for this purpose. The regulation of the fusions is perfect. If it is desired to hasten up the melting of the back set of crucibles, an opening is left over them by sliding the covers apart.

A suitable sheet iron hood about 3 feet above the furnace is connected with the chimney and serves to carry off all fumes, without interfering with the work at the furnace. This furnace will burn a gallon of oil every hour and will turn out a batch of fusions every 25 minutes.

Fig. 3.—This is a double muffle furnace designed to hold two size K muffles, and the regulation of the heat in the two muffles is accomplished by the proper combination of the jet below and the draft above. Ordinarily the bottom muffle will become much hotter than the upper one, but on increasing the air in the jet below and opening the draft above, the two muffles can be regulated to the same temperature. The furnace will burn from ¾ of a gallon to 1 gallon per hour of oil, will be hot enough for cupellation in either muffle in 20 minutes and hot enough for scorification in 25 minutes. An obvious saving in fuel is made in furnaces of this size as, in the oil furnace, the moment the work is done, the oil is turned off and there is no further consumption of fuel, while in a furnace for coal or coke, from half a bushel to a bushel of incandes-

cent fuel is ordinarily left to burn to waste in the furnace after the work is done.

The furnace designated as Fig. 1, Plate II, was designed for drying and washing the gold precipitate from the chlorination process and melting the dried product.

The precipitate is dried and washed in a series of trays on the hearth B of the furnace, any part of which is accessible by sliding the covers, C. After drying and washing the product is transferred while hot to the plumbago pot, A, which has during the washing attained a full melting heat. Any fume or dust is retained in an enlarged section of the shaft pipe which can be opened and cleaned at suitable intervals.

Fig. 2, Plate II, shows a double jet furnace, designed for melting bullion.

The jets form a tangent to the surface of the melting pot and form a whirling flame between the pot and the furnace walls, the products of combustion escaping through a hole in the centre of the furnace cover. This furnace will be found extremely rapid and convenient to use, especially on bullion which requires a good deal of slagging and refining. Any melter who has stood over an ordinary coke furnace for an hour filled with incandescent fuel, will appreciate a melting furnace that at a touch can be so cooled off as to be worked over with no discomfort from either light or heat. The furnace can be placed anywhere in the melting room, requires no expensive smoke stack, and takes up but little room. The furnace itself is ordinarily only 4 inches more in diameter than the crucible it holds, and is only about 4 inches higher. The rapidity of melting must be also taken into consideration. The writer has melted a thousand ounces of retort sponge and slagged it thoroughly clean in less than an hour with the consumption of 1¼ gallons of fuel oil, and has repeatedly melted twenty pounds of brass in less than half an hour with less than half a gallon of fuel.

A great many modifications of these furnaces will suggest themselves to the members of the Institute; but anyone who once tries oil fuel in any of the various furnaces required about an assay office or melting room will afterwards "use no other."

Fig. 1, Plate III, shows an oil reservoir with screen near the top and gauge glass on the side and connected below to a filter, which is simply an enlarged section of the supply pipe filled with coarse clean sand. It will be found a very important matter to free the oil from every trace of suspended matter, especially when using the high pressure jets, as the openings are so minute that a very small particle of grit will stop the flow of the oil. It will be found convenient to locate the oil reservoir at least 10 feet above the jets to keep a proper head of oil on the burners.

Fig. 2, Plate III, roughly illustrates the form of burner used by the writer with an ordinary pressure blower giving a pressure of 6 to 10 inches. The oil comes to the blast pipe through pipe A, its flow being regulated by stop cock B. The blast pipe is contracted to a nozzle E, and the end of the pipe C is flattened as shown in diagram.

Fig. 3, Plate III, shows the ordinary high pressure burner which can be bought now from a number of firms manufacturing oil-burning fnrnaces for steam-raising and forge work.

The air enters through a passage H, its blow being regulated by needle B. It issues through the central orifice F, and sprays the oil entering through a passage C. The flow of the oil is regulated by the cap E, which when screwed up completely closes the opening D of the passage C, without interfering with the passage of the air.

PLATE I

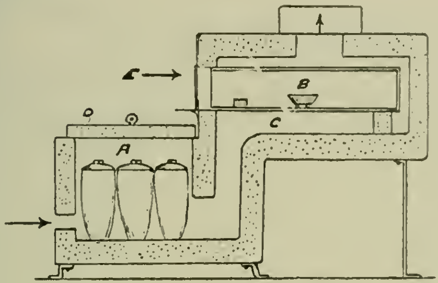


FIG. 1

COMBINATION

MUFFLE AND CRUCIBLE

FURNACE

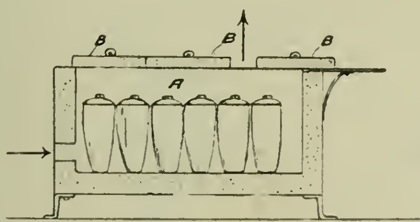


FIG. 2

12 CRUCIBLE

OIL FURNACE

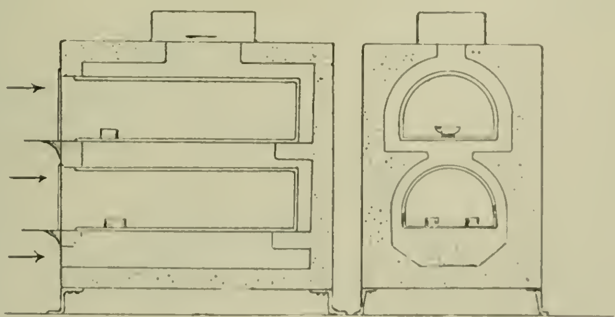
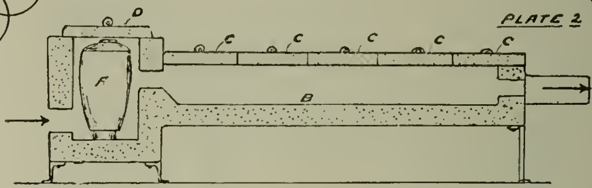


FIG. 3

DOUBLE MUFFLE

OIL FURNACE

PLATE 2



COMBINATION MELTING
AND
REVERBERATORY FURNACE

FIG 1.

MELTING FURNACE
FOR
BULLION ETC.

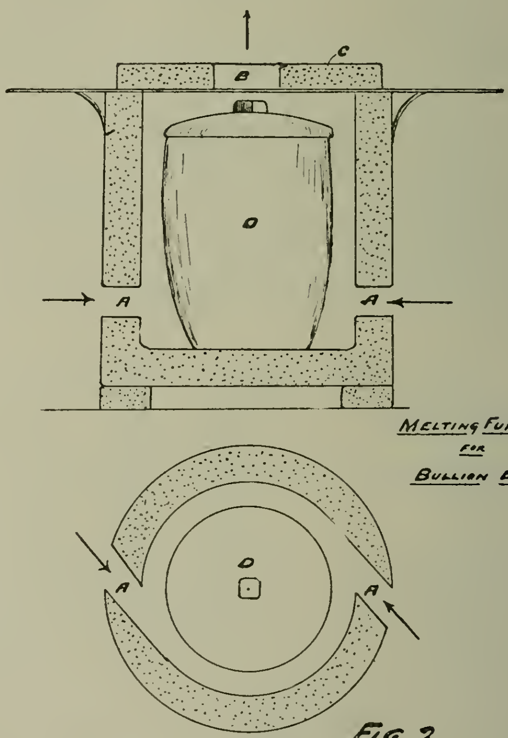


FIG. 2

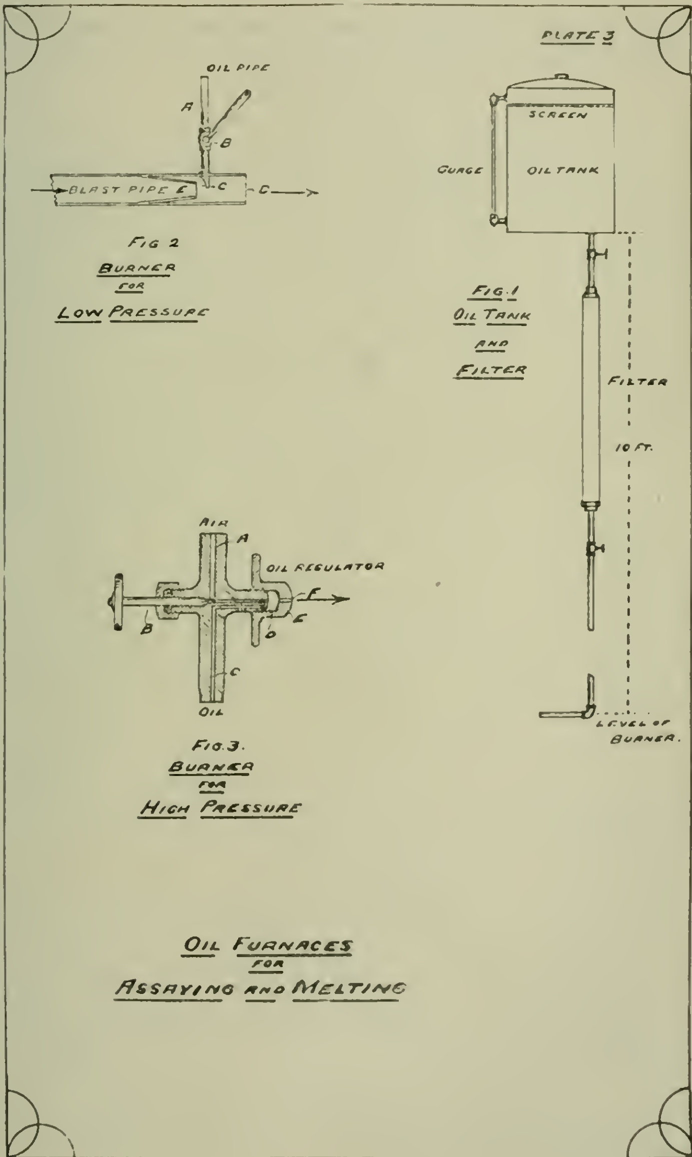


PLATE 3
OIL PIPE
A
B
BLAST PIPE E
C
C
FIG 2
BURNER
FOR
LOW PRESSURE
SCREEN
GUAGE
OIL TANK
FIG. 1
OIL TANK
AND
FILTER
FILTER
10 FT.
LEVEL OF
BURNER.
AIR
A
OIL REGULATOR
F
E
B
D
C
OIL
FIG. 3.
BURNER
FOR
HIGH PRESSURE
OIL FURNACES
FOR
ASSAYING AND MELTING

Certain Conditions in Veins and Faults in Butte, Montana.

By Wm. Braden, M.E., New York.

In practically all of the great mining centres of the world, faults of more or less extent are found. They are by no means an unwelcome feature to the engineer, as they often form an indication to the vein's relations to its surroundings, and may directly or indirectly indicate the genesis and life of the ore deposits. On the other hand, with certain of those indications lacking (ordinarily caused by metamorphism), which an engineer immediately looks for, much annoyance may be the result. However, faults may be well looked upon as one of the most important and interesting phenomena with which we have to deal, be their influence for good or bad, commercially speaking. And here I should say that the result of research in these channels has been largely prompted by commercial motives. By this it is not intended to belittle the very keen interest which is taken in the study of the problems for the technical interest which it affords, but more often than not the necessary data can not be obtained without heavy expenditures. In Butte, Montana, millions of dollars have been spent before facts have been found upon which a positive theory could be based; and with each succeeding year of underground development facts will be uncovered which will further elucidate the more deep-seated effects and causes, the existence of which in some instances can now only be approximated.

Apropos of the above, while the general geology of the Butte District has been so fully described by Dr. S. F. Emmons, W. H Weed, and others of the U.S. Geological Survey, in the special Butte folios, in this paper the district will be outlined as briefly as possible. Then from the writer's personal observation some characteristic features will be noted, which occur in the midst of a region of great interest to the geologist, mineralogist, and mining engineer, and contain one of the most wonderful vein system or systems wherein mineral deposition has taken place.

The copper bearing veins cover an area of about one and a half miles east and west, along their general strike, by one mile in width. From the alluvium-covered Silver Bow valley to the south and east from the mines, the ground rises some 500 or 600 feet, and with the headworks, dumps, and railroad grades skirting the hill-sides, the appearance is not unlike that of an extensive fortification. On the north and west copper-bearing veins give place to veins whose principal commercial value is silver, with little or no copper; and a short distance from this termination on the west, "The Butte" (from which the district takes its name) rises sharply to a height of several hundred feet. This "Butte," representing as it does the latest volcanic activity in the region, consists mainly of a rhyolytic breccia, which is not penetrated by any of the copper veins; in fact, no mineralized veins being found therein. This rhyolytic intrusion was probably an important factor in some of the post-mineral movements which occurred.

The country rock in the copper mining section of Butte is a basic, much altered and decomposed granite, together with east and west intrusive dykes of quartz porphyry ten to seventy-five feet in width. These dykes have branches and apophyses, and are practically vertical upon sinuous lines. This country rock is widely fissured and fractured. The vein fissures have a general east and west strike, oriented within an angle of forty-five degrees. Their dip is usually south, but varies from a slightly north dip to forty-five degrees south. They are mineralized with sulphide ores of copper, accompanied in more or less quantities by quartz and pyrite, sometimes the one predominating and sometimes the other. The mineral solutions have fouud their way into lesser fractures and jointings, and impregnated the country very considerably. While ore deposition has taken place within well defined limits of the fissures, in what are spoken of as "spaces of discission" by Professor Posepney, the bulk of the deposition has been metasomatic. The veins cross each other and bifurcate both on strike and dip. In some cases these crossing veins fault the earlier veins, and a distinct mineralization is seen in each. For the most part the veins are oxidized for considerable depths from their apices. This oxidization, represented by the present water line, reaches three hundred feet or more from the present surface, but varies considerably in adjacent veins, and is undoubtedly influenced by the individual characteristics of the veins and local conditions of the enclosing rock. In this connection another feature to this oxidization is the fact that often, in this zone, a very large vein may, to all appearances, show no greater size than a mere off-shoot or fracture in the country rock, the mineralization of which has also been oxidized. It is possible that this effect is produced by either the mere skeleton of the former vein having been crushed in by its unsupported walls; or, in cases where this is especially noticeable, by the fact of little or no mineralization in "spaces of discission" having taken place, but rather a meagre metasomatic action in the country rock, through which the small solution-carrying fissure or fissures passed. It may be conceived that upon oxidization and saturation by the surface waters, the altered and widely-fissured granite and quartz-porphyry would take on much the same appearance as what might be termed the "vein granite." This latter theory is more acceptable to the writer. It is doubtful that secondary enrichment, due to this leaching out of copper and its re-deposition, has taken place, at least from the present oxidized area. If it has, its influences have penetrated to more considerable depths than have usually been spoken of. The writer's observations have been that such enrichment products as found in the Ducktown deposits in Tenessee are either entirely wanting or are quite superficial in the copper-bearing veins at Butte. As recently propounded by Dr. Emmons in his paper upon this subject, it is possible that the present water line is two or three thousand feet higher than formerly, owing to the great fault from what is known as "East Ridge," which, about two miles eastwardly across Silver Bow valley, rises to an elevation of some two thousand feet, practically in bluff.

Having in mind the general mass of the country as being granite, and the east and west porphyry dykes, and a system consisting of a great number of veins quartering one with the other, so to speak, both on strike and dip a cross fault was encountered in one of the richest sections of the district. The fault was pronounced by the eminent geologist, the late Clarence King, to be a "double normal fault." At the surface, over the course of some hundreds of feet, are two fault planes, from ten to thirty feet apart, practically parallel, though with a tendency to converge at the ends, and with a strike approximately north thirty degrees east. They diverge to the deep so far as developed, the east fault dipping about fifty-four degrees and the west fault about forty-five degrees, both westerly. The extent of the oxidized zone between these two fault planes corresponds with the veins to the east and west of the faults. Between the fault planes, six or seven hundred feet in depth, much crushing, grinding, and kaolinzation is found of the included pieces of veins, as well as the porphyry and granite. As the distance increases to some three hundred feet further in depth, some evidence of regularity is seen; nevertheless the subfaulting and crushing is still pronounced. With this condition and a bewildering geography of underground workings to study, it became the privilege of the writer, together with a distinguished corps of engineers and geologists, to study the problem of establishing the apices of veins, so that the ownership might be demonstrated under that most enigmatical of United States laws known as the "extralateral rights clause." As an exhibit of the large number of veins and streaks, with their bifurcations and intersections, it is interesting to refer to Fig. I, showing a cross-section of an area undisturbed by the fault movement; and Figs. II and III, showing the 450 and 750 foot levels in plan. Veins not actually shown by workings on these particular levels have been projected either from above or below with tolerable accuracy. Referring to the veins from No. 1 to No. 8 east of the east fault, and veins No. 1 to No. 8 west of the west fault, it is seen that there is evidently no matching or correlation of these, though faulted porphyry is found on both sides of the faults, and between, and would seem to be some definite indication of the heave. But by bringing faces of the porphyry dyke into juxtaposition on the same horizon, we still found nearly as hopeless a condition as before, so far as the veins were concerned. This prophyry was a fairly reliable indicator to the heave, however, as it matched up reasonably well, being practically vertical, but in view of apophyses and bifurcations it gave undoubted evidence of a vertical throw, and the nature and extent of this it became necessary to establish. As the country rock was entirely granite of a more or less uniform appearance (no stratified formation being present), the effort was to study the situation from a standpoint of different combinations. To be sure there were certain striations, but there were such abundant evidences of subfaulting and crushing, which might prove misleading, and as the granite was quite soft, there were no hardened faces to act as reliable guides in this direction. It was noted that there was considerably less grinding, trituration, and fault rubble upon the western than the eastern fault plane. Figure IV gives a typical illustration of the latter. At the plane there appeared a clay selvage, from an inch or two to twelve inches in width. Underneath this the country rock, while somewhat more kaolinized than at some distance east of the fault, was comparatively undisturbed. On top of the selvage appeared :—

(a) Comminuted vein matter, granite and porphyry, with pebbles up to the size of a small nut and sub-selvages ; this for a width of one or two feet ;

(b) For another two feet rounded fragments as much as two or three inches in diameter ;

(c) Boulders sub-angular for two to five feet ;

(d) And finally the angular much broken country rock, porphyry or vein, as the case might be, all very much kaolinized.

Of course, it was found that the porphyry, pebbles, and boulders occurred only north of the porphyry east of the east fault, and on this extended only so far as the included porphyry between the faults. In this connection, owing to metamorphosis, the outward appearance of the material going to make up the fault plane in the oxidized zone often bore a striking resemblance to the quartz-porphyry with its rounded grains of glassy quartz. Interesting samples were collected of this material, surrounding included pebbles and boulders of the genuine quartz-porphyry.

Although between the faults were found local complications, it was found possible to gauge the course travelled by the country between the fault planes and west of the west fault plane. In Figures V, VI, and VII the horizontal, vertical, and diagonal courses of movement are shown diagrammatically, the total vertical distance being some 250 feet ; the horizontal distance 200 feet parallel to the fault about north 30 degrees east ; the actual or diagonal distance being approximately 387 feet. It will be seen at a glance that the greater movement occurred upon the plane of the "east fault," hence the greater quantity of fault rubble is found therein.

From the very nature of fault occurrence the movement varies from nothing to the maximum. In this connection reference herein is made to an area subject to inspection during the period of the writer's examinations. Undoubtedly the conditions will be altered to the deep, and in extension of the fault at a distance from the immediate region treated of. However, taking any two levels to one thousand feet in depth, wherein the vertical distance of the workings west of the west fault plane were approximately two hundred and fifty feet below the workings of the level east of the east fault plane, it was found a perfect correlation of veins and porphyry dykes resulted by lifting the plan of vein occurrence on the former level up to the level of the latter, and then moving them two hundred feet southerly parallel to the fault. For example: Placing the 700 foot level west workings in juxta-position with the 450 foot level east workings, in accordance with the measurements shown in diagrams Figs. V, VI, and VII, such correlation is seen in Fig. VIII.

With the above data in hand, without going more exhaustively into the line of evidence, it was found possible to correlate the veins by bringing the country between and west of the faults back to what was assumed to be its original position. Vein bifurcations and intersections which, prior to the demonstration of this correlation, seemed obscure, became clear, and vein development could be carried on with practically positive assurance.

FIGURE 1

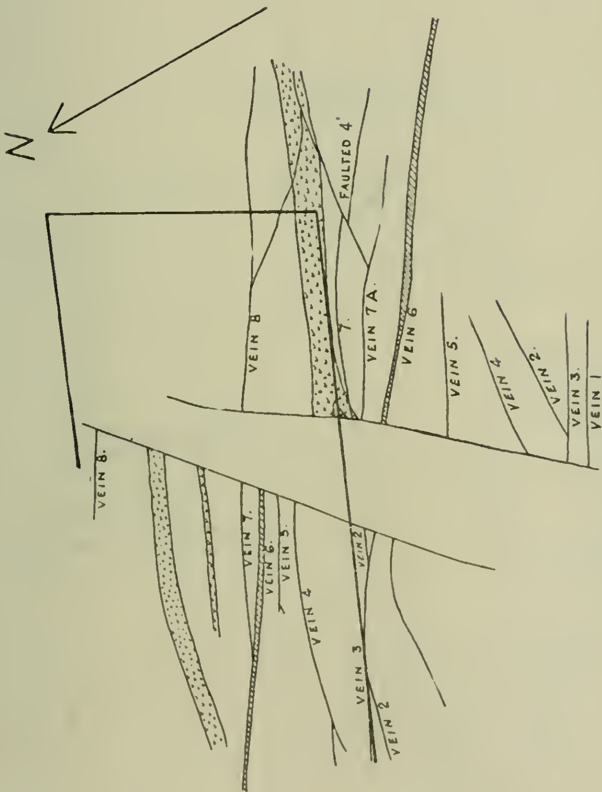

N
FAULTED 4'
VEIN 8
7.
VEIN 7 A.
VEIN 6
VEIN 5.
VEIN 4
VEIN 2.
VEIN 3.
VEIN 1
VEIN 8.
VEIN 7.
VEIN 6.
VEIN 5.
VEIN 4
VEIN 2
VEIN 3
VEIN 2

FIGURE II.

FIGURE. III

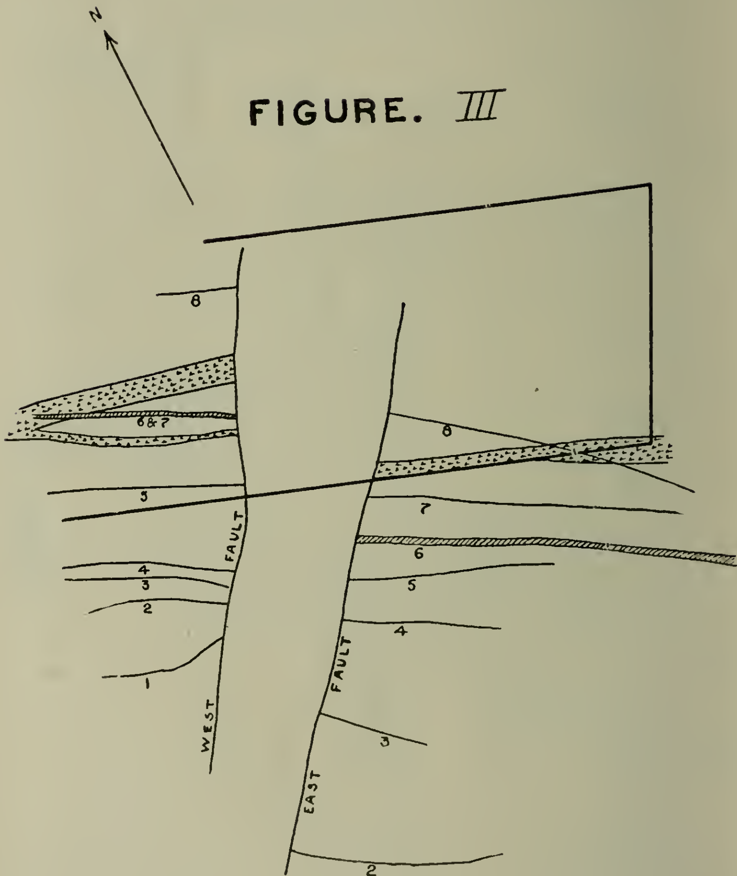


FIGURE. IV

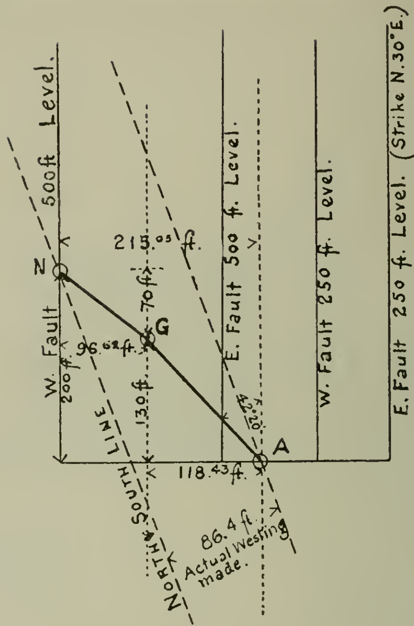


FIGURE V.

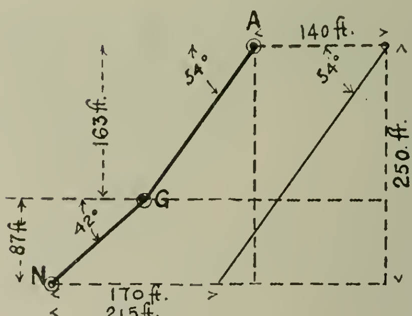


FIGURE VI.

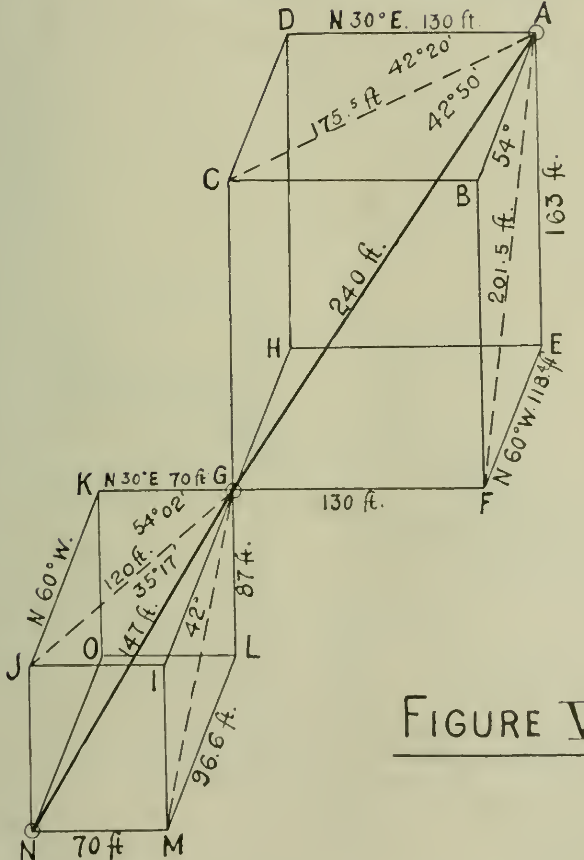
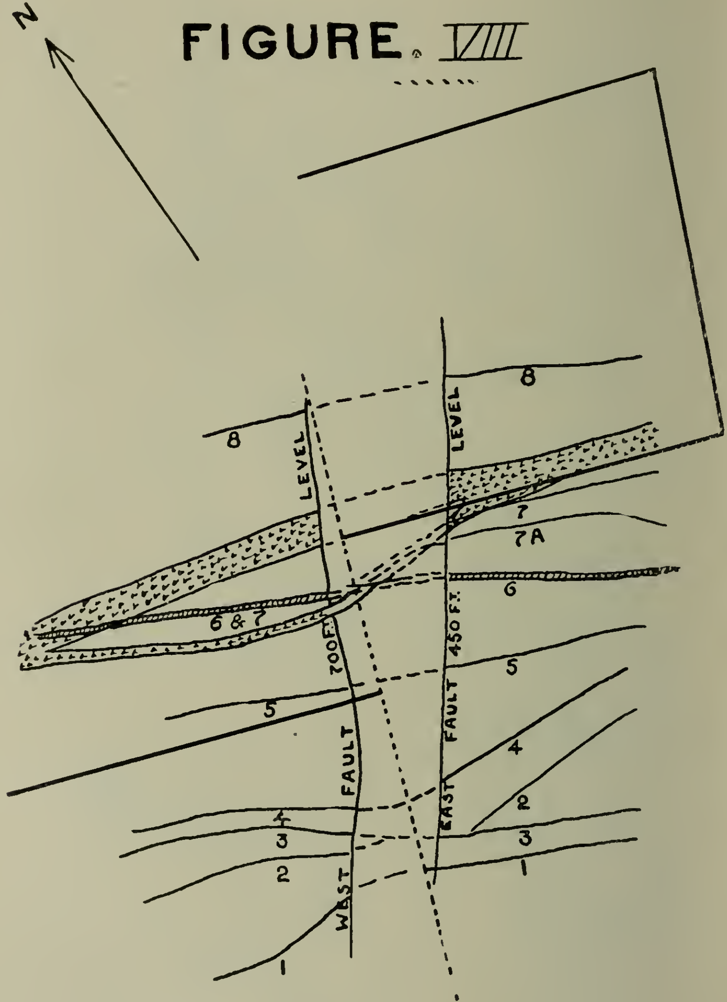

D
N 30° E. 130 ft.
A
175.5 ft.
42°20'
42°50'
54°
C
B
240 ft.
201.5 ft.
163 ft.
H
E
N 60° W. 118.4 ft.
K
N 30° E 70 ft
G
130 ft.
F
N 60° W.
54°02'
120 ft.
35°17'
147 ft.
42°
87 ft.
J
O
I
L
96.6 ft.
N
70 ft
M

FIGURE VII.

FIGURE VIII


N
8
8
LEVEL
LEVEL
7
7A
6
6 & 7
700 FT.
450 FT.
5
5
FAULT
FAULT
4
4
2
3
3
2
1
1
WEST
EAST

Hoisting and Haulage in Mining Operations. A Description of the Plant on the Le Roi Mine, Rossland, B.C.

By Bernard MacDonald, M.E., Rossland, B.C.

Progress in everything is marked by continual change and continual growth. Whatever survives the present must change or grow to meet the demands of the future. What was the nearest approach to perfection in the economic arts and sciences a few yeaas ago is antiquated today. The truth of these aphorisms is nowhere more clearly demonstrated than by the progress made in the art of mining, especially in more recent years

In the early history of mining on this continent, during the 16th and 17th centuries, when the Spaniards were skimming the cream of the phenomenal deposits of silver ores found in Mexico and South America, the Indian peons, climbing notched poles, carried the ore out of the mines on their backs. From the mouths of the mines, donkey pack trains carried it to the reduction works, more or less distant. If water was encountered in the workings, it was filled into leather bags and dragged to the surface by mules or horses. The Indians and the donkeys, moving slowly with loads of from 50 to 200 pounds, and the mules and horses hoisting the sacked water, constituted the hoisting and haulage system used in the mining operations of those days.

While the ores were rich, near the surface, and the mines were comparatively dry, these methods served very well, that is, the mines operated in this way left a margin of profit for the Spanish owner and a living for his peons. But when the ores became poorer, or the mines were exhausted to even inconsiderable depths, or water was encountered, the limit of profitable operations was reached and the mines were abandoned. Thus, human and animal labor, unaided by mechanical appliances, reached their limitation, to use the Western phrase, "very early in the game."

From this time, history shows that the limitations of successful mining have widened continually as progress has been made in the perfection and adaptability of machinery suitable for the work done by manual or animal labor. It may now be asserted that the economies effected by the use of machinery in mining operations are more prominent in the work of hoisting and haulage than in that of any other department. And although it is true that special mechanical appliances have invaded all departments of mining, it must be admitted that hoisting and haulage, on account of this prominence, are entitled to distinction as the mechanical department.

Of course, the introduction of machinery in mining, as in other branches of industry, presumes the certainty of abundance of work, suitability for the work, and proper installation. Without these prerequisites, no installation would be warranted, or the results profitable. Nor does the fact that occasionally it is good business to install auxiliary units of machinery in a large plant to stand guard, as it were, in case of accident, in like manner as insurance is placed, alter this as a general rule.

The economic results obtained from the modern hoisting and haulage plant erected on the Le Roi under the design and supervision of the writer, goes to corroborate what has been said, and as this plant has many novel features, both of design and application, it is hoped that a description of it and the economies affected by its operation will prove interesting. In this description which follows, many incidental circumstances, apparently extraneous to the subject matter proper of this paper, will have to be narrated, in order to give a comprehensive grasp of the economic exigencies which created the necessity for this plant. It is also hoped that such extraneous matter will not be uninteresting, inasmuch as it constitutes a chapter in the history of one of the most prominent mines in this province, and deals with many of the peculiar conditions which are, to a more or less degree, characteristic of most mining enterprises.

Historical.—The Le Roi was located in the summer of 1890, and in November of the same year it was bonded to a syndicate of Spokane business men. This syndicate completed the purchase of the mine, and on the 23rd June, 1891, conveyed it to the Le Roi Mining Company, which they organized for the purpose of operating the mine.

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PLATE ILLUSTRATING PAPER BY MR. BERNARD MACDONALD ON "HOISTING AND HAULING AT THE LE ROI MINE."

VIEW OF THE LE ROI MINE, ROSSLAND, B.C.

Under the auspices of this company the mine was developed into a paying property, and the company realized from its operations $975,000.00 in dividends before selling it in 1898.

The ore which yielded these dividends was extracted from workings comparatively near the surface, where, owing to the concentrating action of meteoric agencies, the values, originally existing in the entire vein, were concentrated into a streak of varying width. The ore mined was sold to custom smelters, which made a direct charge of $11.00 per ton for freight and treatment, besides making certain deductions from the metal values, which amounted to approximately $5.00 per ton. Thus, the aggregate of the direct and indirect smelting charges amounted to $16.00 per ton.

But as depth was attained on the vein, it was found that the values were becoming more uniformly disseminated throughout the great width of vein matter, instead of being, as near the surface, concentrated into a comparatively narrow streak.

Thus, as the work of mining progressed in depth, the ore became too low-grade to stand the cost of freight and treatment formerly paid to the smelters and leave a satisfactory margin of profit.

This change in the character of the ore induced the company to build its own smelter, so that the profit of smelting the ore might be added to that of mining it.

A favorable site was selected at Northport, in the State of Washington, and a smelting plant of the capacity of 250 tons per day was built there in the fall of 1897.

In this enterprise the company associated with it to the extent of one-quarter interest, Mr. James Breen, a man of extensive experience in copper smelting. Mr. Breen's ownership of this interest made it necessary to operate the mine and smelter as separate concerns.

The smelter was operated under terms of an agreement made between Breen and the Le Roi Mining Company, which provided that all the ores produced by the Le Roi mine for a period of five years should be sold to the smelter on the following terms:—The gross value of the metals contained in the ore was to be paid for at New York market quotations, less $8.75 per ton as direct charge for freight and treatment, and certain specified deductions from the gross metal values in the ore, which amounted to approximately $5.00 per ton additional. Thus the total charges, direct and indirect, for smelting the ore at the Northport smelter, amounted to $13.75 per ton, a reduction of $2.25 per ton under the price charged by outside smelters. This contract was, nevertheless, very profitable for the smelter, the profits earned being distributed, three-quarters to the company and one-quarter to Breen.

About this time the president of the Le Roi Mining Company (Col. I. N. Peyton) went to London for the purpose of selling the mining and smelting property of the company. The negotiations which Col. Peyton began, finally resulted in the purchase of all the assets of the company by the British America Corporation, Ltd. This corporation conveyed the property to the "Le Roi Mining Company, Limited," a new company, organized in London to take over and operate the mining and smelting property of the old Le Roi Company.

The mining and smelting operations of the new company were conducted under London management, Mr W. A. Carlyle being the local manager until December, 1899, when that gentleman severed his connection with the company to accept the management of the Rio Tinto Copper Mines, in Spain.

At this time—on the 10th December, 1899—the writer was appointed general manager to fill the position made vacant by Carlyle's resignation. On accepting this position I was informed by the directors that no profit had been made by the company's operations and was instructed to examine the company's property and report as to what would be the probable result of future operation.

I immediately began the examination of the mine, the compilation of records of previous production and working costs, and a study of the commercial problems involved in the mining and smelting operations.

The mine records showed that for the eight months ended June 30th, 1899 (the first eight months after the mine was taken over from the old company) there were 45,167 tons of ore shipped, having an average gross value of $17.33 per ton; and that for the subsequent six months ended December 31st, 1899, there were 51,448 tons of ore

City of Rossland, B.C., showing Headworks of the LeRoi Mine and Mount Roberts, with fog cloud intervening.
Taken from Columbia Avenue.

shipped, having an average gross value of $13.66 per ton, making a total of 96,615 tons of ore shipped during this period, having a total gross value of $1,485,423.19. This made the average daily shipment about 250 tons, which, upon investigation, I found was the maximum which could possibly be obtained from the mine with the equipment and working facilities it then possessed. To maintain even this, the miners were obliged to climb into and out of the mine to depths ranging to 900 feet so as not to interrupt the production, instead of being, as is usual, hoisted and lowered by the winding engine.

The general details of the costs of realization of the gross values per ton of ore for the period under review showed, *without making deduction for depreciation of mine or plant*, as under :

Costs of mining and development	$5.55	per ton.
Railway transportation to smelter.........	.75	"
Cost of smelting to matte	5.59	"
Refining tolls and charges, and freight...	1.25	"
Breen's profit on smelting contract........	2 00	"
	$15.14	

Subtracting the costs of realization from the average gross value of the ore, the first eight months operations showed a profit of $2.19 per ton on the production for that period, or a total of $98,915.73, while the last six months showed a deficit of $1.48 per ton, or a total deficit of $76,202.24 on the production of that period, which brought the nominal profits for the 14 months down to $22,713.49

It should be noted as of particular significance, the general lowering of the average grade of the ore produced, and further, I should state that the production of the last three months of the period under review, that is, October, November, and December, of the year 1899, had an average gross value of only $12.50 per ton, which made a working deficit to the company of $2.64 per ton for the ore produced during these months.

Such were the statistics furnished by the records of the company for the first fourteen months of its existence. From these it was quite apparent that no profit could be earned unless the conditions under which operations were carried on were modified.

The Conditions.—At this time the mine was worked through a three-compartment incline shaft, sunk near the easterly end of the property on the variable dips of the vein, to a depth of 940 feet. In this shaft, at approximately 100 feet distant from each other, stations were cut and level drives run easterly and westerly in the vein. Along and over these drives stopes were opened and worked upwards in the ore bodies. The exhausted stopes were timbered by the square set system. The ore was stoped by drilling with machines run by compressed air, and by blasting with dynamite. The ore when blasted was shovelled into chutes, down which it gravitated to the levels, the larger pieces being sledged into sizes not exceeding 10 inches in diameter. From these chutes it was drawn off into steel push-cars having a holding capacity of from 18 to 22 cubic feet (about one ton of broken ore). These cars were pushed by the trammers to the shaft stations, and their contents dumped into the storage pockets cut under the stations. The storage pockets had a holding capacity of from 700 to 900 cubic feet, that is to say, 40 or 50 tons of ore each. From these pockets the ore was loaded into the hoisting skips having a holding capacity of 1½ tons, and lifted to the surface by a double drum, direct acting hoisting engine, cylinders 20 x 42 inches. These skips, running in counter balance, the empty skip being lowered as the loaded one is hoisted, dumped automatically at the surface.

On being dumped, the ore gravitated into a receiving car, which was pushed along to the various distributing stations over the sorting floor, where it was dumped before the squads of ore sorters, whose duty it was to pick out the second class ore from the shipping ore and shovel the two classes into separate bins.

From these bins the ore was trammed in the receiving bins at the head oi the tramway, and the second-class ore was trammed to the second-class ore dump. From the receiving bins the ore was loaded into four-ton cars and run over a suiface gravity tramway, 700 feet in length, with a fall of 250 feet, to the lower or loading terminal, where it dumped through a chute into the railway cars.

As each of the railway cars were loaded, it was moved by men and an empty one substituted, until a train of from ten to twenty

30-ton cars was made up. When, as often happened, there were no empty cars, all the men at the various stages in the passage of the ore from the stopes to railway cars, were thrown idle because there were no intermediate storages of sufficient capacity to hold the ore accumulating during the interval.

Under these conditions, and with the facilities and equipment thus briefly described, the average output (250 tons per day) for the fourteen months under review, was hoisted from the mine, sorted and loaded on the railway cars

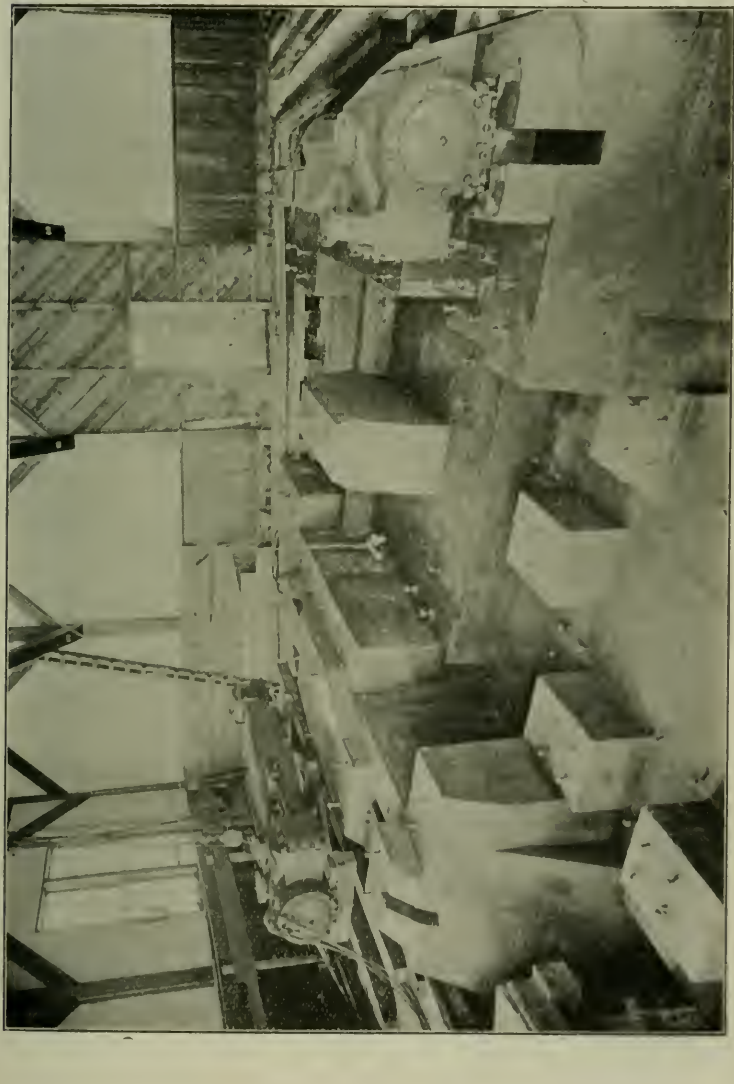
The details of the cost per ton of hoisting, sorting and tramming to and loading on the railway cars is given in table I, following:—

TABLE I.

Hoisting—					
Fuel	8 tons @ $6 00=	$48.00 or	$0.192	per ton.	
Engineers	3 @ 4 00=	12.00 or	0.048	"	
Firemen	2 @ 3.00=	6.00 or	0.024	"	
Skiptenders	4 @ 3.50=	14.00 or	0.056	"	
Interest, depreciation & renewals		1.50 or	0 006	"	
Oils and waste		.50 or	0.002	"	
			———		$0.328 per ton.
Sorting—					
Foremen	2 @ $3.00=	$6.00 or	$0.024	per ton.	
Topmen	4 @ 2.50=	10.00 or	0.040	"	
Waste trammers	4 @ 2.50=	10.00 or	0.040	"	
Ore "	12 @ 2.50=	30.00 or	0.120	"	
Sorters	32 @ 2.50=	80.00 or	0.320	"	
Interest, depreciation, renewals and tools		1.50 or	0 006	"	
			———		$0.550 per ton.
Tramming to Railway—					
Brakemen	1 @ $4.00=	$4.00 or	$0.016	per ton.	
Carmen	5 @ 2.50=	12 50 or	0.050	"	
Carmen at railway	3 @ 2.50=	7.50 or	0.030	"	
Interest, depreciation, renewals and tools		2.00 or	0.008	"	
			———		$0.104 per ton.
Total cost					$0.982 "

After the mechanical handling of the ore produced as above described, the next item of cost attaching was 75 cts. per ton for railway freight between the mine and the smelter. This was the contract price made with the railway some three years before for all the ore to be produced by the mine for the term of five years.

On arrival at the smelter yards, the ore was dumped from the (bottom-dumping) railway cars into the receiving bins. From these



Concrete Foundation ready to receive General Traffic Hoist.

it was loaded into push-cars and trammed to a Blake rock crusher, into which it was fedby shovelling—six men being required for this work. The crushed ore was elevated and put through the sampling mill. When sampled, the ore was again elevated to the "high line" bins and from these it was loaded into push-cars and trammed to the roast yard, and there on trestles over the roast heaps being built.

Table II following gives an itemized statement of the cost of the different handlings of the ore as above described, between the mine and the roast heaps, including the railway freight.

TABLE II.

Railway Freight—					
Under contract					$0.750
Unloading and Crushing—					
2 Dumpmen	@ $2.40	= $4.80	or	$0.019	
6 Trammers to crushers	@ 2.50	= 15.00	or	0.060	
2 Crusher feeders	@ 2.50	= 5.00	or	0.020	
Repairs and renewals				0.050	
					$0.149
Sampling—					
1 Foreman	@ $5.00	= $5.00	or	$0.020	
1 Sampler	@ 3.50	= 3.50	or	0.014	
1 Topman	@ 3.00	= 3.00	or	0.012	
1 Binman	@ 3.00	= 3.00	or	0.012	
Interest, depreciation and renewals				0.100	
Power				0.125	
					0.283
Tramming to Roast Yard—					
6 Trammers to roast	@ $3.00	= $18.00	or	$0.072	
Depreciation and renewals				0.010	
					0.082
Total cost					$1.264

TABLE III.

Summary of the Per Tonnage Costs attaching to the Ore for Hoisting; Sorting; Tramming to Railway; Loading on Cars; Railway Freight to Smelter; Unloading and Crushing at Smelter; Sampling and Elevating at High Line; Tramming to Roast Heaps. 250 tons possible.

Hoisting	Table I.	$0.328
Sorting	" I.	0.550
Tramming to railway	" I.	0.104
Railway freight to smelter, contract	" II.	0.750
Unloading and crushing at smelter	" II.	0.149
Sampling and elevating to high line bins	" II.	0.283
Tramming to roast heaps	" II.	0.082
Total		$2.246

The costs of stoping, timbering and development work will not be considered here, although they were increased to a considerable extent.

Extraneous Conditions.—While my investigation of the economical factors affecting the operation of the Le Roi was proceeding, that is, during the first two months of 1900, new conditions were commencing to affect the mining industry of the Province unfavorably. The burdens of the eight-hour law passed by the Provincial Legislature during its session of 1899 were beginning to be seriously felt in Rossland, which was the only important district that continued mining work after the law became effective, paying the same wages for eight hours' work as was formerly paid for ten hours' work. The law had been in operation for the last eight months of 1899 and the returns were coming in a way that there was no mistaking the result. Careful calculations made by Mr. R. E. Palmer, chief engineer of the Le Roi mine during 1899 and part of 1900, and now assistant to Mr. W. A. Carlyle at the Rio Tinto mine, showed that the additional cost of operating the Le Roi since the eight-hour law became effective, amounted to a sum which added $0.72 per ton on the ore produced (250 tons per day).

During the same year (1899), contract work in the mines had been prohibited by the Miners' Union, and statistics showed that the mining costs during that year reached higher figures in the Rossland mines than in any other camp in the Rocky Mountain regions.

The Provincial Legislature during its session in 1900 passed a law doubling the tax which had previously been imposed on the gross output of metalliferous mines. Prior to this time the Provincial tax had been 1 per cent. on the gross value of the ore produced, less freight and treatment charges. This tax was raised to 2 per cent. on the same basis by the new law just passed.

It will, perhaps, be pardonable to digress for a moment, to say that the Mine Owner's Association of British Columbia protested vigorously against the passage of this law, pointing out that the regular annual addition of the new laws passed by the Provincial Legislature oppressive to the mining industry could only result in driving capital from seeking investment in the Province.

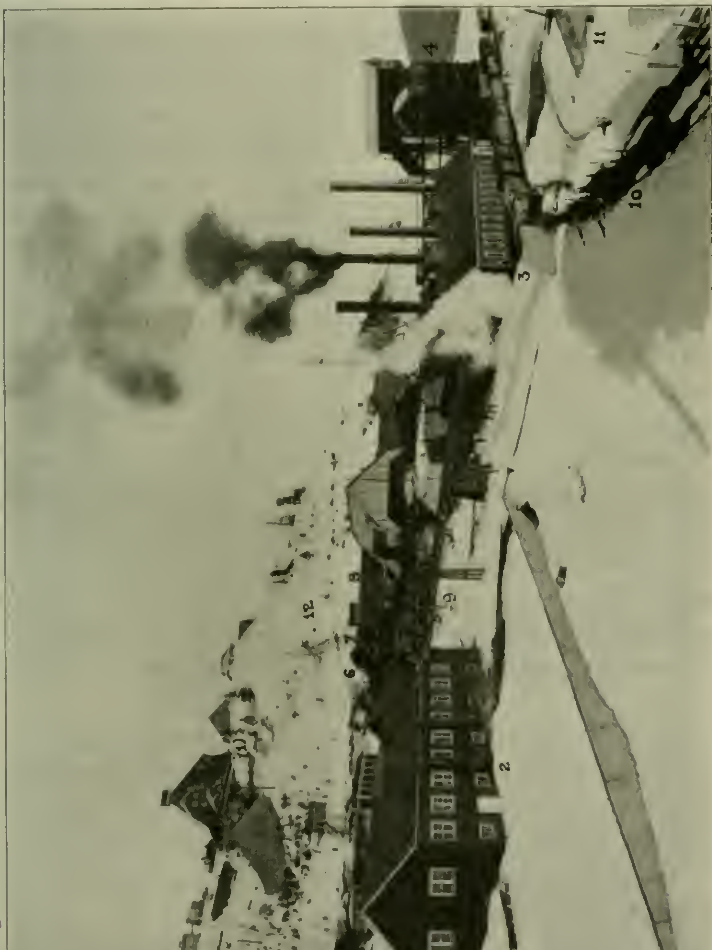
The law was passed, however, in disregard to the mine owners, and, I regret to say, the results then predicted have come to pass. The mining industry, vigorously commenced in the early '90's in a new undeveloped mineral region of exceptional promise, should have advanced by leaps and bounds, but it has, on account of accumulating legislative burdens, barely held its ground, and while the tonnage produced has increased in some instances, the dividends are few and far between.

Thus stood the economical conditions affecting the operations of the Le Roi mine in February, 1900, two months after the writer had assumed its management. The prospect was not very bright; in fact, it was very gloomy. All the per tonnage expense of mining, development, depreciation, renewals, hoisting and delivering the ore to the roast heaps at the smelter, government taxes, smelting ore to matte, loss in smelting operations, freight charges on matte to Eastern refineries, refiners' tolls and charges, interest and discounts, and Breen's profits of $2 00, amounting to $15.15, had to be paid from the gross values in the ore, which had fallen to an average of $12.50 per ton during the last quarter of 1899, and the balance was expected to be—profit, to pay dividends to shareholders.

Facts to be determined—It could not be expected that the metals in the vein would reverse the persistent and natural tendency they manifested from the surface to the 800-ft. level already noticed, and become concentrated into smaller and richer streaks such as were found near the surface.

The average character and grade of the ore in the vein already found to exist below the circulation of surface waters was the best that could reasonably be hoped for in the deeper levels, that is the metals would be found distributed more or less uniformly throughout the entire width of the vein-filling in the deeper levels, which meant a larger tonnage and a lower-grade ore. Future operations would have to deal with these facts intelligently if they would be profitable.

The experience of the previous fourteen months, wherein 96,000 tons of ore were mined and smelted leaving practically no profit showed how fuitle it would have been to continue operations on the same scale in the face of a lower average grade of ore than was dealt with during



General arrangements of the several units of LeRoi Plant.—1. Headworks at the Construction Shaft. 2. Compressor Building. 3. Boiler Plant. 4. Ore Bins at Railway. 5. Stores Building. 6 Blacksmith Shop. 8. Carpenter Shop. 7. Machine Shop. 8. Carpenter Shop and Timber Framing Shed. 9. Portal Black Bear Tunnel, which connects with Black Bear Tunnel at a depth of about 300 feet. 10. Great Northern Railway. 11. Cooling Reservoir. 12. Aerial Tramway.

that time. Could existing conditions be modified so as to make operations profitable? This was the problem which had to be solved affirmatively or the mine abandoned, for the company could not be expected to continue operations while making a loss of from $2.00 to $3.00 per ton of ore produced.

Of the numerous factors required for the solution of this problem, the main one was the determination of the quantity and grade of the ore in the mine, and the probability of its downward continuation. This was the one which had to be more or less accurately determined before it was worth while to consider the others.

In due course it was ascertained that there were approximately 1,000,000 tons of ore in sight in the mine, having an average gross assay value of $12.50 per ton, and it was considered probable that the ore bodies would extend indefinitely downward. The problem, thus simplified, then appeared as follows:—

Can the costs of realization, now $15.14, be so reduced as to leave profit on the $12.50 ore; and if so, what profit can be reasonably expected?

Contingent Calculations.—Proposed Plans.—Careful calculations showed that the costs of realization might be reduced to $8.00 per ton providing an expenditure of about $1,250,000.00 was made on new development and equipment of the mine, and increase of the capacity of the smelting plant. This expenditure provided for:

1. Freedom of the company from dictation of the Miners' Union so that, by the re-establishment of the contract system, the company could contract its work to the best workmen, and would have to pay only for the work actually done, instead of the time spent in doing it.

2. The purchase of Breen's one-fourth interest in the smelter, and his contract for smelting the ore.

3. The sinking of a five-compartment shaft on the mine, and the erection of a modern plant of hoisting machinery and handling facilities at its head, of adequate capacity for an output of 1,000 tons per day of 10 hours.

4. To enlarge the Northport smelter so as to have a marginal capacity of from 400 to 500 tons daily for custom ore, in addition to

that required for smelting the increased production of the Le Roi, viz., a total capacity of 1,500 tons per day.

Plans Authorized—Difficulties Overcome.—When the position of the company, as above described, was fully understood by its directors, I was authorized to carry out these plans if the necessary financial arrangements could be provided for from the operation of the property.

The difficulty of making satisfactory arrangements for financing the company seemed, at first, almost insurmountable—the chartered banks of the Dominion being prohibited by law from lending money to mining companies on any other the security of liquid assets such as ore on dump or in stock in smelter yards or furnace products in transit. This required a margin of production over and above that required to finance the normal mining and smelting operations, sufficient to meet the cost of the new work.

Fortunately, however, this difficulty was soon solved. A two-compartment winze sunk on the vein from the Black Bear tunnel to the mine workings on the 700-ft. level was equipped with a 150 h.p. electric hoist and pressed into service as an auxiliary shaft. All mining timbers and supplies, the general mining traffic and the miners going to and from their work, passed through this new outlet. This relieved the congestion at the old shaft so that it was soon posssible to almost double the ore production. The output was immediately increased to an average of 443 tons per day, and later on to 600 tons per day, which gave the desired margin of unincumbered ore available for security for the funds required for the proposed improvements, which could now proceed as rapidly as desirable.

The option previously obtained to purchase Breen's interest in the smelter for $300,000.00 was exercised, this sum being borrowed from the bank. This left the company the complete owner of the smelter and all the profits on the smelting operations, which reduced to it the costs of realization to $13.14 per ton, except the deduction for interest on the $300,000.00 borrowed.

The proposition to introduce the contract system in the mine was next tackled. This was vigorously opposed by the Miners' Union, who refused to allow their members to work by contract. The mine was, in consequence, closed down for a period of 66 days. At the end of this time the Union consented to allow their members to work by contract, as proposed, and the mine was re-opened under freedom to utilize this system.

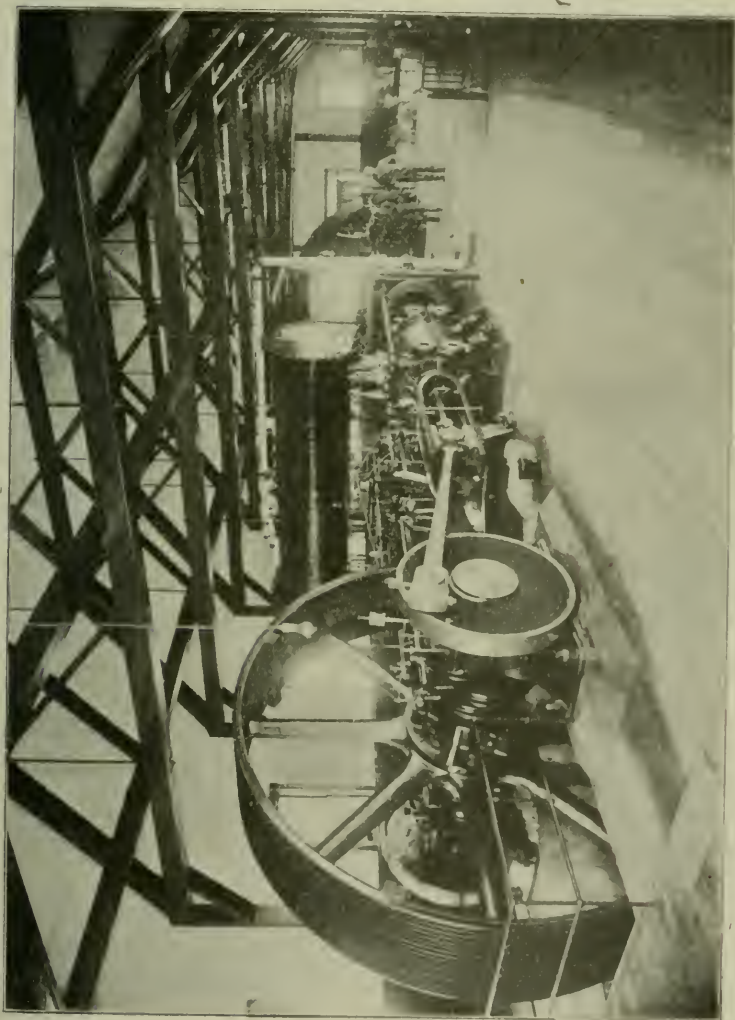
The results proved very satisfactory to the company and to its employees as well. The possibility of earning wages commensurate with skill and experience attracted the best miners from surrounding camps. In the hands of skilful miners, the maximum capacity of the machine drills was soon reached, and with the increase of output came a general lowering of tonnage costs, although the miners working by contract earned more than the standard scale of wages.

A suitable location for the five-compartment shaft had been selected and its construction commenced. Simultaneously, the excavation for the foundations of the several units of the proposed new plant was begun, as was also the preliminary work for increasing the capacity of the smelter. During the latter part of March, or the early part of April, all the necessary preparations were made, and the work of constructing the new plant commenced.

The Mining Plant.—The general arrangement of the several units of the new plant, as completed, is shown in the plate made from a " winter scene " photograph. This arrangement was suggested by the local topography, the accessibility of the railway spurs and the isolation of the independent units from each other, necessary to minimize the risk of fire communication between the several buildings.

On the plate referred to, 1 is the head works at the combination shaft; 2, the compressor building; 3, the boiler plant; 4, the ore bins at railway; 5, the stores building; 6, the blacksmith shop; 7, the machine shop; 8, the carpenter shop and timber framing shed; 9, the portal of Black Bear tunnel, which connects with the combination shaft at a depth of about 300 feet; 10, the Great Northern Railway; 11, the cooling reservoir; 12, the aerial tramway.

Inasmuch as a detailed description of the several units comprising this plant would be very lengthy and, perhaps, too tedious, I will content myself with the following brief description of them, referring only to their more prominent features.



Interior of LeRoi Compressor Building.

Boiler Plant.—This plant consists of nine horizontal, return tubular, steel shell, high pressure boilers, set in three batteries of three boilers each; and two Heine Safety Water Tube boilers set in one battery.

In the aggregate, this plant has about 2,000 nominal horse power—sufficient to supply the steam necessary to operate all the machinery connected with the mine and have one of the four batteries out of service. The spare battery is always held ready for steaming when any of the others in service require cleaning or repairs. This plant is modern and complete in all its details, and is equipped with all the most improved devices (except mechanical stokers) to provide for safety and continuity of operation at the lowest cost for attendance and maintenance.

The selection of the site chosen for this plant was suggested, (1) by its accessibility from the high line spur of the railway from which the coal is delivered to the storage bunkers behind the building; (2) because of its safe distance from the other units, in the event of fire originating in it; (3) convenience to the large cooling reservoir, where the steam pumps for fire protection and pumping back the water for condensing purposes, are located.

Steam is transmitted from this plant to all the steam engines through a series of insulated steam lines. A 9-inch steam line, carrying steam at 140 pounds pressure, connects with the two air compressors. Two additional steam lines run through the Black Bear tunnel and connect with the hoisting engines at the head works of the combination shaft. One of these is an 8-inch and the other a 6-inch line, the 8-inch line being the one generally used, the 6-inch being held in reserve in case of accident to the 8-inch line.

Each of these lines is insulated by two layers of cellular asbestos covering, and provided with the requisite number of steam traps and expansion joints. This arrangement of concentrating the boilers into one suitable location and transmitting the steam to the separate units of the plant, gives greater economy, satisfaction and security from fire than could be obtained if separate boiler plants were installed adjacent to the engines requiring the steam.

Air Compressing Plant.—This plant consists of two compressors, one having 22 x 36 x 48 inch cross compound condensing steam cylinders, with 22 x 36 x 48 inch two stage air cylinders; the other, 22 x 36 x 48 inch, with cross compound condensing steam cylinders, with 22 x 38 x 48 inch two stage air cylinders. The combined capacity of these two machines is 8,000 cubic feet of free air per minute at sea level, compressed to 95 lbs. gauge pressure.

One of these compressors was installed during my management, and the other installed by the old company in 1896, but this latter was remodelled in some essential details at the time of the newer installation. Both compressors were built by the Canadian Rand Drill Co., and both have given entire satisfaction, although in economy and efficiency there is a very marked difference in favor of the more recent installation. It is very interesting to note the improvements made in the manufacture of this class of machinery in the four years that transpired between the building of the first and second of these machines.

The operation of this plant has proven very economical, a working test extending over a period of thirty days during ordinary working conditions showed a coal consumption of 1.9 pounds per horse power per hour, and that air was being compressed to 95 pounds per square inch at the low cost of $1.59 per each 100,000 cubic feet of free air compressed. This calculation did not include the interest on the investment or depreciation, but all other costs.

The air compressed by this machinery is transmitted into the mine workings through a series of air receivers and two pipe lines. The air receivers consist of boilers rejected from the old steam plant and erected in the open air immediately outside the compressor room. The two pipe lines leading from these receivers extend to the bottom of the mine workings, and consist one of 8-inch and the other of 6 inch pipe, with branch lines leading off, carrying the compressed air to the workings on the various levels.

The extensive cooling surface afforded by the number of tubes in the boilers thus converted into receivers, permits of the condensation of the moisture contained in the conpressed air; besides, the long, ample pipe lines in themselves serve as a second series of receivers, passing through which most of the moisture contained in the air is condensed and precipitated, to be blown off as it accumulates in the receivers placed on every working level in the mine. The air, thus drained of its contained moisture, goes to the drills and the pumps in the best condition for service, and freezing of the machines driven by it is unknown.

Hoisting Plant—This plant, installed at the head works of the combination shaft, consists of two modern types of first motion winding engines, one of 1,000 and the other of 500 nominal horse power. The larger hoist is the standard Allis Chalmers design, with some special features incorporated to meet our views. This engine is used exclusively for hoisting ore, and is not called upon to do any of the general traffic of the mine. Devoted to this specialty, its efficiency and capacity is increased, as the engineer has only this special work to perform and is not confused by call signals for other purposes.

The smaller hoisting engine consists of a pair of 20 x 30 high pressure engines, operating double drums, and is equipped with four auxiliary engines, with which the clutches, reversing gear and brakes are handled.

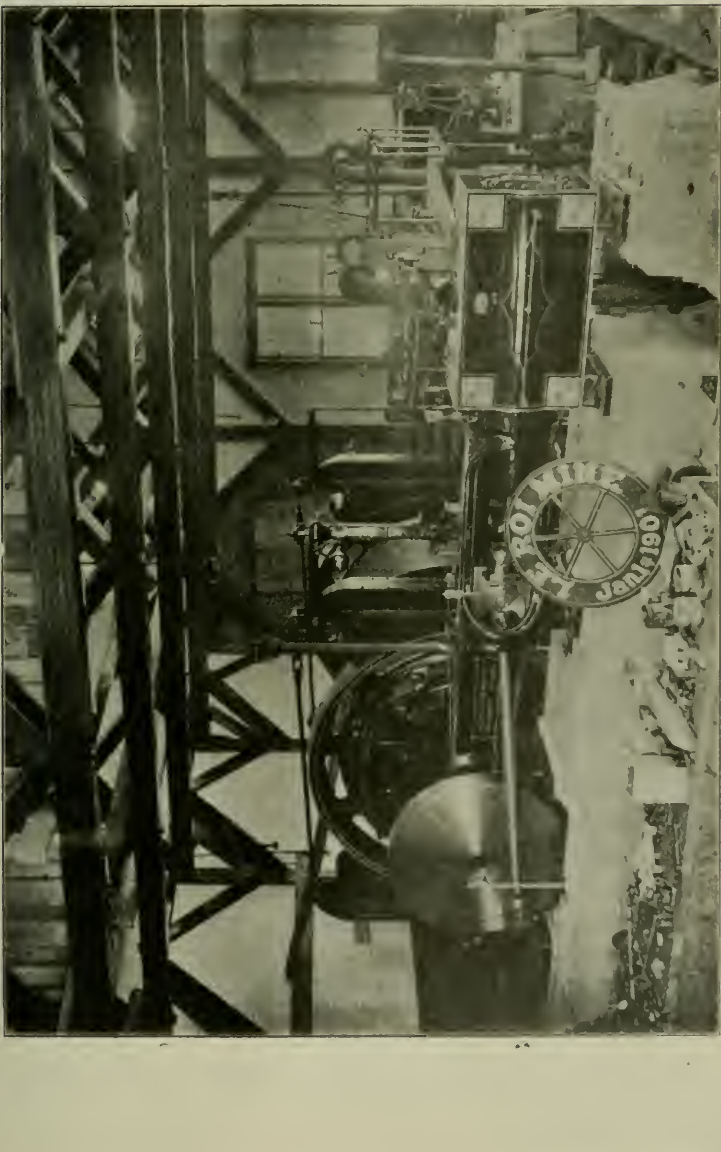
This engine was especially designed for the rapid and safe hoisting and lowering of men, and the general traffic incidental to the mining operations, and is exclusively used for these purposes. The winding drums of both hoists may be run in counterbalance or singly, as desired.

Heating Plant.—This consists of a Sturtevant fan heater, and heats the headworks and sorting room by heat generated from the exhaust steam of the hoisting engines.

Combination Shaft.—This shaft, having dimensions of 27½ x 6 feet clear of outside timbers, is sunk on the average dip of the vein, 69° from the horizontal, to a depth of 1,125 feet (June 30th, 1901).

It is divided into five compartments, two of which are used exclusively as roadways through which the ore is hoisted from the pockets at the stations on the varions mine levels and delivered to the crushing machinery at the headworks; the two adjoining ones being used for the general mine traffic, that is, hoisting and lowering men, timber, tools and mining supplies; the fifth compartment being used as a manway and for the compressed air and water pipes, and electric wires.

From the hanging wall side of the shaft at the various levels, sta-



LeRoi Winding Engine in course of installation.

tions have been cut to accommodate the general traffic of the mine. Underneath the floor of these stations, pockets are excavated having a holding capacity of about 500 tons each. These pockets are used to receive and store the ore trammed from the stopes until it is suitable to hoist it.

At the 900-ft. level, a large catch basin or water tank having a holding capacity of 50,000 gallons, has been excavated in the solid rock in the footwall side of the shaft. This tank receives all the water flowing from the various parts of the mine. Over it the mine pumping plant is installed, and the accumulated water is lifted a height of 600 feet to the Black Bear tunnel, through which it flows to the surface.

The four hoisting compartments in the shaft are tracked with 36-lb. "T" rails and provided with timber guides, to prevent the hoisting skips from leaving the track.

Head Frame at Shaft.—This is 85 feet high from the collar of shaft to the bearings of the sheaves, and is built of Douglas fir in a very substantial manner, calculated to withstand the strains due to the rapid lifting of heavy loads from a state of rest by the two hoisting engines.

The ore hoisted is dumped automatically on grizzlies set in the head frame at a height 65 feet above the collar of the shaft. The delivery of the ore at this height provides sufficient elevation for its automatic passage by gravity over the grizzlies and through the crusher into the storage bins beneath, from which it is delivered, by automatic feeders, to the Sorting Tables.

Crushing, Sorting and Sampling Plant.—This plant occupies in part the building enclosing the head frame at the combination shaft, and continues into a wing extending from it 100 feet in length by 30 feet in width and three stories high.

The machinery of this plant was especially designed for the crushing, sampling,sorting,and conveying of ore in continuous operation as comes from the mine, completely preparing it for smelting operations.

The transportation and handling of the ore from the time it is broken in the stopes to its delivery in the smelter yards, is briefly described as follows:—

The ore, when blasted down in the stopes, is broken into pieces of suitable size, say 10 inches in diameter, shovelled into chutes, and from them trammed to the storage pockets at the combination shaft.

From these pockets it is drawn off into the hoisting skips through chutes opened and closed by steel gates, actuated by compressed air cylinders. By these means the ore is loaded rapidly and cheaply, it only requiring a few seconds to fill a four-ton skip.

The loaded skips, holding 4 tons, are hoisted to the surface and dumped automatically over the grizzlies, which are arranged to divide the ore into three classifications The size too large to fall through the grizzly bars, gravitates over them to Comet crusher, set to crush to 4-inch sizes, the largest size suitable for the subsequent sampling and feed for the smelting furnaces. The fines falling through the grizzly bars pass directly to the "fines" receiving bin, from which it is automatically fed to a conveying belt and carried to the sampling machinery without sorting.

The ore passing through the Comet crusher falls into the "coarse" receiving bin, from which it is fed automatically to two endless conveying belts. These belts, including the belt carrying the fine ore, are each 100 feet in length between centres, and adjusted to travel at the rate of 45 feet per minute. On either side of the two belts carrying the coarse ore the sorters are stationed, who pick out the waste and second-class ore, allowing the shipping ore to be conveyed past them to the sampling machinery.

On falling from the conveying belts, the ore passes through the sampling machinery, consisting of three Constandt cone samplers, a Blake crusher, Cornish rolls, Bridgeman sampler, small Comet crusher and small Bridgman sampler, where a uniformly proportional sample for assay is "cut out" and quartered, ready for the assay office.

The sorted ore, after passing through the sampling machinery, falls into a storage bin, having a holding capacity of 1,000 tons. This bin was intended to hold in storage the production of the mine for 24 hours, in case of accident or repairs needed for the aerial tramway, which could be stopped for 24 hours without interfering with the mining operations.

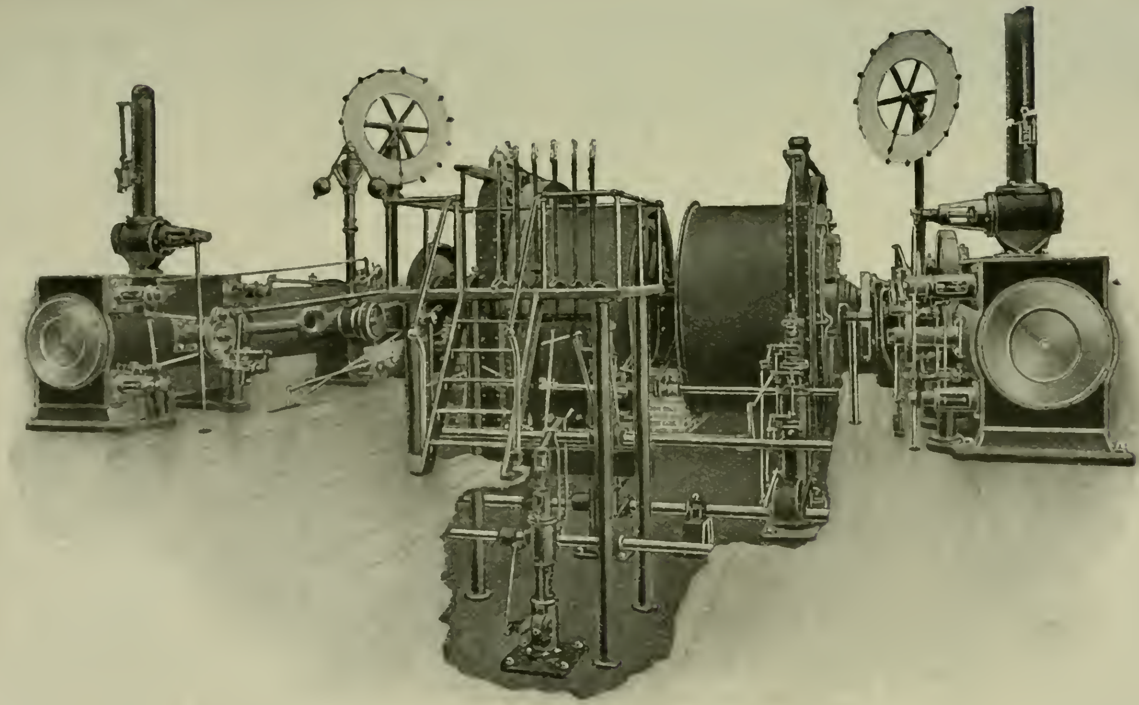
All the operations of hoisting, screening, crushing, conveying and sampling the ore in its passage from the pockets at the shaft stations in the mine to the railway cars, is automatically conducted, and the cost of this work, as may be seen from Table IV, is reduced to a very low figure.

Electricity is the motive power used for driving this plant, one 150 horse power induction motor driving the Comet crusher and one 125 horse power synchronous motor driving all the rest of the machinery. This power is supplemented by a 250 horse power Corliss engine, to be used as the motive power for driving all the machinery in case of accident to the electric motors. The electric motive power has given very satisfactory and economical results.

Ore Bins and Aerial Tramway.—When the ore is crushed, sorted and sampled, it falls into a bin having a holding capacity of 1,000 tons. This bin is situated under the sampling mill, and is equipped with a delivery chute, which is opened and closed by a steel gate attached to the piston of an air cylinder, embodying the same principle of construction as the chutes from the pockets in the combination shaft.

The ore is fed through this chute into an automatic loading device, which loads the buckets of the aerial tramway while in motion. This device is operated by one man, who easily loads and controls the travel speed of the tramway, so as to deliver 120 tons per hour at the terminal bin at the railway.

The Aerial Tramway is of the two rope system—one stationary, carrying the sheeve wheels from which the buckets are suspended; the other hauling them and controlling their speed. It was built by Mr. B. C. Riblet, and has numerous patent devices owned by that gentleman. The attachment of the compressed air cylinder for operating the loading chute was designed by the writer, and is said to be the only tramway equipped with that device. There are 26 buckets attached on the moving rope and spaced on it 65 feet apart. This rope has a normal speed travel of 268 feet per minute. The buckets have a holding capacity of 10 cubic feet, or 1,000 pounds of crushed ore, and are arranged to dump automatically at the railway terminal bin. Only the



Description of Hoisting Engine built for the LeRoi Mining Company.—This engine embodies the latest principles in hoisting engine construction, and consists of two 24-inch by 60-inch Corliss Engines with two drums 10 feet diameter by 5 feet face mounted directly on the crank shaft. Each drum is equipped with a powerful band friction clutch and a powerful post brake operated by steam. The engine is provided with special valve gear for hoisting engine work, and is controlled by link reversing gear operated by an auxiliary engine. It is furnished with all devices for proper handling and safety. Maximum capacity 14,500 lbs. unbalanced load raised at 2,000 ft. per minute with 100 lbs. steam pressure.

one man who operates the automatic loading device and the brake at the loading terminal is required to operate this tramway to its full capacity.

As the ore dumps in the terminal bin at the railway, it falls on grizzlies, the bars of which are spaced 1½ inches apart, and set at an angle of 40° over the centre compartment of the bin.

In passing over the grizzlies, the ore is screened into two classes, coarse and fines. The fines, passing through the grizzlies, fall into the centre compartment of the bin, the coarse, gravitating over the grizzlies, goes to the outside compartments. This separation gives the classification desirable for building the heaps for roasting at the smelter. This bin has a holding capacity of of 1,600 tons of crushed ore, and, as above indicated, is divided into three compartments, the centre compartment holding the fines, the two outside compartments the coarse ore.

The ore from these compartments is loaded into the railway cars through triple chutes, one triple-mouthed chute leading from each compartment. These chutes are opened and closed by compressed air lifts, and operated by one man.

A train of from 20 to 25 empty cars, each of which has a holding capacity of from 30 to 40 tons of ore, are "spotted" at these bins by the engine, which also moves each car of the train under the spouting apron of the chutes as required. It requires less than a minute to fill a car from this bin.

It may be explained here that when the plans for increasing the output of the mine were made known to the officials of the Great Northern Railway, they consented to modify the contract existing with the company by reducing the freight rate to 40 cents per ton, on an output of 1,000 tons per day being maintained.

The ore is hauled to the smelter in bottom dump cars, which empty their contents into the ore bins set under the spur track recently built. This spur track and the ore bins built under it are part of the recent construction for increasing the smelter's capacity and cheapening the handling of the ore there. From these bins the ore is drawn off into push-cars and trammed directly to the roast heaps, the repeated handlings of crushing, sampling and elevating formerly required to be done at the smelter being unnecessary now since all that work is done at the head works of the mine automatically by the machinery installed there. Thus it will be seen that the ore is taken from the pockets of the mine, hoisted and conveyed through the crushing and sorting processes, trammed to the railway, loaded on to trains and then hauled to the smelter yards, all by machinery and with the least possible handling in transit.

It is hypothetically possible for the ore to pass from the pockets at the 900-ft. level of the mine to the roast heaps at the smelter, 18 miles distant, in 1 hour 41 minutes 8 seconds, this time being occupied between the various stages of passage as follows:—

	H.	M.	S.
Loading in skip at 900-ft. level	..	..	05
Hoisting and dumping at surface	..	..	30
Crushing and feeding to travelling belts	..	..	10
Passing over travelling belts before sorters	..	2	18
Gravitating through sampling mill machinery to bins beneath	..	..	05
Loading buckets of tram and delivering to bins at railway	..	3	..
Loading on railway cars	..	1	..
By rail to smelter, 18 miles	1	30	..
From smelter ore bins to roast heaps	..	4	..
Total	1	41	8

In ordinary operations this speed is modified by the length of time any given quantity of ore rests in the bin storages provided between the different stages of progress from the 900-ft. level of the mine to the roast yards at the smelter. In fact the pockets at the various levels in the mine or the storage bins underneath the crusher or at both terminals of the aerial tramway are seldom empty, a condition that would be necessary to effect the travel speed given in the above table.

The costs of hoisting, crushing, sorting, sampling, aerial tram to railway, loading on railway cars, railway haulage to smelter and distribution to roast heaps, of 1,000 tons of ore daily between the pockets in the mine and the roast yards at the smelter, as above described, is given in Table IV. following:—

TABLE IV.

		Per day		Per Ton.	
Hoisting—					
Fuel, 10 tons......	@ $5.75 per ton =	$57.50 per day or		$0.0575	
Foremen........	2 @ 3.00 per day =	6.00 " "		0.0060	
Engineers......	2 @ 4.50 " =	9.00 " "		0.0090	
Wipers	1 @ 3.50 " =	3.50 " "		0.0035	
Skip tenders....	2 @ 3.00 " =	6.00 " "		0.0060	
Interest, depreciation and renewals..		4.40 " "		0.0045	
			$86.50 "		$0.0865
Crushing, Sorting, Sampling—					
Foreman.......	1 @ $5.00 per day =	$5.00 per day or		$0.0050	
Crushermen....	1 @ 3.00 " =	3.00 " "		0.0030	
Sampler.......	1 @ 3.50 " =	3.50 " "		0 0035	
Oilers..........	1 @ 3.00 " =	3.00 " "		0.0030	
Sorters........	30 @ 2.50 " =	75.00 " "		0.0750	
Oil and waste......................		1.00 " "		0.0010	
Electric power.....................		10.00 " "		0.0100	
Interest, depreciation and renewals..		2.00 " "		0.0020	
			$102.50 "		0.1025
Aerial Tram to Railway—					
Tram runners...	1 @ $4.00 per day =	$4.00 per day or		$0.0040	
Interest, depreciation and renewals..		5.00 " "		0.0050	
			$9.00 "		0.0090
Loading on Railway Cars—					
Spouting into cars, attendance......		$0.50 per day or		$0.0005	
			$0 50 "		0.0005
Haulage—Railway to Smelter............		$400.00 " "		$0.4000	
			$400.00 "		0.4000
Distribution to Roast Heaps—					
Foreman.......	1 @ $4.00 per day =	$4.00 per day or		$0.0040	
Trammers......	15 @ 3.00 " =	45.00 " "		0.0450	
Interest, depreciation and renewals..		11.00 " "		0.0110	
			$60.00 "		0.0600
Totals......................			$658.50 "	per ton	$0.6585

In Table V following, is given a comparison of the Per Tonnage Cost of hoisting, sorting, crushing, sampling, tramming to railway and loading on cars, railway haulage to smelter and distribution of ore to the roast heaps, as done with the old machinery and facilities, and that done by the new plant.

TABLE V.

	Old Machinery.		New Machinery.	Difference in Favor New Machinery.
Hoisting—Tables I, III, IV......	$0.3280		$0.0865	$.02415
Crushing, sorting, sampling—Tables II, III, IV....	0.9820		0.1025	0.8795
Aerial tram to railway...........	......	$0.0005		
Loading (spouting) railway cars.	0.1040	0.0090		
Tables I, IV................	......	———	0.0095	0.0945
Haulage, railway to smelter—Tables II, IV.......... ...	0.7500		0.4000	0.3500
Tramming to roast heaps—Tables II, III, IV...........	0.0800		0.0600	0.0220
Totals..........	$2.2460		$0.6585	$1.5875

From this Table the following deductions may be made :—

Daily................	Saving effected on output of 1,000 tons...	$ 1,587.50
Monthly (25 days)...	" " "	.... 39,687.50
Yearly (300 days)....	" " "	.... 476,250.00

which is the annual saving which the operation of the new plant affects.

In connecction with the installation of the hoisting and haulage plants above described, various accessory facilities, including railway spurs, have been constructed, which have materially cheapened the costs of realization that have previously prevailed. A general description of some of these follow, but the economies effected are not given, as the main object of the paper is to describe the new system of hoisting and haulage at the Le Roi mine and the economies effected by it, as compared with the old system.

Carpenter Shop and Framing Shed.—Here all the mine timbers are delivered from the railway cars, aud are framed to square sets by machine saws, of which there are two sets, each complete in itself. The high line spur of the railway is on a level with this plant, so that the timbers roll directly from the cars to the framing saws. When framed the timbers are loaded on the timber trucks, run through the Black Bear tunnel to the station at the combination shaft, there loaded on the cages and lowered to the different levels in the mine. The mining timbers are thus handled and framed in a most economical manner, and a very material saving is effected on the cost of wagon haulage and hand labor by which this work was formerly done.

Blacksmith and Machine Shops.—These adjoin each other, and are furnished with modern designs of forges, power hammers, lathes, shears and the general equipment necessary for the repairs and maintenance of a plant of this character. The forges and machinery for these shops, as well as for the carpenter shop and framing shed, are run by compressed air or steam. These shops are on a level with the railway, and all supplies used are delivered directly from the railway cars.

Powder Magazine.—A new fire-proof powder magazine has been built of stone and brick, alongside the high line spur that passes the portal of the Black Bear tunnel, blacksmith shops, etc., at a convenient though reasonably safe distance from the works.

Thawing House.—On the same track, and midway between the Black Bear tunnel and the powder magazine, a thawing house, equipped with steam heat, has been built. This is reached by the mine cars, which carry the thawed powder directly to the Black Bear station in the combination shaft, from which it is sent to the various levels as required. These arrangements do away with the cartage and consequent risk incidental to the extra handling of the powder, the importance of which will be recognized when it is known that the amount used daily in the mine approximates 2,000 pounds.

Water Supply and Fire Protection Systems.—A complete system of water supply for the machinery and for protection against fire has been installed, and, as a consequence, a very material reduction in the rates of insurance has been effected. The systems are a combination of the gravity and pumping systems, each supplementing the other. The gravity system operates under a head of 300 feet, and the pumping is done by two Standard Underwriter's pumps having a capacity of 500 gallons per minute each against a 400-ft. head.

The arrangement of these systems, which includes 31 hydrants strategetically located around the various buildings, is such that a very efficient fire service can be maintained with very little cost to the company, and the safety of the plant from fire may be considered assured if ordinary precautions are taken.

On the completion of this plant, the insurance companies made a reduction of 40 per cent. in the premiums previously paid for insurance.

The construction of the entire plant as above described was not finished until the month of May, 1901, although many of its units had been completed and utilized in the mining operations several months before. Owing to the industrial activity that prevailed during the period of construction, it was almost impossible to close a contract for the delivery of machinery of any considerable size short of nine or ten months from date of signing contract. This and other factors prolonged the time occupied in construction to double what would have been sufficient under favorable conditions.

The working of the completed plant was successul from the start, and the results shown in the preceding tables have been taken from actual operations.

Smelting Plant.—The enlargement of this plant had kept pace with the facilities provided at the mine for the increased extraction of ore, and in the month of May five furnaces, having a total capacity of 1,250 tons per day, were erected. The sixth furnace was on the ground ready to erect, which would have brought the total daily capacity of the smelter up to about 1,500 tons.

For the purposes of this paper it will not be necessary to give a description of the smelting plant, except to mention that its increased capacity and the facilities afforded for handling the increased output of the mine, very materially cheapened the cost of smelting.

In the installation of the mining and smelting plants, great care was exercised in the choice of such machinery as was best adapted for the work to be done, while every portion of the plant was constructed with a view of obtaining the highest possible efficiency and economy in operation at the lowest cost.

The saving effected in the hoisting and haulage operations of this plant over that of the old plant is worthy of the attention of mining engineers, for, as is shown in Table V, this alone would make a very considerable profit on the mining operations, when conducted on a large scale.

All the cost of installation of the mining and smelting plants, and the purchase of Breen's quarter interest in the smelter was paid from the profits of the mining operation for the eighteen months ended June

30th, 1901, besides leaving a balance of $135,132.79 unencumbered product at the smelter.

The following statement, Table VI, shows the cost of these plants, and hence the profits earned during the period named:

TABLE VI.

Smelter—		
Cost of James Breen's smelting contract and one-quarter interest in smelter.........	$300,000 00	
Cost of interest paid on this amount...... ..	10,785 75	
" New smelter additions and handling facilities	185,442 00	
The total cost of the smelting plant............		$496,227 75
Mine—		
Cost of 1,125 feet combination shaft, mine development and exploration..........	$292,426 40	
Cost of new mining machinery.............	210,086 05	
" " buildings enclosing the plants..	99,311 13	
" underground machinery and equipment..................................	64,453 45	
The total cost of mine development, machinery and equipment............................		666,277 03
The total cost of mining and smelting plants		$1,162,504 78
On hand at smelter, ore and furnace products, unencumbered as security to Bank		135,132 79
The total net earnings for eighteen months.....		$1,297,637 57

Economies Effected.—As indicating the extent to which the costs of realization of the gross values in the ore may be reduced under full operations of the new mining and smelting plants, Table VII, giving the costs for the fiscal year ended June 30th, 1901, follows:—

TABLE VII.

Mining—		
Stoping	$3.362 per ton.	
Exploration	.138 "	
Equipment.............................	.094 "	
Depreciation of buildings	.030 "	
Depreciation of machinery	.106 "	
Freight on ores.........................	.510 "	
		$4.420 per ton.

Smelting—

Matting ores	$4.252 per ton.		
Depreciation smelting plant	.100	"	
		4.352	"

Realization of Smelter Product—

Interest and discount	$0.145 per ton.		
Eastern representative	0.027	"	
Sacking and crushing matte	0.044	"	
Freight on matte	0.536	"	
		0.752	"
Making the total cost of realization		$9.344	"

In the foregoing table, the costs of realization show a reduction of $5.80 per ton under the costs prevailing while Breen owned the quarter interest in the smelter, or $3.80 per ton not counting Breen's profit of $2.00 per ton of ore smelted.

For the year reviewed, in Table VII, the mining operations had comparatively little benefit from the completed plant, although it must be acknowledged the saving effected by the several units of it completed earlier in the year, was very material.

Nevertheless, with the full benefit of the completed plant, a still further reduction in the costs of realization may be confidently expected and while the direct saving effected by the new hoisting and haulage plant is only $1.5875 per ton over that of the old machinery, it will be readily seen that the saving effected in the other departments on account of the high capacity and efficiency of this plant is solely, though perhaps indirectly, attributable to it. In other words, the hoisting and haulage plant and the associated facilities installed on the Le Roi mine have made possible whatever reduction under $13.14 can be made in the costs of realization. It has been shown that with only part of the plant in operation during the year 1900-'01, the reduction amounted to $3.80 per ton. And it is reasonable to expect that with the larger output now possible, the operations will show a still further reduction of costs in all departments.

Concluding Remarks.—The data collected in this paper show that for effecting the highest economy in mining operations where a large output can be maintained, the following equipment and facilities should be provided:—

1. An efficient and up-to-date system of hoisting and haulage.

2. Such associated incidental facilities as will ensure, as nearly as may be, the contiouous operation of every unit of the plant comprising the system.

3. Intermediate storages of ample capacity for ore, in the mine and between the different sections of the plant, to provide against the stopping of the entire plant if an accident to any one of the units occur.

4. Separate sets of hoisting compartments for the ore, and for the general traffic of the mine, the skips or cages of each set to be run in counterbalance.

5. All loading from the main storage bins to be done through chutes opened and closed by compressed air.

6. Where hand sorting of ore is advisable, it is to be done on travelling tables of steel or rubber passing before the sorters at a speed not exceeding 45 feet per minute.

7. The waste and second grade ore to be picked out and dropped into bins underneath the sorting floor, the sorted ore to be allowed to be conveyed and delivered to the sampling machinery automatically.

8. The boiler plant to be installed not nearer than 200 feet to any of the other units of the system and at a point, if possible, where the delivery and storage of a reasonable quantity of whatever fuel is used can best be effected.

9. A convenient grouping arrangement of the various units of the surface plant adjacent to the entrance of the mine, which should be accessible by railway, or by an easy system of wagon roads.

10. An efficient system of fire protecton operating preferably by gravity, or, a combination of gravity and pumping. If the latter is used sufficient tank storage should be provided, so that, in case of fire breaking out, water under sufficient pressure will be available at once while the pumps are being started.

These features, so far as possible, have been kept in sight in the design and construction of the plant, herein described.

Before closing this paper, I feel it my duty to state that in the design and construction of this plant, I was ably assisted by Mr. William Thompson, who occupied the position of Assistant Manager with the company.

Asbestos and its Production in Canada.

By W. MOLLMANN, M.E., Black Lake, Que.

Amongst the minerals which have gained during the last decade a prominent position in Canadian mining, must be placed asbestos. Commercially, it occurs almost exclusively in serpentine, and possesses such valuable properties as to give it a commanding place in the arts and industries.

Asbestos is a fibrous mineral, in which the fibres are either parallel or divergent. It is often lustrous, and its color varies from white to gray, brown, and green. Amongst its valuable properties may be mentioned incombustibility, flexibility, and ductility, besides it is a non conductor of both heat and electricity. Its resistance to the action of acids is also worthy of note.

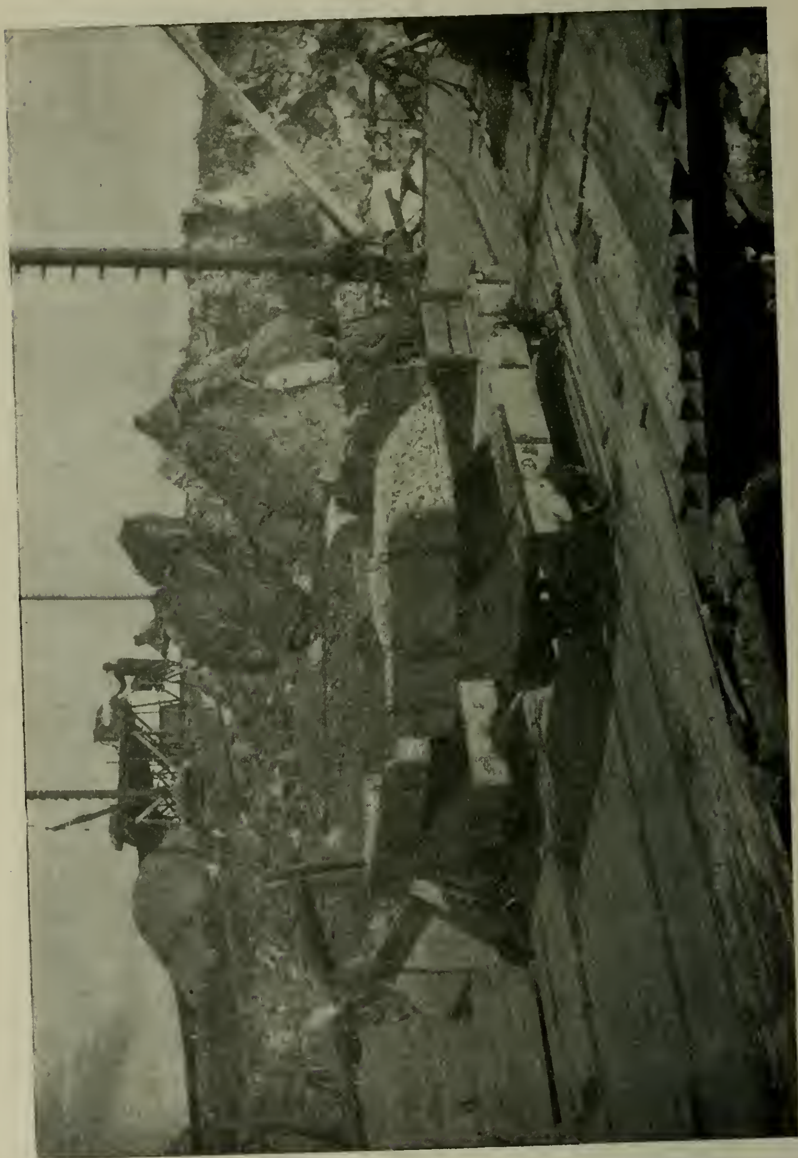
The particular prominence that asbestos at the present time has attained is through its resistance to fire. This property was known to the ancients more than 2000 years ago, and asbestos was utilized by them for the wicks of the lamps in the temples and for other purposes.

Now its use has become quite general, and its application for various purposes is continually increasing. Among the uses to which it is put may be mentioned : packing in various forms ; covering for steam boilers and pipes ; firemen's clothes ; theatre curtains ; boxes for money and valuable papers ; covering for walls and roof ; acid filters ; powder bags ; etc., etc.

As a matter of fact the demand for asbestos has been so great of late years that the opening of new mines has scarcely been able to keep up the required supply. Chemically, asbestos is a silicate of magnesia and lime—however with a fluctuating ratio of its constituent parts. Iron and aluminium are generally associated with it.

The asbestos of commerce contains about 14 per cent. of water, while a variety, which is, however, only of interest to the mineralogist, is almost wholly free from water, or only slightly hygroscopic.

The following table, taken from the admirable work "Asbestos and Asbestic" of R. H. Jones, of Montreal, gives the analyses of the principal kinds of commercial asbestos.



Interior of one of the great Asbestos Quarries worked by King Bros. at Thetford Mines, Que.

General View of Thetford Mines, Que

	Italian Fibre.	Canadian Fibre.	
		Thetford.	Broughton
Silica	40.30	39.05	40.87
Magnesia	43.37	40.07	41.50
Ferrous Oxide	.87	2.41	2.81
Alumina	2.27	3.67	0.90
Water	13.72	14.48	13.55
Totals	100.53	99.68	99.63

Mineralogically and genetically we distinguish two particular groups or forms of asbestos :

1. Hornblende asbestos.
2. Serpentine asbestos (of the mines).

The first form is so called because it forms one of the varieties of hornblende in the amphibole series. Among the latter may be mentioned actinolite (radiated) and tremolite, which are also known as amianthus or hypsolite when of fine fibrous structure. The color of amphibole asbestos varies greatly, but the more common is whitish-gray or green.

Especially during the period 1897-1900 has the great distribution of this mineral over the whole surface of the earth been established. In consequence of the high value of commercial asbestos it has been prospected all over the world. Although reports of finds have come from many quarters, yet very few have proved profitable for mining. When a find was reported it was generally found to be amphibole asbestos, which is materially inferior in quality to the serpentine variety. The difference between the two is that the former is less fine and less flexible, besides lacking that silky lustre.

The species of the second group is a variety of serpentine, the latter a mineral of great geological interest. This asbestos goes under various names : chrysotile, mineral flax ; liquiformed asbestos ; mountain leather ; mountain cork ; etc. With the exception of the first, the rest have all a yellowish-brownish appearance, and occur frequently in fissures or small seams (Canada, Norway, Germany). They are seldom available in industry.

Technically, chrysotile takes the first rank of the varieties of asbestos mentioned. Under the name chrysotile is designated that variety of serpentine asbestos, in which the fibrous structure is arranged in fine parallel threads of silky lustre. It is generally of a greenish color, although grey or yellow is found. The principal deposits are in Canada, in the Province of Quebec, where enormous deposits are found, which during the past twenty years have developed into an active mining industry.

Although many attempts have been made in many countries to supplant the Canadian article, yet up to the present they have not succeeded. The Italian, Russian, and American (U.S.) varieties cannot compete with the Canadian, as they lack fineness and toughness of the fibre. The greater length of the Italian fibre is not of much account when compared with the Canadian, as the latter, when only half an inch in length, can readily be spun. Furthermore, in the spun thread, the strength of the thread when composed of fibre over three inches in length, is no longer directly proportional to the length of the fibre.

Asbestos is found in the United States in Vermont, Pennsylvania, Georgia, and California. The latest discoveries in the Green mountains in Vermont look very promising, and it is expected that the veins will increase in size as the work progresses.

The total production in 1900 of asbestos was as follows:—

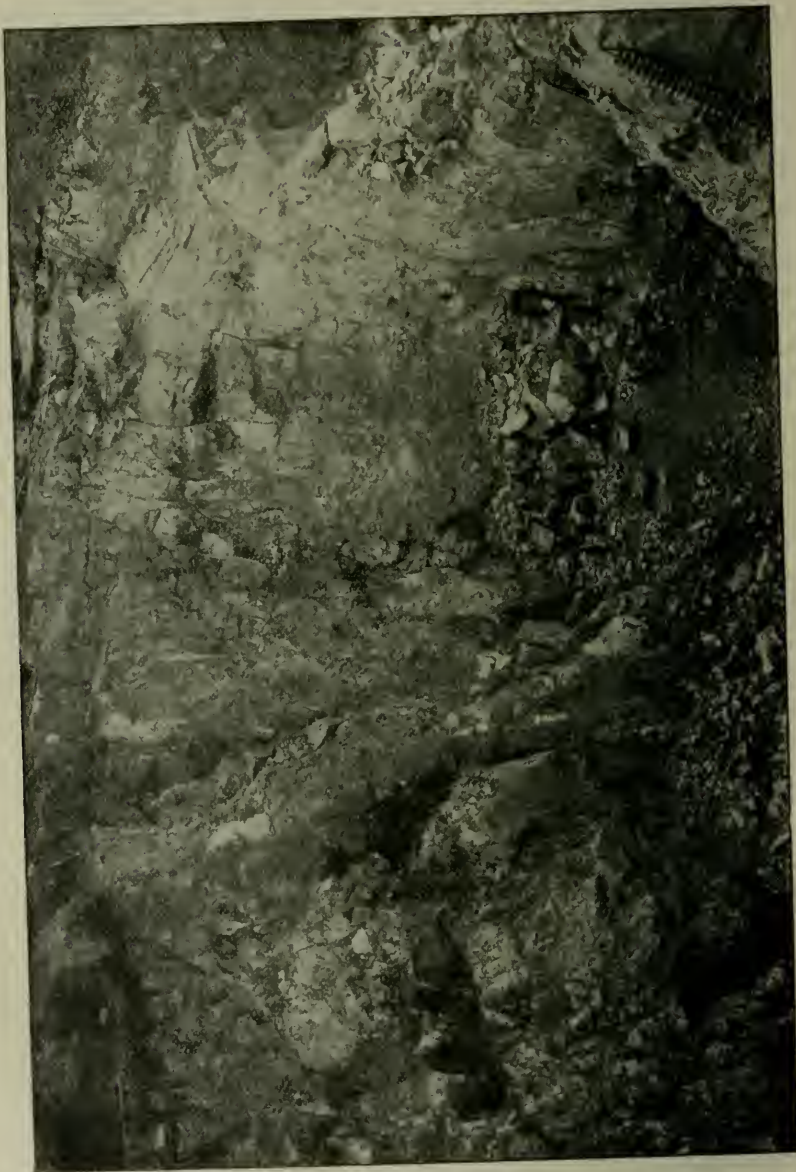
	TONS.
Canada	30,641
United States	1,054
Italy and Russia	1,500
Total	33,195

For 1901 we have—

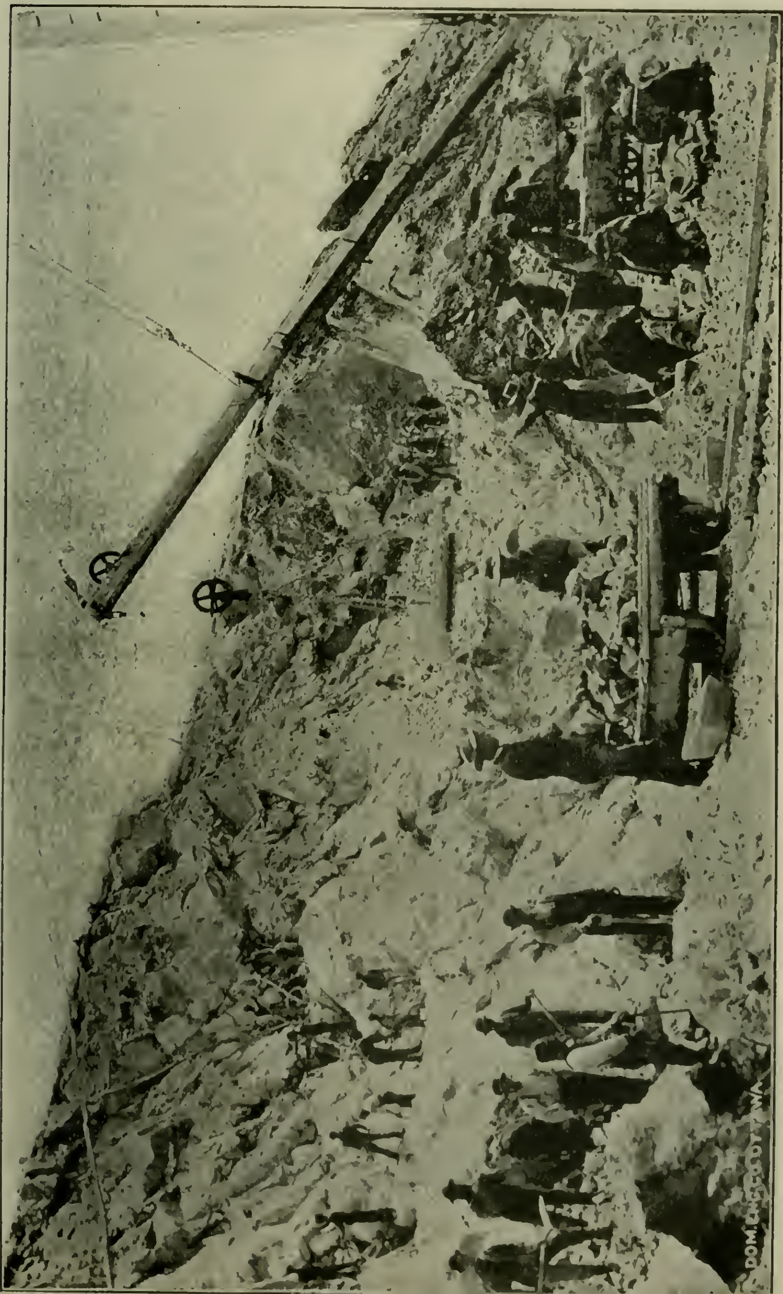
Canada	38,500
United States	1,300
Italy and Russia	2,000
Total	41,800

Although the production of Canada has enormously increased, yet prices have been well maintained, and this serves as a guarantee for the steadily growing demand for asbestos.

The following table will be undoubtedly of general interest, show-



Interior of Big Pit—King Bros. Asbestos Mines, Thetford, Que.



Asbestos Mining at Black Lake, Que.

ing the annual production in Canada and the United States of this mineral.

Year.	CANADA.		U. S.		Year.	CANADA.		U. S.	
	Quantity. Short Tons.	Value. $	Quantity Short Tons	Value $		Quantity. Short Tons.	Value. $	Quantity. Short Tons	Value $
1879	300	19500	....	....	1891	9279	999978	66	3960
1880	380	24700	150	4312	1892	6042	388462	104	6416
1881	540	35100	200	7000	1893	6473	313806	50	2500
1882	810	52650	1200	36000	1894	7630	420825	325	4463
1883	955	68750	1000	30000	1895	8756	368175	795	13525
1884	1141	75079	1000	30000	1896	12250	429856	504	6100
1885	2240	142441	300	9000	1897	30442	445368	580	6450
1886	3458	206251	200	6000	1898	23785	486227	605	10300
1887	4619	226976	150	4500	1899	25536	485649	681	11740
1888	4404	255007	100	3000	1900	30641	763431	1054	16310
1889	6113	426554	30	1800	1901	38500	962500	1300	20150
1890	9860	1260240	71	4560					

(From U.S. Geol. Survey: "Production of Asbestos in 1900," by J. Pratt.)

To give an idea of the important place asbestos takes in the mineral products of the Province of Quebec in the year 1900, the following table is given:—

KIND OF ORE.	Number of Workmen.	Quantities Produced, Shipped, or Utilised.	Gross Value of Ore Shipped or Utilised
Magnetic Iron Ore (long tons)......	10	1550	3875
Bog Iron Ore	120	17186	34372
Calcined Ochre.... (tons of 2000 lbs)	52	1182	9300
Chromic Iron .... (long tons)	130	2068	83449
Low grade Copper ....(long tons)	270	33742	150152
Galena .... (long tons)	24	286	87381
Asbestos ....(tons of 2000 lbs)	1040	21408	719416
Asbestic............ ditto	....	7935	15948
Graphite, prepared.. ditto	....	13	2500
Graphite, raw....... ditto	25	388	6964
Phosphate .... ditto	....	1370	8900
Mica, thumb-trimmed ditto	500	335	138600
Mica, not prepared.. ditto	....	150	25000
Feldspar .... ditto	....	147	441
Sulphate of baryta.. ditto	8	460	3220
Slate............... ditto	60	915	10131
Flag stone............(square yards)	9	4000	3500
Cement .... (barrels)	40	22100	36570
Granite...........................	170	.....	65000

(From Report Department of Colonization and Mines: "Mining Operations in the Province of Quebec," by J. Obalski, M.E.)

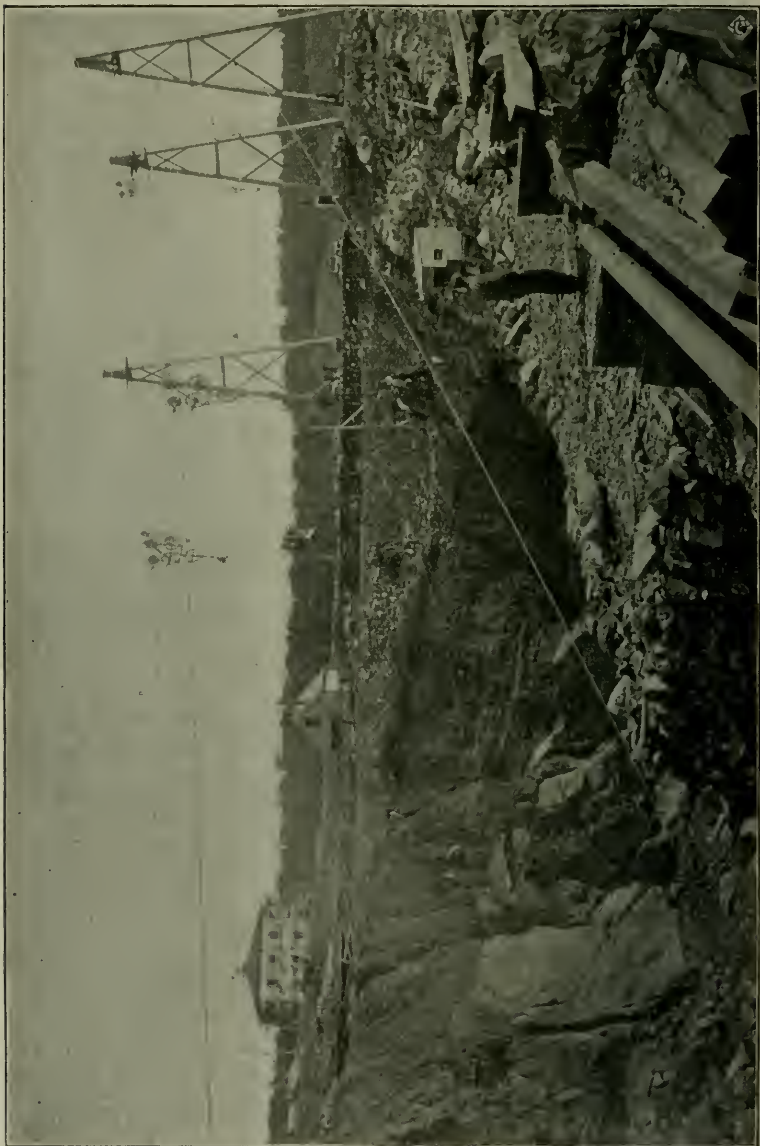
The principal localities in the Province of Quebec where asbestos is mined are Black Lake and Thetford, lying about midway between Quebec and Sherbrooke, on the Quebec Central Railway.

The asbestos is here found in narrow fissures, one to one and a half inches in width (maximum five inches) of the belt of serpentine; and the fibres are generally perpendicular to the walls of the seam. Although the veins seem to run in all directions, yet on closer examination a certain order is discernible. Foremost among the latter is the grouping of the fissures in long-drawn zones, which again may include narrower and richer ones. It does not always follow that by penetrating deeper the veins enlarge, in fact, the reverse is often the case.

As long as the genesis of asbestos is not thoroughly understood, we shall not be able to set up definite rules and methods, as obtains in the mining of ore and coal, to assist in the opening and development of asbestos mines. I surmise that the formation of asbestos from the serpentine magma was materially influenced by granitic eruptions.

The frequent occurrence of fissures, running in all directions, in the serpentine gives evidence that the area must have been subjected to intense disturbances after the cooling or solidification of the serpentine. The effect of these disturbances causes the greatest difficulties in the development of an asbestos area.

The mining of asbestos is carried on by quarrying. As the fissures or seams are small it naturally follows that a great deal of dead matter has to be moved. The serpentine carries on the average from three to four per cent of asbestos, and rarely does it reach as high as six per cent. Dynamite is used as the explosive, and is put into 10 to 12 feet deep drill holes. In out-of-the way places the hand drill is still used, otherwise steam or compressed air is utilized. The broken rock is reduced to smaller pieces by means of heavy sledges and steel wedges, and then smaller hammers are used for separating the asbestos from the gangue. The latter work is done either in the quarry, or under cover when a purer asbestos is desired. For this work boys from 14 to 16 years of age are employed. As magnetic iron ore is sometimes found in the asbestos, particular attention must be paid that the fibres are not unnecessarily damaged in separating the mineral. This treat-



View of the Quarry of the Asbestos and Asbestic Company at Danville, Que.

An interior view of the Main Pit of the Bell's Asbestos Co. at Thetford Mines, Que.

ment furnishes what is known as "crude" asbestos, which is then ready for shipment, in bags of 100 lbs. There are two grades—Crude No. 1 and Crude No. 2.

On account of the relatively small percentage of asbestos in the rock blasted, it is necessary to have special appliances for moving the latter. For the smaller mines the ordinary crane answers, but for the larger ones the crane is supplemented by cables. In the latter case the cable is put at an angle of not less than 30 degrees, so as to utilise gravity in returning the pit-boxes to work.

It is evident that by either of the above two methods the area that can be served is very limited, and this has led to the introduction of cable derricks with tail-rope. In applying the latter means a cable, one and a half inches in diameter, is stretched across two masts, from 30 to 60 feet high. One end of the cable is fastened to some high point in the quarry, while the other end is fastened on the other side of the mast, and distant as far as possible from the foot of the mast. By means of the endless cable the engineer is enabled to lower the pit-box quickly, and to hold it at any desired point. The hoisting cable (3/4 inch) brings up the load. The pit-boxes are shallow wooden boxes lined with sheet iron, and carry from 1 to 1 1/2 tons. After being hoisted to the surface they are either loaded directly on to waggon frames or are dumped into larger dumping cars, and then moved by horse or steam power. For hoisting, twin steam engines of from 15 to 20 horse-power are used.

After having given a general description of the mining operation, a few words may be added about the treatment of the less valuable asbestos. This latter consists of waste (mostly serpentine) from the crude asbestos, and of larger pieces of serpentine traversed by small veins of asbestos, which, however, it would not pay to treat, as heretofore described, by hand.

The extraction of the fibre from this inferior material is done by machinery in asbestos mills. The broken material, or at least the smaller pieces, is first subjected to a drying process in rotating cylinders; it then passes through stone crushers and rollers, whereby it is reduced to a given fineness, when it passes into the "cyclones," where further reduction takes place, especially the disintegration or separation of the individual fibres. This process (centrifugal) continues until the rock is ground to sand and the asbestos fibres are thrown on to the separating sieves. From the latter the fibers are drawn away by exhausts, and the sand is blown into bins. Nothing remains now to be done but to fill this asbestos, known as "paper stock," into bags of 100–150 pounds for shipment. According to quality it is designated as Nos. 1, 2, or 3.

It is probably scarcely necessary to state that the above description is but very brief, and the actual work is not at all so simple, but we cannot here enter into greater detail.

As already stated, asbestos commands a good price, and higher than ever, although the production has greatly increased.

"Crude" asbestos, No. 1 sells from $150 to $250, and No. 2 from $80 to $150 per ton ; paperstock runs from $20 to $40 per ton. To explain the difference between the above prices it is necessary to state that in the different mines for a given class different prices obtain, depending upon the length of the fibre, and upon the per cent. of impurities.

Beside the mines of Black Lake and Thetford, those at Broughton and Danville deserve mention.

Although asbestos occurs near Ottawa, yet it is in too limited quantity, the veins being small in number, to be of any commercial importance. The fibre is very pretty, and of a light yellow-green color, the same as the serpentine.

So far as known there are no other localities in Canada where asbestos could be profitably mined. At the present time there are in Canada twelve asbestos mining companies, with a capital of four millions ; the mines requiring at present about 3000 men. Difficulty is experienced, especially during the summer months, in obtaining sufficient labor, and efforts are made to obtain the requisite supply. The wages, for 10-hour shift, are from $1.25 to $1.50, which is considered fair pay, considering that the cost of living in the Province of Quebec is relatively low.

From the foregoing the importance to Canada of the industry of asbestos mining must be apparent. In this she rules the markets of the world, and to all appearances will continue to do so on account of the extensive area of her asbestos deposits and of their high quality.

We may safely say that, with the very good prices prevailing, and the rapidly increasing demand, asbestos mining in Canada has a decidedly bright future in store.

Cable Derrick Plant at the Union Mines, Black Lake.

On the Possible Occurrence of a Coal Area beneath the Neo-Carboniferous or Peruvian Strata of Pictou County, Nova Scotia.

By Dr. H. M. Ami, Ottawa.

"The Pictou Coal Field is of a very complicated character," wrote Sir William Logan in 1869,† as he described a portion of the Pictou coal field, Nova Scotia. All previous and subsequent workings of coal seams in that field have corroborated the view there expressed by this eminent field geologist, as one may gather from the numerous writings of the Messrs. Poole, Hartley, Dawson, Gilpin, Fletcher, Rutherford, and others. "Undulations, important faults," or dislocations combine to make mining in this area rather difficult and intricate.

Millions of tons of bituminous coal have been obtained from the mines within the Pictou coal field. The Acadia and Intercolonial collieries together produced no less than 590,638 tons in the year 1900. The various workable seams have been described carefully, from the "main seam" to the smallest workable stratum of coal, and their respective character need not be entered into here.

One of the most important faults of the district is that known as the "North Fault," to which is ascribed a vertical displacement or throw of several thousand feet. Alongside this fault, and in the vicinity of its line of outcrop, near Blackwood Brook, New Glasgow, the black bituminous and coal-bearing shales and strata of the Stellarton formation, which carries the productive coal measures of the Pictou coal area to the south of this fault, as recognised in the Vale, Acadia, Intercolonial, and other mines of the area, are seen to abut against the tilted sandstones and associated strata of the older and subjacent Westville formation, the latter constituting the so-called "millstone grit" formation of European geologists—subjacent to the coal-measures of England, etc., and very doubtfully the equivalent of the Westville formation of Canada.

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* Trans. American Institute of Mining Engineers, Vol. XXX.

† Report of Progress, Geol. Survey, Canada, 1866–69, p. 4. 1870, Montreal.

There is but a narrow strip of the Westville formation visible in the Blackwood brook in New Glasgow (west side), between the outcrop of the New Glasgow conglomerates (which in their eastward extension constitute Fraser's mountain) and the "north fault," but larger areas of this formation occur both east and west of this point; east, over the area on which the telegraph road runs from New Glasgow to Weir's Mill and Sutherlands' Bridge, etc., as well as west of New Glasgow. At this point there occurs, therefore, a conspicuous unconformity, in which a series of newer conglomerates and sandstones capped by calcareous bands of sandstone, as well as some shales and freestones, cap unconformably the tilted measures of the Westville formation, otherwise designated as the "millstone grit."

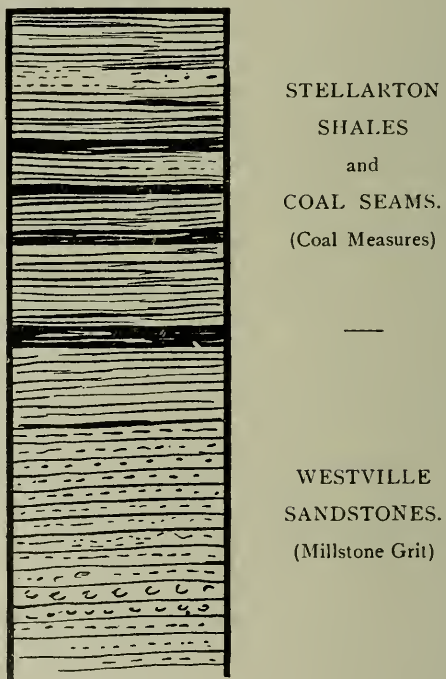
That the tilted strata which are seen to underlie the New Glasgow conglomerates and their superjacent formations in Pictou County, north of Blackwood brook, are of "millstone grit," or Westville age, has been generally conceded by many geologists, in fact, by all who have described the geological or underground structure of that portion of Nova Scotia, and I have not seen any reason, as yet, why this view is not correct, and therefore accept it until such evidence is forthcoming to clearly disprove it.

It is well known that in the neighbourhood of the town of Westville and the areas south of the "north fault" generally in Pictou County, down to the south fault, and east of the west fault the Westville formation, in its normal development, is always capped by the Stellarton coal-bearing formation, and would present, if undisturbed, the following succession as represented in Diagram A.

In Figure A the Stellarton formation, or productive coal measures of Pictou county, rest directly over the Westville sandstones, grits and conglomerates, or "millstone grit" formation of most writers, so that wherever the productive coal measures of the Stellarton formation occur in their normal condition of deposition, undisturbed by faulting and tilting, the Westville sandstones and grits would be reached by traversing the Stellarton shales and coal seams.

Inasmuch as the original structure and condition of the strata since deposition have been considerably changed by later dynamic forces at work in the Pictou coal basin, and these have dislocated the strata, tilted them in many localities and let down into the depths of the earth between some of those deep faults which affect the carboniferous measures of this field, the productive and workable seams, so as to protect them from agencies of erosion which came subsequently, one of these changes may be best illustrated by means of a diagram—

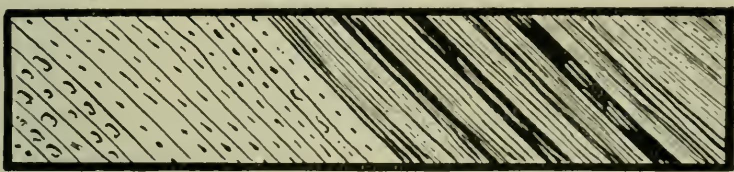
FIG. A.



(See Figure B) — illustrating the case where the Westville and Stellarton formations are tilted at a high angle and their edges denuded. It will thus be seen that the Westville formation, with its sandstones, grits, and conglomerates, underlie unformably, and in its regular and normal position, the shales and productive coal seams and associated strata of the Stellarton formation. The block of Westville and Stellarton strata, thus represented in Figure B, though diagrammatical, nevertheless shows the relations which these two district geological formations bear to each other in various portions of the Pictou coal basin, south of the "north fault," and which may possibly obtain north of the same fault in the area in question and discussed in this brief paper.

Supposing, now, as is the case in the outcrop of the strata of the Westville (or millstone grit) formation at Blackwood brook, that its strata dip at an angle of 60 degrees towards the north, presenting the upper edges of the strata in an eroded condition, then, in the event of the succession of the carboniferous strata, these being normal and

FIG. B.



WESTVILLE Formation or "Millstone Grit." — STELLARTON Formation or "Coal Measures."

regularly without the intervention of a fault (of which there is no evidence whatever), it is reasonable to suspect—provided the unconformity prevails for a considerable distance north of the "north fault," in the direction of the mouth of the East river of Pictou or of Pictou town—that the newer and higher stratas constituting the Stellarton formation, or productive coal measures, will be found overlying the sandstones of the Westville formation exposed on Blackwood brook somewhere to the north, and the contact between these two formations would be somewhere between the latitude of Pictou town and that of Blackwood brook. The contact of the two formations—if it exist at all—is hidden by the overlying strata of the New Glasgow conglomerate formation, and the various geological horizons or formations which overlie the New Glasgow formation perfectly conformably, up to the measures of the overlying and newer Pictou and Cape John formations, which, by some geologists, are classed as Permian, by others as permo-carboniferous, and by others still as members of the carboniferous system.

Unfortunately there is but little of the Westville strata exposed in Blackwood brook, and also very little of the contact between the two unconformable series visible.

The bevelled appearance and condition of the Westville strata in Blackwood brook clearly indicate strong erosion by wave-action at the time of the deposition of the New Glasgow conglomerate, and subsequent formations, the tilting having taken place not very long after the deposition and hardening of the strata.*

While the plane of marine erosion was being formed in the underlying tilted series of strata the wave action was accumulating the materials which now constitute and make up the New Glasgow formation of Fraser's mountain as well as the formations of impure limestone, sandstones, clays, sandy shales, bituminous shales, freestones, and conglomerates overlying the New Glasgow formation, and these materials, as may be gathered from the false bedding visible and the general character and structure of these materials deposited in these formations indicate rapid deposition or accumulation. Two or three small coal seams occur in these newer sediments also, whilst not a few of the layers of sandstone show innumerable grains of coaly matter—grains of coal, coal dust—accumulated or spread over the layers and throughout the strata themselves, along the divisional planes of stratification.

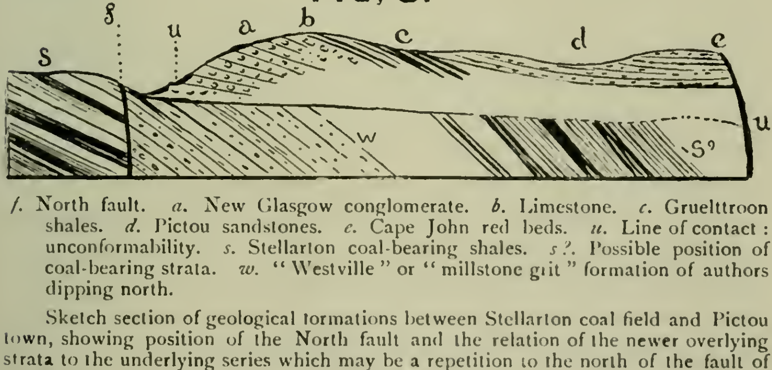
Taking for granted, then, as we did at the outset, that the New Glasgow conglomerate overlies the "millstone grit" or Westville sandstones at Blackwood brook, which latter dip to the north, why can we not expect to meet the productive coal measures on Stellarton coal-bearing shales and shaly strata by boring through the new overlying strata capping the tilted series of strata unconformably?

* NOTE.—The faunas and floras discovered entombed in the overlying series of newer strata indicate an upper carboniferous facies with Permian affinities in the highest beds of the strata in Pictou County, near Cape John. It is difficult for me to be thoroughly persuaded that the tilted strata of Blackwood brook are of the Westville or "millstone grit" age.

The very pressure of coal dust or finely broken coaly matter disseminated over the surfaces of the overlying strata predicates, in my mind, the fact that erosion in strata that were probably coal-bearing, though I must confess that the erosion of the shales would lead to the deposition of clays and mud-stones, which are, however, conspicuous by their almost total absence in the section from New Glasgow to Pictou or Cape John.

As to what portion of the Westville formation crops out along the line of contact and unconformability at Blackwood brook has not been ascertained precisely as yet, as far as I have been able to ascertain. Accordingly, at what distance north of the north fault and New Glasgow the top beds of the Westville formation occur and the beds of the

FIG, C.



f. North fault. *a.* New Glasgow conglomerate. *b.* Limestone. *c.* Gruelttroon shales. *d.* Pictou sandstones. *e.* Cape John red beds. *u.* Line of contact : unconformability. *s.* Stellarton coal-bearing shales. *s ?.* Possible position of coal-bearing strata. *w.* "Westville" or "millstone grit" formation of authors dipping north.

Sketch section of geological formations between Stellarton coal field and Pictou town, showing position of the North fault and the relation of the newer overlying strata to the underlying series which may be a repetition to the north of the fault of the Pictou coal area now worked to the South.

Stellarton coal-bearing formation begin, depends entirely upon what portion—the lower, middle, or upper portion—of the Westville series crops out in the bed of Blackwood brook.

The newer or overlying series consist of more or less horizontal strata, and the precise thickness and extent of this formation has not been definitely ascertained as yet by boring. Should boring operations be carried on so as to give the locality a fair test to ascertain the probable occurrence of a coal field north of the great north fault, and in the vicinity of and underneath Trenton or the country to the north, between the Straits and the fault, such boring operations will furnish the geologists with much data that are necessary and requisite in order to be able to state with precision to what thickness the overlying strata cap the tilted and supposed coal-bearing beds beneath.

That there should be a possible coal-field beneath the newer overlying series and in the inclined beds below is a question of much interest and worthy of more than cursory notice.

The prevalence of the coal basin depends upon the continuity of the unconformable contact between the two series of sediment, such as are exposed in Blackwood brook.

It may not be out of place here to state that far back an attempt was made to put down a bore hole with a view of obtaining coal, but inasmuch as the hole was not carried down to a great depth, neither was a careful log preserved of the strata traversed during boring operations, the results were negative rather than positive, and whilst at Blackwood brook the underlying, tilted series of beds are near the surface of the ground, and a few hundred yards north of the brook, probably only a few hundred feet from the surface of the ground, the precise thickness of the overlying strata can only be ascertained by boring or sinking a shaft.

It is to be hoped that before long the locality in question will receive a fair test—bore holes put down so as to traverse the newer overlying series—in order to ascertain the occurrence or non-occurrence of the coal-bearing shales and strata of the Stellarton formation in that portion of Pictou county north of the "north fault."

The Ore Deposits of the Boundary (Creek) District, B. C.

By R. W. Brock, B.A., Ottawa.

The district treated of in this paper is that lying along the International Boundary line, in the neighborhood of and between the valleys of the north fork of the Kettle river and Boundary Creek, B.C. Following upon the construction of the Columbia and Western railway, a little over two years ago, and the installation of smelters at Greenwood and Grand Forks a year and a half ago, the district at once took a foremost place in British Columbia lode mining and it now ranks as one of the most important factors in the production of copper in Canada.

While the mountains are not rugged and the western and southern slopes are often open, prospecting has not been easy, on account of the covering of drift which conceals the rocks over a considerable portion of the surface and on account of the complex geological structure of the district.

* Eruptive rocks, including granites, greenstones, lavas (and associated tuffs) and various intrusive dykes have the widest distribution. More or less altered sedimentary rocks (limestones, argillites, quartzites) together with more highly altered metamorphosed rocks, including serpentine, are met with in all parts of the district, but do not, as a rule, have large dimensions in any one place, being usually nothing more than inclusions of older formations caught up in the intrusive rocks.

The oldest rocks recognized in the district are the sedimentary and crystalline rocks. In the south-eastern part of the district just west of Grand Forks, some crystalline mica and hornblende schists and crystalline limestone occur, which resemble lithologically the rocks of the Shuswap series (Archean), but they may possibly merely represent in a more highly metamorphosed form the argillites and limestones found elsewhere in the district.

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* The rocks have not been studied microscopically, and cannot therefore be named with strict scientific accuracy, but still closely enough for most practical purposes.

The argillites are normally dark or red, occasionally highly carbonaceous, but are often altered to gray knotted schist, or hornfels, or they may be largely silicified. The limestones are usually white and crystalline, but occasionally show an original black color. In places the lime is replaced by silica, forming cherty or quartz-like jasperoid rocks. True quartzite is only sparingly found. Closely associated with these is a serpentine, probably derived from a basic eruptive rock. It is frequently altered to a siliceous dolomite or magnesite. These rocks form a series closely resembling, and probably of the same age as, the Cache creek series described by Dr. Dawson, and ascribed by him to the carboniferous formation.

Somewhat younger than the sedimentary rocks is the greenstone, which has the greatest areal distribution of all the rocks of the district. Often it is altered, but where its structure is preserved it appears to be an augite-porphyrite, sometimes agglomeratic, similar to that rock found in many parts of West Kootenay, notably around Rossland. It cuts and holds inclusions of the older rocks. Indeed, in most of their occurrences, the latter appear simply as islands in the greenstone, varying in size from small fragments, closely packed and almost filling the greenstone matrix, to bands hundreds of meters long. Under pressure it becomes schistose and difficult to detect from some of the included argillites. Occurring with it are bands of tuff, filled with fragments of the older rocks, and interbanded with fine-grained ash-beds.

Younger than and cutting the greenstone is a gray hornblende-biotite granite which is exposed near Greenwood, in Wellington camp, and on Hardy mountain. Gray granite porphyry dykes from it cut the older formations a long way from the parent masses. The white altered porphyry on McCarren creek and at the City of Paris mine, may belong to this series of dykes. This granite will probably prove to be the same rock as the Nelson granite, of West Kootenay, and about Jurassic in age.

Near Central Camp and northwest of it are bosses and dykes of a gray diorite porphyrite, which microscopically closely resembles the Rossland monzonite, but until it has been carefully studied it is still uncertain that it is the same rock. Younger granites occur just outside the area described.

Beds of volcanic rocks are found at several points overlying the rocks already referred to. These are remnants of a sheet of volcanics which once covered the entire country but which, in this district, have been largely removed by erosion. The series consists of coarse and fine tuffs, ash-beds and shales (in which coal is sometimes found) with sheets of andesites, basalts, and other volcanic rocks. These latter are sometimes locally termed "bird's-eye porphyry." This series is probably of Tertiary age.

Dykes of a reddish or yellowish syenite-porphyry, having a fine-grained ground-mass, with conspicuous rosette-like phenocrysts of feldspar and some biotite, are common in the mineralized portions of the district, though wanting in the unmineralized. On the Carbonates claim, this reddish porphyry is seen as a contact facies of a coarse syenite-porphyry similar to those observed east of the North Fork and in the Rossland district, where such dykes are known to be from the Rossland granite. They would appear to have the same relationship here, but it is yet to be proved that they have no genetic connection with the volcanic flows as well. Dark lamprophyric dykes and some of a brownish basalt-like rock also occur.

The ore-bodies may for convenience be roughly divided into three classes: (1) The large low-grade copper-bearing sulphide deposits; (2) the oxydized copper veins, and (3) the small gold and silver-bearing quartz veins.

Undoubtedly the most striking characteristic of the deposits of the first class is their enormous size. In the Mother Lode mine development work so far has exposed an ore-body, for a length of 1180 feet, and a width of 140 feet, which is continuous to the bottom of the workings, at present 500 feet. The Knob Hill–Ironsides lead is of as yet unknown dimensions. It extends through the greater part of the length of both claims and probably into the Gray Eagle. The lowest stopes are 700 feet below the highest point of the vein, but diamond drilling has proven the vein for another 100 feet. Its proved width is said to be 400 feet. On the second level three ore shoots are said to occur, one of 150 feet, one of 100 feet, and a third of 200 feet in width. These with the poorly mineralized rock between, would give a total width to the vein at this point of approximately 800 feet. One stope, 100 by

200 feet, is all in ore. While these figures are only approximate, they serve to illustrate the great size of the ore bodies and the extent of mineralization. These are of course the largest ore bodies yet disclosed, but some of the less developed properties have also very large deposits.

In structure these deposits belong to composite-vein type, formed by mineralizing solutions traversing the country rock, principally along fissures or zones of fissures in which they deposit the economic minerals and from which they replace with their mineral contents, particle by particle, sometimes only partially, sometimes completely, the original material of the country rock. On the outskirts of an ore body this substitution may be seen in all stages of development, the individual constituents of the country rock being one by one replaced Sometimes, as on the Emma claim, the replacement of the country rock has gone on so evenly that a completely banded ore has resulted. A banded structure cannot here be taken as a proof of open filling.

According to the most prominent mineral content, this class of deposits may be subdivided into a pyritic type, in which pyrrhotite, chalcopyrite, with some pyrite, are the chief minerals, and a magnetitic type in which magnetite, chalcopyrite with some pyrite, are chief minerals. Excepting that the pyrrhotite of the one is represented by magnetite in the other, these two types appear to be identical. Both the magnetite and the pyrrhotite replace the constituents of the country rock in the same way, both seem to have been formed, on the whole, a little prior to the other vein minerals, holding them in little veins or as points scattered through, yet sometimes interbanded with them; they are both accompanied by the same accessory and gangue minerals and the country rocks show the same alterations in both cases. Rarely do both the pyrrhotite and magnetite occur in the same deposit. In the Mother Lode a very little pyrrhotite is however reported, and in one or two small veins, as on the O. P. and Wolverine claims, both are found. The B. C., Maple Leaf, Winnipeg, Lake and Morrison, may be mentioned as representatives of the pyritic type, while the Knob Hill—Ironsides, Mother Lode, Brooklyn, Snowshoe, Oro Denoro, Emma and R. Bell belong to the magnetitic type.

Besides the metallic minerals already mentioned some marcasite appears to occasionally be present, and sometimes arsenopyrite, galena, zinc-blende, and molybdenite, but these are in all cases subordinate in quantity. Tetrahedrite has been found on the City of Paris. Specular iron is found somewhat sparingly in the Knob Hill, Brooklyn, Stemwinder, Snowshoe, B.C., and other mines; and bismuthinite occurs on the Bluebell claim, Summit Camp.

Calcite is a common gangue mineral, sometimes well crystallized, forming large masses, and also in the form of little seams through the ore and country rock. Seldom is it found in large quantities in those parts of a vein in which magnetite is heavily concentrated. Quartz is also an abundant gangue-stone, occurring in the same way as the calcite, though I have not observed it well crystallized. Silicification of the country rock to a cherty or quartz-like (jasperoid) mass, is a common, though not invariable phenomenon in the neighborhood of a vein. Red and green garnet (probably grossularite and almandine) and epidote are very abundant in and near the veins, both well crystallized and massive, often interbanded with the ores and forming a very large percentage of the vein material. The progress of their formation may be observed at many points in all stages, not only when limestone, but also when greenstone and granite form the country rock. In the Mother Lode, where limestone seems to be the country rock, while these minerals are developed the chief mass of the altered rock is made up of a felt-like aggregate of short green fibres, apparently of actinolite. A beautiful white radial tremolite occurs in the limestone at the Morrison mine. Kaolin, chlorite, and serpentine are probably among the alteration products, but until the microscopic examination of the rocks has been made an accurate account of the secondary minerals and their relative importance cannot be given.

The ores occur in all rocks except the most recent, the latter being the youngest granites, the porphyry and basic dykes and the Tertiary volcanics. In age, then, these deposits are probably early Tertiary. So far as yet found mineralization is confined to districts which show evidences of recent disturbance, more particularly where the older rocks are cut by the recent intrusives. Limestone in such a district seems favorable for the deposition of ores. In some cases the ore occurs in the limestone itself, but more frequently it is found in a rock along its contact with limestone. Thus in a greenstone where it holds inclusions of limestone, the ore often occurs in the greenstone along its contact with the limestone, while the latter may show little or no mineralization. The lack of mineralization in the limestone in such cases may be due to the fact that the limestone often flows and forms compact lenticular masses, instead of fracturing, under pressure, and thus furnishes no channels for the mineralizing solutions. If attacked and replaced by them, it must have been along the contacts and this must have taken place comparatively evenly, leaving a clean-cut unmineralized wall. While this may have been the case in some of the larger deposits, in many of the smaller veins occurring along such contacts the mineralization shows a distinct preference for the greenstone, the limestone remaining unmineralized. That the contacts between lime and other rocks should be favorable may have been due in part to the chemical influence of the lime in precipitating the mineral contents of the solutions, but it was also due to the lack of firm cementing between the limestone and the contact rock, which left free channels that the solutions used as highways and bases for their operations. But while such contacts are favorable, mineralization is by no means confined to them. In fact in tne largest deposit yet found in the district (Knob Hill–Ironsides), with the exception of an insignificant island of it, found on the intermediate level, limestone is conspicuously absent, although it occurs at numerous unmineralized points in the vicinity. While most of the deposits are in greenstone, limestone or contacts between these, they also occur in the serpentine, argillites and gray granite.

Porphyry dykes are usually to be found in close proximity to the ores, sometimes as at the No. 7 mine the ore lies parallel to a dyke along its contact or in the immediate neighborhood. At the B. C., Mother Lode and other mines dykes lie almost horizontal, running through the ore-bodies at approximately right angles. The ore is continuous on borh sides of the dykes, little or not at all faulted or otherwise altered by them. The dykes, while containing traces of metallic minerals, show no signs of mineralization. In age they are about the same or a little younger than the ore deposits, showing the deposits to have been formed during or before the close of the cooling of the eruptive magmas.

While the deposition of the mineral contents of the veins is evidently largely hydrothermal, many of the minerals formed are characteristic of contact zones and there seems to be strong reasons for supposing the deposits to be connected with eruptive after-actions. The reasons for this belief cannot be discussed at length in the limits of a short paper. The magnetite appears to have been formed in the same way and under the same conditions as the pyrrhotite. It appears to be a primary constituent of the ore. Its formation seems to have depended upon a deficiency in sulphur, the available sulphur being siezed upon by the copper and going to form chalcopyrite. On account of the variety of rocks in which the ores are found it is evident that the source of the material of the veins cannot have been local. From the fact that the mineralized districts are much cut up by eruptive dykes, that areas of recent eruptions are close at hand and vents from which the volcanic series was ejected are probably near by, and that magnetite has so far seldom or never been found to have resulted from the deposition of ordinary mineral-bearing underground solutions, while common in contact metamorphism and as the result of solfataric action, it seems fair to conclude that the deposits have a connection with the recent eruptive rocks and that at least some of the material was derived from the magma of the eruptives brought up by the after-actions characteristic of vulcanism. This view is supported by the independence of the deposits with regard to the country rocks, the resemblance of some of their materials to that of nickel-pyrrhotite and other deposits considered to be the products of magmatic secretion and others to the products of volcanic after-action. At the same time it is not claimed that deep-seated underground circulating waters have had no share in the mineralization. Indeed the mingling of solutions from the two sources may have had a marked infiuence in the precipitation of their mineral contents.

Somewhat similar deposits, though on a much smaller scale, of magnetite and chalcopyrite occur at * Cherry Bluff, Kamloops lake, near what Dr. Dawson considered a volcanic vent. These have no doubt been formed by volcanic after-actions.

† In the Kristiana district, Norway, magnetite and specular iron,

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* Geological Survey of Canada, N.S., Vol. 7, 1894, p. 341B.

† Zeitsch. für Praclt. Geology, 1894, pp. 177, 464; 1895, p. 154.

together with the sulphides of copper, zinc, lead, etc., occur within the metamorphosed zone of eruptions, especially granite, though as far as 2 kilometers from the actual contact. In association with them are contact minerals similar to many in the Boundary District. These deposits are explained by Vogt and others as the result of contact metamorphism and after-actions.

Similarly the Norwegian pyrite deposits have been shown by the same authority to be connected with contact metamorphism due to gabbro and granite.

‡ The pyrrhotitic deposits of Rossland, B.C., have many points of resemblance to the Boundary deposits, although differing somewhat in the accompanying minerals.

In ore-bodies formed by the replacement of the country rock along and from fissures, it is to be expected that mineralization should often be irregular and the ore-bodies should show correspondingly irregular forms. This is here the case. Often the deposits have no definite walls, the country rock in the neighborhood being mineralized to a greater or less distance from the main deposit, the line between the two bhing often merely a commercial wall. Unmineralized portions of the country rock are apt to be found as remnants in the vein and bunches or masses of ore may wander into the country rock. The ore is usually found in the veins in the form of shoots of various outlines. Sometimes several of these occur, often rudely parallel. In some places veins with similar filling intersect at various angles. Small stringers leading from the main veins are not uncommon. Most of the larger veins have a northerly strike with a high dip to the east. In the case of the Knob Hill–Ironsides the dip is as low as 45 or 50 degrees. Not enough development work has been done to generalize on the forms and pitches of the shoots. That of the Mother Lode pitches south. In the B. C. mine, a horizontal plating of the ore is quite pronounced.

There have been considerable movements since the ore was deposited; numerous slips, some with gouge or secondary filling, traverse the ore bodies. This broken nature of the ground, coupled with the original irregularity in the form of the ore body makes the exploitation

‡ Trans. Canadian Institute of Mining Engineers, Vol. 2, 1899, p. 72.

of the smaller deposits sometimes difficult and precarious. The slips so far encountered have not been sufficiently large to have seriously affected the larger deposits. The serpentine is particularly full of slips, some prior but many subsequent to the formation of the ores, which make it probably the least satisfactory country rock in the district.

The values in the ores are principally in copper and gold, sometimes with accessory silver. Further study is required to formulate the laws governing the distribution of gold values. Generally magnetite and pyrrhotite when occurring alone are almost barren, yet this is not always the case. In the Knob Hill–Ironsides the massive magnetite is said to have a gold value. This is said to be the case on the Seattle claim, but in an assay of this magnetite made for the writer no gold was found, though the accompanying chalcopyrite was auriferous. In the Winnipeg mine pure pyrrhotite carries as high gold values as have been found in the mine, but at other points in the same mine barren pyrrhotite is found. Chalcopyrite occurring in magnetite and pyrrhotite is generally a gold carrier, but the gold value of an ore does not always increase with the copper percentage. Thus in the Mother Lode the best gold values are said to be found where the ore runs about 2 per cent. in copper. In the B. C. mine the gold is said to be confined to the chalcopyrite—pyrite and pyrrhotite being barren. On the other hand, in the Brooklyn, Stemwinder and Rawhide the best gold values are reported from the pyrite and ore-carrying specularite. So far as could be superficially observed, the local opinion that the intersection of veins or stringers with the main bodies does not cause an enrichment, seems to be supported by the facts. It may be noted that where dykes cross the ore bodies there appears in some cases to be an enrichment of the ore. Possibly there may prove to be a relationship between the quartz and the tenor of the ore. Though segregated in places, the chalcopyrite is on the whole remarkably evenly distributed through even the immense deposits. Away from the chief centres of mineralization while magnetite and pyrite are still sometimes found, the copper and gold are only sparingly present. The actual values of the ores per ton and the cost of mining and treatment have not been made public. The ores, as a rule, are certainly very low-grade, lower than was at first hoped. This has been partly counterbalanced by the size the bodies have shown on development and the remarkable adaptability of the ores to smelting. The magnetite, quartz and calcite are present in the required proportions so that no fluxing or roasting is necessary, so that the cost of smelting, as well as the cost of mining these ores, is exceptionally low. It is generally admitted that many of the properties can only be successfully operated by doing their own smelting; for this reason a union of the smaller mines or the building of a union smelter has been suggested.

A member of the Dominion Copper Company kindly furnished permission to publish the following figures regarding the contents cf the ores of this company, which are more or less representative of the ores of Greenwood Camp.

GROSS RETURNS.

Si O	39.00	per cent.		
Ca O	17.00	"		
Fe O	14.00	"		
Cu	1.95	"	=39 lbs. Cu (at 10c. per lb.)	$3.90
AU			.119 oz.	2.40
Ag			.44 oz.	0.22

NET RETURNS.

Cu	$3.10
Au	2.40
Ag	.22
	$5.72

Values as high as $30 per ton are reported on car lots of ore from the Winnipeg mine, but such returns are exceptional, for the ores of the district as a whole.

The method of mining adopted in the large mines is to be presented in another paper and need not be referred to here.

A striking feature in the deposits is the lack of surface oxydation or alteration. At most, a few feet below the surface of the ground the ore exhibits the same characters as are found in depth. The soil overlaying a deposit is often quite unstained, offering no indication of the underlying ore, and consequently adding to the difficulties of prospecting; sometimes the surface of the ore even retaining the glacial polishing. The explanation of this feature is probably to be found in the heavy glaciation to which this region has been subjected. The old oxydized, and perhaps enriched, upper portions of the veins have been cut away by the Cordilleran glacier and since then the surface has been often more or less protected.

In Copper Camp oxydized copper-bearing veins occur, forming at first sight a totally different type of deposit. A short description of the King Solomon claim will illustrate this type. This deposit is found at a contact between a dyke of porphyry and crystalline limestone. Wedge-shaped tongues of the porphyry extend from the main dyke into the limestone. Both the limestone and the dyke are much fractured and traversed by little slips. These fractures cut the limestone into small blocks. In the limestone, and to a less extent in the fractures in the porphyry, along the contact, are deposited various oxydation minerals of iron and copper, including native copper. These embrace red massive and earthy hematite and yellow limonite, crystallized and massive malachite and azurite, a black amorphous substance, a mixture containing copper oxide (melaconite, lampadite and chalcocite), cuprite, often in transparent crystals, native copper, chrysocolla and probably copper-pitchblende. The edges of the small limestone blocks have often been dissolved and the copper ores then occur as encrustations surrounding a core of lime. The main fissures are filled with the iron and copper minerals, the smaller principally with the copper. In the porphyry it is only the fractures near the contact which contain a thin film of copper ore, the rock itself remaining fresh and unaltered. About 650 feet from the main working on the King Solomon is a small vein. The rock is here not so badly shattered. On the suface carbonates and other copper minerals with iron oxides are found; a little below the surface the sulphates of these metals occur, and below these unoxydized pyrite and chalcopyrite begin to appear. What can be seen to be taking place here on a small scale is probably what occurred on the King Solomon ledge proper on a much larger scale, so that this type of deposit is probably an oxydized and secondarily enriched form of a sulphide deposit, similar to the first type of Boundary deposits and produced by the action of surface waters. The iron of the sulphides has been removed or redeposited as hematite and limonite; the copper has been more or less concentrated in the form of various oxydized minerals. At greater depth the unaltered iron and copper sulphides will presumably be found, although between the oxydized minerals and the unaltered sulphides it is quite possible that a zone of enriched sulphides will be found. That a zone of oxydation and enrichment should be found in the veins of Copper Camp and not elsewhere in the district may in part be explained by the local topography, and the broken nature of the country rock, but the chief factor, in all probability, has been the capping of volvanic rocks which covers the hill-tops all around and extends almost to the King Solomon and other of these deposits. In glacial times these rocks are likely to have extended a little farther, in which case they would have protected the deposits from the scouring effects of the ice-sheet. In addition, the contact between the volcanic and older rocks is likely to be a natural waterway.

The quartz veins, constituting the third type of deposit, are found in the neighborhood of the first type, but seem more abundant on the outskirts of the areas of chief mineralization. They are sometimes parallel to the large sulphide bodies, but do not, as a rule, show the same regularity in their strike. In form they are more regular and they are usually enclosed between well-defined walls. Chalcopyrite, pyrite, arsenopyrite, galena and zinc-blende are the chief metallic minerals. Tetrahedrite and some rich silver minerals are said to have been found in some of these veins. The principal values are in silver and gold. High assays are reported to have been obtained from a number of these veins, but the only one at present being worked in the district embraced in this paper is the No. 7 mine. In age and mode of formation there have been little difference between these and the previous deposits, though in that case they would probably represent the closing stage of mineralization.

Some of the practical deductions from an examination of the ore deposits may be summarized as follows :—

Ores may be found in any of the older rocks where the other conditions for mineralization were favorable.

Districts which show evidences of late disturbances through vulcanism, manifested by intrusions of recent eruptives and heavy dyking, are promising fields for prospecting.

Limestone contacts in such areas should, in particular, be carefully prospected.

Since, with the exception of certain deposits in Copper Camp, there is no zone of oxydation and secondary enrichment in the main deposits, while the general conditions remain unchanged, no loss of values is to be expected in depth.

On account of the irregular form which the ore bodies may possess and the complex nature of the rock formations, a careful and detailed study of the surface of the ground in the neighborhood of the mines would be of great practical assistance in the exploitation of the ore bodies. For the same reason development work must always be kept well ahead of the actual mining. Cross-cutting must frequently be resorted to, to determine the actual limits of the deposit, and to prove the existence or non-existence of parallel ore shoots. The limits of mineralization must be actually proved, and similarly only that ore can be with certainty reckoned on which has been actually blocked out.

In this connection diamond drilling can be used with advantage. Careful magnetic surveys would also be of great value in locating ore-bodies under the covering of drift, and also in testing for ore in the mines themselves. Especially good results should be obtainable by this method in the magnetitic type of deposit, but it should also prove successful in the pyrrhotitic deposits. It has proved successful in such deposits in Scandinavia, and I am informed that experiments made with it on the Sudbury pyrrhotite deposits, last summer, have yielded good results.

Where the ore occurs at a limestone contact the limestone wall may often be used for following the ore, it being kept in mind that the ore does not always follow strictly along the contact, and that the limestone may pinch out without causing the ore to likewise give out. The dykes in some cases may be used in the same way.

The pyrrhotite and magnetite should always be assayed, as barren-looking material may carry good pay values. The minerals in the ore and the conditions where pay values occur should be carefully studied with a view to ascertaining which carry the values, and what were the causes which produced the concentration of values. The porphyry dykes themselves, while not mineralized in the same way as the country rock, may in places prove auriferous. In a specimen from a similar porphyry dyke, from the Valkyr mountains, east of Lower Arrow lake, examined last winter, free gold was plainly visible, even with the naked eye.

In prospecting it is to be remembered that float may have been carried a considerable distance, even across valleys, by the former glacier. The general course of the latter was about S. 30 E., but it was influenced by the local topography.

In a promising deposit of the oxydized copper type, one would be warrented in testing the deposit to a sufficient depth to ascertain if a zone of enriched sulphides exists between the oxydized zone and that of the unaltered sulphides. As *Emmons and Weed have pointed out, the bonanzas of high-grade ore in Butte, in Arizona, and other points, are situated between the zones of oxydation and unaltered sulphides. Below the limits of alteration the deposit may or may not be rich enough to work.

Safety Lamps and Colliery Explosions.

By JAMES ASHWORTH, M.E., Mount Chaddesden, England.

The fearful explosions which are continually occurring in various parts of the world, notably that of the Universal Colliery in South Wales, the Fraterville coal-mine in Tennessee on the 19th of last May, and lastly the one at the Fernie No. 2 tunnel workings of the Crow's Nest coal field, on the 22nd of May, about 7.30 p.m., are sufficient in themselves to cause those who have the charge of mines which give out firedamp, as well as those who have money invested in them, to seriously consider in what way this risk may be lessened, if not almost totally prevented.

It is suggested by the newspaper reports on the Fernie disaster, that the explosion originated from blasting in the coal. Similarly it was also suggested that the explosion at the Universal Colliery, Senghenydd, was caused in a similar way, but in the latter case only one witness could be found to suggest that an explosive had originated the disaster, though many witnesses proved that it could not have thus originated, and that it was in all probability caused by a totally different cause, and in a totally different part of the mine. The other cause and in all probability the true one, was the failure of a safety lamp to prevent the flame inside the lamp igniting the firedamp outside.

Under the Mines Regulation Acts of Parliament which regulate the management of coal-mines in Great Britain, all the lamps in use must be bonneted, that is to say, the gauze part of the lamp must be protected by a shield, so that an explosive air current cannot impinge directly on the naked gauze and cause it to become so quickly overheated as to destroy its protective value. Experiments have proved most conclusively that gauze lamps of the Davy type, such as the old Scotch gauze lamp, cannot withstand an explosive current of the lowest velocity on account of their large cubic contents, because the ignition of a large volume of firedamp exerts such a high velocity that the flame is forced through the mesh of the wire almost instantaneously, and without waiting to overheat the gauze. In like manner the naked Davy lamp which was in use by deputies, firemen, and shot firers for so many years throughout Great Britain, and was almost universally trusted by mine officials as the best lamp to use for the detection of firedamp, and also as the safest lamp for a workman or miner to use, was frequently condemned by experimentors until the Royal Commission on Accidents in Mines made experiments, and finally condemned the lamp as unsafe and reported that where used it must be protected by a shield covering the whole gauze. So great a favourite has the Davy lamp been in the hands of mine officials, that it is still in use in some mines in its original form (Fig. II), and in others when protected by a metal and glass shield, the glass being moveable as shown in the section Fig. III. Where the Davy lamp has not been in use for detecting firedamp the Stevenson (Fig. IIa) and the Clanny (Fig. IV) lamps have been used, but as these are as unsafe as the naked Davy, they also have been put to one side, excepting the latter when bonneted as shown in Fig. V.

The safety value of the Davy and Clanny lamps, both naked and bonneted, is well known so far as their exposure to explosive currents of air and firedamp are concerned, but when we expose them to mixtures of air, firedamp, and coal-dust, the latter factor completely upsets the confidence which the official tests of safety lamps in mixtures of firedamp and air have heretofore inspired. Thus, in the North of England Institute of Mining and Mechanical Engineers' Transactions, so long ago as 1880, a paper on Improved Safety Lamps of the Davy and Mueseler types will be found, in which it is shown by most careful experiments, which have been checked and verified, that if a mixture of air and firedamp contains only a normal per centage of coal dust, that is, just as much as the slow moving current of 370 feet per minute will lick up from the floor or carry along in suspension, 4½ per cent. of firedamp is sufficient to make the mixture so dangerous and highly explosive that a standard Davy lamp with a tin shield will pass the flame through the gauze in the short space of time of seven seconds. Without the presence of coal-dust such a lamp would safely withstand a similar current, containing only 4½ per cent. of firedamp, for many hours without failure. Nothing carries convincement to the miner's mind so forcibly as a practical experiment, and although the evidence of disasters resulting from the failures of safety lamps are not very voluminous, yet they are so definite and accurate in their details that they cannot be pooh-poohed, and treated as *chateau d'Espagne.* Thus Mr. A. R. Sawyer, formerly an assistant inspector of mines in England, and now well known in the South African gold and coal fields, relates in one of his papers contributed to the North Staffordshire Institute of Mining and Mechanical Engineers, that on one occasion he took hold of a miner's Davy lamp, hanging at

FIG. I.—Scotch Gauze Lamp.

the face of a slightly dusty working, to examine it, and on giving it a slight tap with his hand, there was instantly a reddish flame of some magnitude outside the gauze, extending to a distance of about two inches. This fact makes it quite clear that if there had been any accumulation of firedamp in this dusty working, Mr. Sawyer would have lost his life, and we should not have had this valuable note out of his book of experiences. Since then many other failures have occurred. For instance, at Bryncoch, South Wales, in 1896, a Davy lamp failed in a very low velocity of current which had become fouled by a heavy fall of roof in another part of the mine. Many other explosions resulting from the failure of Davy lamps to withstand conditions which are frequently to be found in most coal mines, might be added, but need

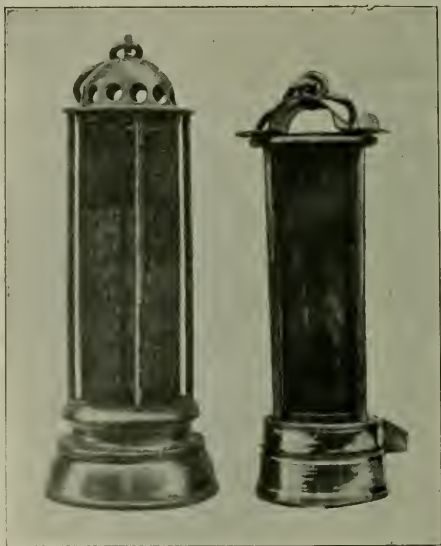


FIG. II.—(a) Davy Lamp. (b) Stephenson.

not be further referred to, as the Clanny type of lamp was the one in use at Fernie, and failures of this type will probably be of greater interest to Canadians.

At the Whitfield Colliery, North Staffordshire, in 1886, a Mueseler lamp (Fig. VI), which is a safer lamp than the Clanny, and is under ordinary circumstances automatically extinguished by an explosive current, failed entirely to resist what may be termed a very practical test. The lamp in question was hung on the side of a heading in the Cockshead mine (which is a thick coal having an inclination of about one in four), and the collier who was working by its light was moving dirt out of an old level into which he had thurled. Whilst doing so a slight fall of roof took place in the old level, bringing down with it a small quantity of gas and dust, which, on coming in contact with the lamp, immediately exploded, and burned the man slightly. The lamp was carefully examined after the explosion, and was found to be quite correct, and to all appearances safe, but it was noticed that the lamp gauzes were perfectly clean, and as bright as a shilling, whilst another lamp hanging close against it was found to be very dirty from the dust.

To show that experimental results are often confirmed by practical

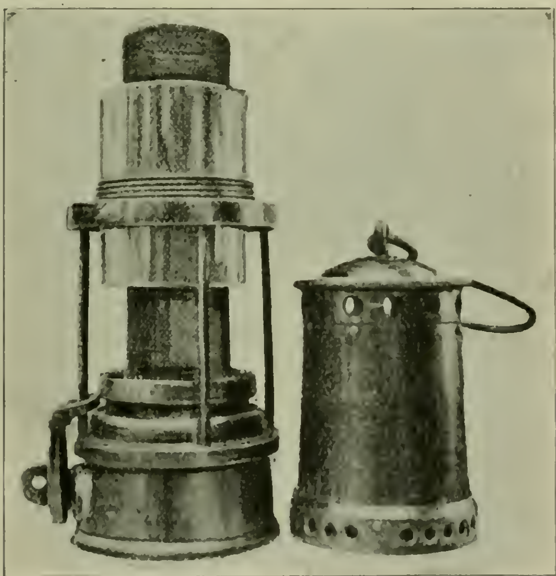


FIG. III.—Cambrian Davy Lamp for Firemen, showing glass part raised and the bonnet removed.

demonstration may be shown by the failure of a double gauze Marsaut lamp. The inventor of this type of lamp, in his book on safety lamps, states that he obtained one failure out of every nine tests with similar lamps when they were suddenly surrounded with an explosive mixture of firedamp and air. At the Wishaw colliery, Scotland, in 1895, an unbonneted Mueseler which was being used to test by a fireman for firedamp in a narrow heading partly ventilated by the exhaust from an engine worked by compressed air, suddenly passed the flame through both gauzes without the lapse of any appreciable interval, and immediately exploded the accumulated firedamp. Several miners who were present and saw what occurred were waiting to go into the heading to fetch out their tools, but no one was killed.

Passing on to the modern type of Clanny, viz., the one known as the bonneted Clanny, we find that at the Allerton Main colliery in

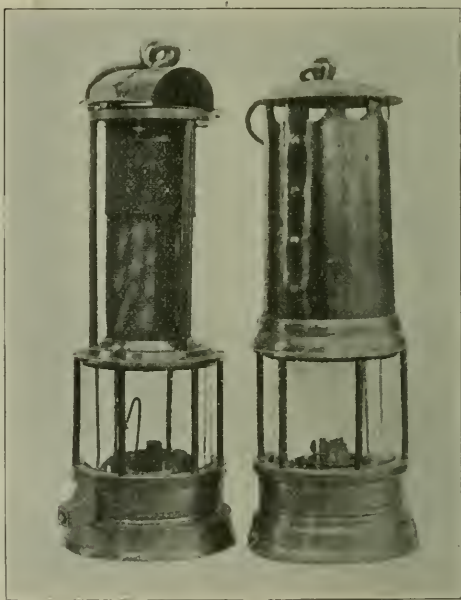


FIG. IV.—Clanny Lamps.

Yorkshire in 1894, whilst several men were engaged in placing, and also replacing some air pipes which were used to ventilate a heading through a fault, an explosion was originated by the failure of a bonneted Clanny lamp to withstand a mixture of air, firedamp, and dust, moving at a low velocity. These lamps were afterwards submitted to Prof. Lupton, of Leeds, who tested them in high velocities of mixtures of firedamp and air, but without coal-dust, and failed to make them explode the outer atmosphere.

Another notable failure of a bonneted Clanny occurred at the Shakerley Colliery, Lancashire, in 1895, where a party of officials were engaged in trying to move an accumulation of gas by clearing an air-way. All the lamps had been extinguished excepting one, and the man who was using it was practically in a quiescent atmosphere, but the heading being old and very dusty, undoubtedly dust, disturbed by the movements of the men, was a factor, along with the mixture of firedamp and air, in causing this one lamp to fail and explode the mixture. Every man present was instantly killed. The lamp which had failed was tested by Mr. Hilton, of Wigan, who had had considerable

FIG. V.—Bonneted Clanny, Mueseler or Marsaut. Arrangement for gas-testing.

experience in the testing of safety lamps, but he could not explode it in any of the mixtures of fire-damp and air that he used. We may particularly note that in these experiments, as in those on the Allerton Main lamps, no coal-dust was added to the explosive mixture.

In the year 1901 we have the suggested failure of either a bonneted Davy or of a bonneted Clanny at the Universal Colliery, South

FIG. VI.—Mueseler Lamp.

Wales, in a mine which was both fiery and dusty, and in which men were engaged in one part of the mine, as at Allerton Main, in adding air pipes to ventilate a heading through a fault. Later in the same year, viz., on December the sixth, a non-fatal explosion of gas occurred at the Shirebrook Colliery in Nottinghamshire, which was worked exclusively with locked (magnetic locks) double gauze bonneted lamps of the Wolf type (Fig. VII). And the following is the Inspector of Mines' report on the occurrence :—

"A night shift of workmen was sent to do some road repairs near the coal face, and near a fault. The place to be repaired was a breakdown of the roadway, leaving a high cavity in the roof. An official of the mine visited the place at about 11.15 p.m., and reported that he found no gas, and the men continued at work until "snap" time. They had just resumed work when the gas was ignited.

"The injured person had taken his lamp and placed it upon a bar about 8 feet 6 inches from the ground, whilst he stood upon a tub to

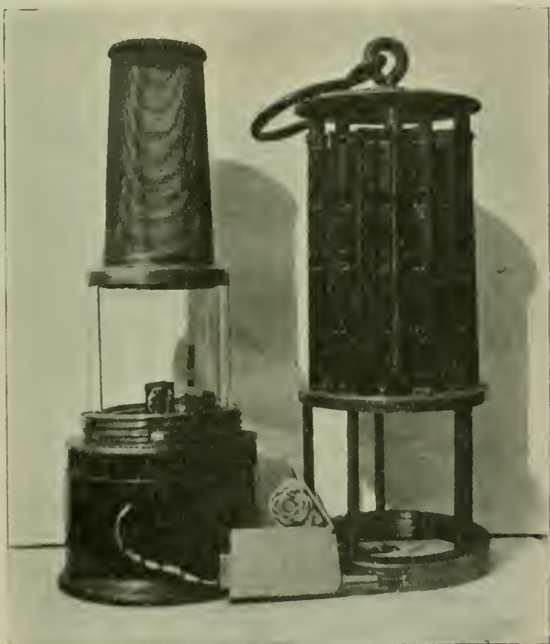


FIG. VII—Wolf Lamp. Illuminant Benzolene. Showing arrangement for lighting without opening the lamp. Magnetic locking.

fix some timber across the cavity above the bar. While doing this work an explosion of gas occurred and burned the man who was standing upon the tub. The other man was uninjured, but a number of men ran to the shaft in a panic. The explosion set fire to two brattice sheets and a wood pack, and so quickly did the fire extend that but for the energy of the officials and the use of hand grenades the fire would probably have soon been out of control, and have become exceedingly dangerous.

" After the extinction of the fire the firedamp again appeared, indicating that the fall of roof had liberated a small feeder from the fault. The lamp which was supposed to have fired the gas was carefully examined, but no serious defect was found."

This lamp was afterwards tested in an explosive mixture of gas and air without any failure. There was no appearance of overheating, and the gauzes were clean and free from dust.

These instances might be greatly enlarged if problematical cases

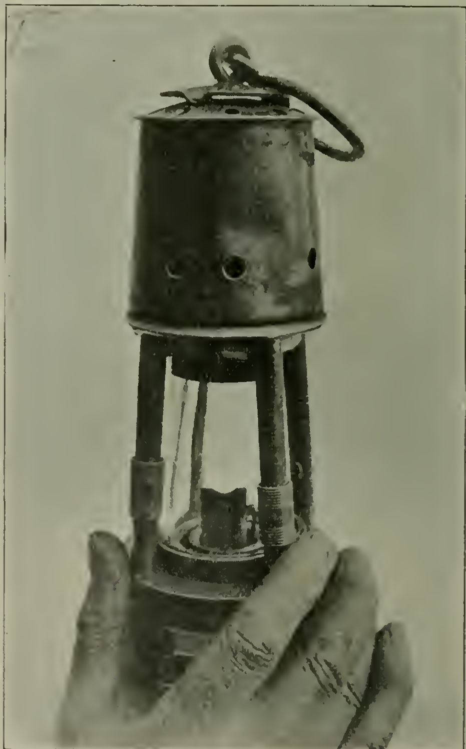


FIG. VIII.—Ashworth's patent Gray, Deputy or Fireman's Lamp. Showing mode of manipulation when testing for firedamp.

were added, but no event, as originating a colliery explosion, is so difficult to prove as the failure of a safety lamp, because the principal indication is not necessarily the evidence of an overheated gauze, but rather its great cleanliness as compared with other lamps in the immediate vicinity. This fact would, in the opinion of most people, be the most convincing proof that it had not failed. Experiments, as well as practical experience, has proved that the most dangerous condition to which a safety lamp may be subjected, is when the lamp is suddenly raised into an explosive atmosphere of firedamp, air, and dust, or when a ventilating current becomes suddenly charged with an access of firedamp, or approaching the lamp from the top

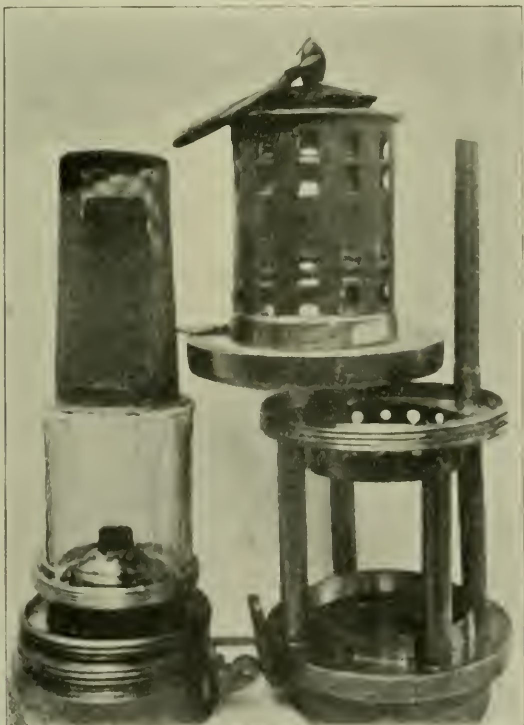


FIG. IX.—Gray's No. 2 Patent Safety Lamp for Deputies, Firemen or Miners. Showing gas-testing tube in position. Lead lock. Gives a particularly good light. Illuminant—paraffine or mineral colza.

crushes down the wick flame. From this proving, mine officials will readily understand that any lamp which admits of a down current, and the crushing down of the wick flame, cannot be a safe lamp to put into the hands of officials who have to examine the mine for gas, or who have to make careful tests of the place, and also the adjoining places to that in which a shot or shots may have to be fired.

There are many sorts of lamps which are called deputies', firemen's, and shot firers' lamps, but very few of them are really safe to use under the conditions which surround the work of these officials. Yet there is one type of lamp which came out of the Royal Commission on Mine Accidents tests with distinguished honour, viz., the one known as the Gray. So impressed were the Commissioners by the suitability of this type of safety lamp for gas-testing, that one of the Commissioners, Prof. Clifton, tried to improve it. After the publication of the report an improved form was brought out by the writer, who has had a life-long experience in experimental work with safety lamps, and also in their practical use, and this lamp is well known throughout the English coal-fields and also in the colonies, as Ashworth's patent Hepplewhite Gray (Fig. VIII). The lamp, as thus improved, did not find the favor it might have been expected to have done in the fiery mines of South Wales, and so late as 1901 the original inventor, Mr. Gray, again took out a patent, which he calls No. 2, combining all the best points of the Gray and Ashworth lamps. Very long and careful practical experiments have been made with this lamp, and Mr. Gray may be congratulated on being able to provide his officials with such a valuable, simple, and useful safety lamp with which to ascertain the real state of a mine, and which produces such a good illumination that it is a pleasure to pass along the roadways of a mine where everything can be clearly seen, and the old idea of groping about a pit with the miserable light of a Davy lamp is no longer necessary. This type of lamp may be so constructed that it will be automatically extinguished when in a miner's hands if the air current becomes in any way fouled by a percentage of firedamp which would be indicated only faintly on the flame of a Davy lamp. It is also impossible to produce a down current, that is, to reverse the air current within the lamp, so well are the inlet and outlet air openings protected, and the lamp may be carried in any current of air without its being extinguished. Fig. IX shows the lamp in sections, and on reference to this it will be seen that when the lamp is not being used for the purpose of gas detection all the air required for combustion, and to keep the lamp cool, enters directly above the cylindrical glass, and, passing down the four air tubes which replace the ordinary solid standards connecting the top part of the lamp with the bottom, goes through the ring gauze below the glass, and after supplying the wick flame, finds its escape with the products of combustion through the conical tin chimney, and then, as an extra protection through the slightly conical gauze which entirely covers and surrounds the chimney, and finally into the surrounding air through the double deflector openings in the top of the shield, as well as through a hole in the extreme top of the shield, which is perfectly protected from all down or angular currents by the baffle plate to which the handle is attached. As no mining laws in any part of the world make any stipulations with regard to the percentage of firedamp which a safety lamp shall be capable of detecting, it is only necessary to say that this lamp will detect more readily, and with greater certainty, the presence of the "blue cap" than any Davy lamp which was ever made. When the fire boss, fireman, deputy, or other official wishes to make a test for firedamp, he puts his hand in his pocket, and, taking out a short brass tube, places it on to one of the fixed air tubes, and is thus enabled to test the condition of the mine close up to the roof, without canting the lamp. If firedamp is present, it passes down this single tube, and is indicated on one side of the wick flame without extinguishing it, and no form of bonneted Davy, Clanny, Mueseler, or Marsaut can make such a close test either so quickly or so accurately.

If such a lamp as this had been in use at the Fernie mines, it would have been impossible, excepting with the grossest and most criminal negligence, to have allowed a shot to be fired when the mine was in an unfit state for shot-firing. Not only is a mine jeopardized by inaccurate examinations for firedamp, but by the class of workmen employed, as stated in the CANADIAN MINING REVIEW in the issue of February 28th, 1901. That this risk is not confined to the Fernie mines was amply demonstrated by a recent explosion in a pit near Wigan, England, where the contractor for the work, finding that the pit was dangerously fouled with firedamp, sent all the safety lamps out of the pit, and left his men to continue their work by the aid of electric lamps coupled direct to a cable from the pit top, but during the shift, a Pole, who could not read English, struck the main cable with his spade, causing a short circuit and an arc which originated an explosion of the accumulated firedamp, and which killed nearly every man in the pit, as well as the man on the top of the pit. Judging from the plan of Mine No. 2, printed in the CANADIAN MINING REVIEW, of the 31st of March, 1901, it would appear that an electric pump was at work in a place ventilated by return air, and in the immediate vicinity of a large area of gob, which, if unventilated, as shown, could not fail to be a source of very great danger, and would make the examinations of firedamp of even greater importance than in a mine where electricity was not in use.

A mine at such a high altitude above the sea must present points of great scientific interest. Thus, the barometrical pressure is very low compared with English fiery mines, showing a difference of at least six inches of mercury, and probably the air is very dry, therefore, if a low barometer indicates a danger, the dry state of the air compensates the danger to some extent. And moreover, as every cubic foot of air contains less oxygen than in an English deep mine, the proportions of air and firedamp required to form an explosive mixture must be altered also. It is therefore more than probable that the capacity of any lamp to detect firedamp will be lessened by a low barometer, and raised by a high barometer, because the heat of the testing flame will be reduced by the low barometer. Under like circumstances, the lighting power of safety lamps will be reduced, and if candles have to be abandoned an ordinary type of safety lamp like the Clanny will be a poor substitute.

The capacity of a safety lamp to detect small percentages of firedamp depends entirely on its heat and its non-luminosity, but principally on its heat, and these are the reasons why hydrogen gas and alcohol spirit were adapted by the writer to his Hepplewhite-Gray type for laboratory and main air current testing in coal mines.

In conclusion Canadian colliery managers should carefully consider the subject of gas detection, and thus provide against the horrors of colliery explosions as well as against the great loss of capital which these disasters inevitably cause.

The Electrolytic Production of Metals, with Special Reference to Copper and Nickel.

(Communicated to the Secretary.)

Sir—In accordance with your request, I herewith send you a few notes with a view to correcting certain statements in Mr. Koehler's interesting paper on "Electrolytic Production of Metals" presented at a recent meeting of the Institute.

In the first place, the statement made to the effect that the two principal processes for the recovery of metals from their solution are those of Siemens and Halske and Hoepfner, certainly needs modification, as Mr. Koehler will readily admit that fully 90 per cent of all the copper recovered from its solution is obtained by neither of these processes, but from acid sulphate solutions by ordinary electro deposition with soluble copper anodes, which is essentially the old Elkington process, patented in 1865-70.

While it is true that the Hoepfner process, or rather a modification of this process, is being practically applied, both at Cleveland and Papenburg, in the production of a limited tonnage of electrolytic copper and nickel, it is likewise true that the solution and deposition of copper and nickel from chloride solutions is neither as rapid and simple in reaction as it is with sulphate solutions, nor as economical, all things considered, and the Hoepfner process was therefore abandoned by several companies after extensive trial.

Now to another matter. Mr. Koehler mentions and shows a diagrammatic sketch of the process I proposed years ago for treating Sudbury ore, giving me full credit, but adds that this is the process I now propose using at Sault Ste. Marie, which is wrong. As a matter of fact the process I advocate does not include separation smelting (the Bartlett-Thompson or Orford process), as Mr. Koehler states, as this is a patented process, both cumbersome and imperfect in effecting the separation desired, and is not at all necessary in my method of treatment.

My improved process, which is protected in Canada, the United

States, and in Great Britain, embrace the following essential features and improvements :—

1. The difficulties hitherto experienced in attempting to bessemerize nickel-copper matte to a higher percentage than 80 per cent, involving losses of cobalt, etc., are entirely obviated, in my process, by the addition of sufficient copper bearing material in the matting furnace to reduce the percentage of nickel in the converter charge to 20 per cent. or less of the copper present. I am thus enabled to convert the matte up to 95 per cent. metal and above, instead of 80 per cent, and I also reduce the total percentage of metal going into the converter slag, and which, of course, requires retreatment, by largely protecting the slagging-off of the nickel by the copper.

2. The crude nickeliferous and argentiferous copper is cast into anode plates and hung in electrolytic tanks in an acid sulphate solution, just as in ordinary copper refining, and pure copper plated out on copper cathode sheets.

3. What I consider the most important feature of my process consists in the regular withdrawal of a small proportion (say 2 per cent.) of the total quantity of electrolyte in circulation in the copper depositing tanks, firstly, in order to keep down the increase of the nickel contents in the same, by replacing the withdrawn solution by one practically free from nickel, and secondly, in order to accomplish the regular recovery of the nickel, which is extracted from the withdrawn electrolyte by simple chemical means, followed by electrolysis.

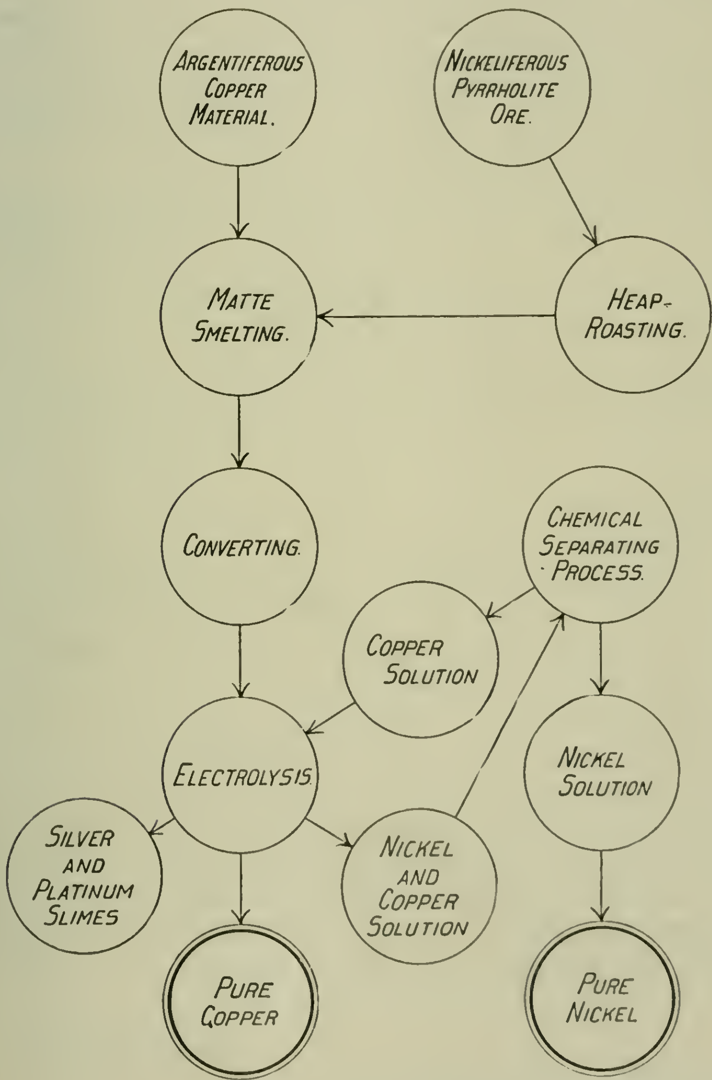
4. Pure nickel is readily obtained, in my process, by electrolysis of the slightly ammoniacal, heated, nickel sulphate solution with lead anodes, depositing the nickel on nickel cathode sheets, and remelting and casting of the cathodes into whatever shapes are desired. The subjoined plate shows a diagrammatic scheme of the essential steps of my smelting and refining process, as applied to nickel and copper material.

I am, very truly,

TITUS ULKE,

Supt., Copper Refining Dept.,
Lake Superior Power Co.

Sault. St. Marie, 27th May, 1902.


ARGENTIFEROUS COPPER MATERIAL.
NICKELIFEROUS PYRRHOLITE ORE.
MATTE SMELTING.
HEAP-ROASTING.
CONVERTING.
CHEMICAL SEPARATING PROCESS.
COPPER SOLUTION
ELECTROLYSIS.
NICKEL SOLUTION
SILVER AND PLATINUM SLIMES
NICKEL AND COPPER SOLUTION
PURE COPPER
PURE NICKEL

Sir—Your favor of the 30th to hand. In answer to Mr. Ulke's criticism, I would reply that I purposely did not enter upon the subject of refining, knowing very well that almost everybody is well aware of the fact that about 90 per cent. of copper used at present time is electrolytically produced through the refining of crude copper from an acid sulphate solution. This process is so old and so well known that giving details of same is more or less a waste of time.

There is a vast difference between refining using soluble anodes, when the deposition of metal upon the cathode depends upon the metal contents of the anode going into solution, and having simply a solution of a metal from which metal is being precipitated, without the solution's metallic contents being replenished.

In accordance with the last statement, the Siemens and Halske and the Hoepfner process are the only two recognized processes.

I am not accountable for any changes, improvements, etc., etc., which Mr. Ulke has decided to adopt since his proposal of procedure a few years ago.

All metallurgical processes are more or less subject to deviation.

In Mr. Ulke's description of his improved process, section 2, he cites: "Crude nickeliferous and argentiferous copper is cast into anode plates and hung in electrolytic tanks, in an acid sulphur solution, just as in ordinary copper refining, and pure copper plated out upon copper cathode sheets"; while in Europe (1895) scrap metal containing about 75 per cent. copper and 25 per cent. nickel, also mixtures of iron, copper, nickel, silver, and zinc, in other words, nickeliferous, or more generally speaking, metaliferous copper, was cast into anodes, hung in an electrolytic tank in an acid chloride solution just as in ordinary copper refining (except the substitution of an acid chloride solution for an acid sulphate solution), and pure copper plated out on copper cathode sheets.

Very truly yours,

WM. KOEHLER.

Cleveland, 2nd June, 1902

Sir—Allow me to again call your attention to Mr. Ulke's criticism.

1st. Mr. Ulke evidently has not carefully looked over the paper re copper and nickel production. For example he says:—

"Electro-metallurgy is divisible into two branches, first, the *electrolytic refining of crude metals*, and second, the direct production of metals from their solutions."

The Siemens and Halske and the Hoepfner processes are the two recognized methods of obtaining metals *direct from their solutions*. This statement needs no modification.

2nd. It is a well-known fact that about 90 per cent. of copper used in arts is obtained through refining of crude metal from an acid sulphate solution. This subject comes under *1st heading refining*, and was purposely only casually mentiened. The process is so old and so well known that in giving details of same is more or less a waste of time.

3rd. Regarding the advantages or disadvantages in obtaining metal from a sulphate against a chloride solution, it is my impression that the time will come when a chloride solution will more or less supersede a sulphate solution.

In the electrolysis of a sulphate solution no valuable by-product is obtained at the anode, while with chloride solutions you obtain (from a nickel chloride solution), for every 59 equivalents of nickel 71 equivalents of chlorine gas.

It is a well known fact that the electrolysis of a chloride solution will require a trifle more costly apparatus than will that of a sulphate solution. There will also be a slight difference in the power factor (viz., energy necessary for electrolysis), but when it comes down to dollars and cents I believe the chlorine gas obtained will more than overbalance the difference. The Canadian Copper Co. think they have their process down very nearly to perfection. This speaks well for chloride solutions.

4th. Mr. Ulkes' process has been cited according to his proposal of a few years ago.

I am not responsible for the Orford Copper Co. upholding their patented separation smelting process in Canada, neither am I accountable for any changes or improvements which Mr. Ulke may have made since he has begun practical operations.

All metallurgical processes are subject to deviations according as necessity demands.

5th. Mr. Ulke's improved process, section 1st:

The object of this paper has not been matting and converting mattes, etc., to the state of crude metal. This is a subject foreign to electrolysis.

6th. Section 2nd. Concerning crude nickeliferous and argentiferous copper cast into anode plates and refined. Mr. Ulke certainly does not claim anything new for this.

While in Europe in 1895, scrap metal containing 75 per cent. copper and 25 per cent, nickel, also mixtures of copper, iron, nickel, silver, and zinc, in other words nickeliferous copper, or more generally speaking, metalliferous copper, was cast into anode plates suspended (identically as in copper refining in an acid sulphate solution), both in acid chloride and acid sulphate solutions, also in neutral and alkaline solutions and fine metal, obtained upon sheet copper cathodes.

7th. Section 4th. Concerning the winning of pure nickel by Mr, Ulke's process, through the electrolysis of a slightly heated ammoniacal nickel sulphate solution with lead anodes.

This method is the analytical method of determining nickel adapted to commercial use, which has been used in analytical laboratories for years, the substitution of a lead anode for the much more expensive platinum anode, and the use of an electrolytic bath of large dimensions, instead of beaker or a platinum dish, being the principal differences.

Very truly yours,

WM. KOEHLER.

Cleveland, June 4th, 1902.

Sir—In reply to Mr. Koehler's interesting comments upon my remarks, I beg to submit the following, and thank you for your kindness in allowing me space for this discussion, which, I trust, will be final, as practical work of very pressing importance is keeping me so busy, nowadays, that I have but little leisure, unfortunately, for digressions of this sort.

Allow me to take up Mr. Koehler's comments in their order :—

1st and 2nd. After carefully looking over Mr. Koehler's interesting article, I noticed the unscientific and illogical character of his classification of electrometallurgy into the two following branches, viz. : 1, the electrolytic refining of crude metal, and, 2, the direct production of metals from their solution. Every metallurgist should be aware that the second branch is covered by the first, and that *the direct production of metals from their solution* is the final step of *every* electrolytic refining process.

3rd. Regarding the advantage of obtaining metal from a sulphate as against a chloride solution, this fact certainly seems decisive, that those in charge of our large electrolytic refining woiks have never been prevailed upon to adopt the chloride solution method, instead of the method at present in almost universal use, for many reasons. *The chloride method is old*, has been tried under a great variety of conditions and with many modifications, *but has not yet attained commercially practical prominence.* Electrometallurgists are aware that the speed of reaction is too slow, and the apparatns and process too complicated for ordinary practical purposes. In a few cases it may be desirable to utilize the evolved chlorine, and the chloride method may then be found suitable, but it is out of the question, at the present time, for large refiners to go to the expense of erecting a costly plant for liquifying chlorine gas or making bleaching powder when it is considered that the returns would be reduced to an unprofitably low figure as soon as such methods were generally adopted and the market flooded with chlorine obtained in this way.

The only electrolytic nickel and copper refinery running, I believe, in America at the present time, is the Canadian Copper Co.'s small plant near Cleveland. This company may or may not think that they have their process down to perfection, and they may soon have reason to revise their claims, just as they are beginning to see that their Sudbury mine equipment is not the best, nor that their method of handling ore to and from roast heaps is the cheapest.

4th, 5th, and 6th. Does not require any comment.

7th. Concerning obtaining pure nickel through the electrolysis of a slightly heated ammoniacal nickel sulphate solution, *with lead anodes*, I beg to note that Mr. Koehler is in error when he states that this is the analytical laboratory method in use, for it certainly is not. I will add, in conclusion, that United States, Canadian, and British patents have been granted to me, covering the use of lead anodes in such solutions in electro-depositing nickel.

You would confer a favor by sending me a copy of this discussion, if it should appear in print. Thanking you for your kindness,

I am, very truly,

TITUS ULKE.

Sault Ste. Marie, Ont., 9th June.

SIR,—Again referring to Mr. Ulke's comments upon my paper permit me to say :—

1st. I have no alterations to make concerning my communication of the 4th inst. and must refute the assertion as to my unscientific and illogical character of the classification of electro-metallurgy. In fact other metallurgists go still further.

Dr. Carl Schnabel, in his eminent work upon metallurgy in general subdivides the production of copper through electro-metallurgical means into three (3) distinct classes. What applies to copper can also to a greater or less extent be applied to other metals, viz.: nickel, cobalt zinc, etc.

The three subdivisions according to Dr. Schnabel are—

a. The production of copper from ores.

b. The production of copper from matte, etc., etc.

c. The production of copper from crude copper alloys, etc.

Process *a* coincides with the direct production of metals from solution.

Processes *b* and *c* coincide with refining process.

(See German edt., *Handbuch der Metalluittenkinde*, Dr. Carl Schnabel, Vol. 1, page 250.)

There is a great difference between refining crude metal and producing metal from solutions using insoluble anode material, *no matter what may be said to the contrary.*

3rd. Regarding the advantages of producing metals from a sulphate as against a chloride solution, this fact is certainly not decisive and should receive more consideration. I admit that the chloride process is old and has not yet attained prominence, but the sulphate method is older, and before its successful introduction had the same obstacles to contend with that are now blocking the chloride method.

In refining from a sulphate solution one kilo watt hour at a potential difference of 0.5 volts will produce 2.36 kilos of copper. From a chloride solution working at the same potential difference (0.5 volts) 4.72 kilos of copper are produced by one K. W. H. I admit that it is difficult to hold the potential difference of a chloride bath down to 0.5 volts but the same has been successfully accomplished.

The above figures may speak for themselves regarding THE SPEED OF REACTION.

The assertion of Mr. Ulke to the effect "that it is out of the question at the present time for large refiners to go to the expense of erecting a costly plant for liquifying chlorine, producing bleach, etc., WHEN IT IS CONSIDERED that the returns would be reduced to an unprofitable low figure *as soon as such methods were* GENERALLY ADOPTED," speaks for itself. (Special emphasis upon general adoption.)

7th. Concerning the obtaining of pure nickel through the electrolysis of a slightly heated ammoniacal nickel sulphate solution using lead anodes, I have only to repeat what has been said in my communication of the 4th inst.

For the benefit of those who may read these comments I wish to state without going into details regarding method that in the quantitative determination of nickel, the compound containing same is brought into the condition of a sulphate solution, the nickel is separated from other metals associated therewith, the solution made ammoniacal and this ammoniacal nickel sulphate solution subjected to electrolysis using platinum anodes and cathodes. To hasten this deposition and also to obtain a firmer plating the solution is kept slightly heated during the time that the electrolytic deposition takes place. Therefore with all due regard for patents, I will leave the decision as to whether I MADE AN ERROR OR NOT to the judgment of those who may read these comments.

Very truly yours,

WM. KOEHLER.

Cleveland, June 27th, 1902.

The Le Roi Mine.

By OLIVER HALL, McGill University, Montreal.

The Le Roi Mine, of Rossland, B.C., is so well known as to need neither geographical nor historical introduction. It has been known for years as a solid mine working on a thorough business basis. In describing it one has the advantage of describing a type mine, one of the best of its class. The subject, however, is so large as to necessitate the restriction of many details. Where these would be of special value, as far as possible, photos, blueprints, or drawings have been added.

GEOLOGY OF THE DISTRICT.

Rossland is built upon the core of an old volcano. Along the contact of this core with the surrounding rocks, have been found all the most productive veins. The core area, now deeply eroded, is gabbro of diabasic character, containing chiefly plagioclase, pyroxene, and biotite, with iron sulphides. The surrounding area is volcanic, brecciated and ash rocks predominating. I quote Mr. Ferrier : "The productive veins belong to the shear zone class, a series of parallel fissures mineralized by deep seated waters."

THE LE ROI VEIN.

The Le Roi owns the Le Roi, Black Bear, and Le Roi Star fraction claims, aggregating 71 acres. Developments are wholly on the Le Roi claim, on which are three outcroppings, the North or Tregear, the Middle or Main, and the South or Black Bear. The mine seems rather a mineralized mass than a vein. It would seem, however, as if what are known by the miners as the Miller, Main, Mulligan, and Tregear ore shoots constitute one fissure vein, with a strike of S 68 W, and the Black Bear and Centre Star another S 62 or 63 W. The Main is the intersection and hence the most important, and dips to the north at about 70 degrees. The ore body ranges in width from ten to nearly a hundred feet, averaging about forty. The wall rock is monzonite, dark, basic, and eruptive. The vein matter ranges from low grade silicified masses to almost solid sulphide of varying proportions of pyrrhotite, chalcopyrite, and pyrite, carrying one to two per cent. of copper, a little silver, and varying gold. Numerous dykes occur, but, with the exception of the Josie, they cut off the ore only temporarily. The Josie, near the Black Bear claim, is sixty feet wide, and to the west of it no ore has as yet been found.

THE SURFACE.

The surface map shows the detailed position and extent of the workings which lie on the slope of Red Mountain. To use gravity advantages economically the shafts, engine, and ore house are at the upper workings, the railway facilities, boilers, compressors, stores, and repairs at the lower. Water for domestic and boiler purposes is brought by a flume from a creek up the Josie gulch, first to the upper, thence to the lower level. At the upper workings are two shafts, the old and the new. The old shaft, a three-compartment one, is not in use, but was straightened and refitted this summer to hoist the ore of the neighbouring mine, the Josie, which is connected by a drift on the ninth level. The development of the mine necessitated a larger and more centrally placed working shaft. A new five-compartment one was accordingly driven in 1900 about 350 feet west of the old one, and is now down between eleven and twelve hundred feet It is built on the hanging wall at an incline of 67° 12′. This fact makes it necessary to leave a large block of good ore as a supporting pillar. The new shaft is tapped 268 feet below by the Black Bear tunnel, which has its entrance at the lower workings about 800 feet west.

THE BOILERS

There are in all eleven boilers centralized in a building 40′ x 120′, and 160′ from any other building. Two high pressure Heine boilers of 400 horse power run the compressor plant, the remaining power being furnished by one battery of three Fraser and Chalmers return tubular, and two batteries of three Jenckes. The Jenckes specifications are h.p. 150, diam. 6′, length 15′, thickness of shell ½″, heads $\frac{9}{16}$″, 98 3½″ tubes, steam drum 36″ x 72″, smoke stack, 4′ x 80′. They are set with double brick walls 4¼″ apart, and are covered on top with 2″ of asbestos cement. The boilers aggregate about 2,000 h.p.

Fig. 1.—Le Roi and other Mines on Red Mountain.

THE COMPRESSORS.

The compressing plant of Le Roi consists of two duplicate cross compound steam and air Corless-Rand compressors. Steam from the Heine boilers enters the 22″ high pressure cylinder at from 140 to 160 pounds, passing into the 36″ low pressure at about 20 pounds. Air is compressed to about 21 pounds in the 40″ low pressure cylinder, passing through the intercooler and emerging from the 22″ high pressure cylinder at 95 pounds. It is held in two 4′ x 16′ receivers. Running at a 48″ stroke and at 70 revolutions the capacity of these machines is 4000 feet per minute. They are, roughly, 40-drill compressors. Air loses one pound of pressure per 1000 feet of travel before reaching the drills. The compressors are on a foundation of bed rock covered with 7½ feet of hydraulic cement. An intercooler test gave the following result: Air entering 205°, leaving 55°; water entering 52°, leaving 55°.

BLACK BEAR PIPING.

The power of the Le Roi in the shape of compressed air and steam is led into the mine by the Black Bear tunnel. The compressed air passes through 6″ and 8″ pipes to the ladder way of the new shaft, thence down to the machines. Steam passes through 6″ and 8″ pipes to shaft and up to hoisting engines on the surface. These pipes are provided with brass sleeves for expansion and are jacketed with two inch layers of cellular asbestos separated by half-inch strips of wood arranged lattice fashion. The steam is at 420. The outside is scarcely warm. To take up water of condensation an 8″ T is placed every 180 feet. Drip pipes lead below, and condensed steam is returned to the boilers. There are, besides, two 4″ pipes, one for fire, one for mine water. It is a rule to duplicate parts. There are two receivers, two air pipes, two steam pipes. Work proceeds by the other if one gets out of order.

HOISTING ENGINES.

There are two hoisting engines, the larger handling ore, the smaller timber, tools, and men. The ore hoist is a direct acting double drum Allis-Chalmers engine, with Corless valve link motion. Its cylinders are 24″ x 60″. It runs usually at about 50 strokes, the steam entering by an automatic valve at 100 pounds pressure. The

FIG. II.—Another View.

FIG. III.—Le Roi Mine.

drums are 10′ diam., 5′ face. The engine is handled by six auxiliary engines, two governing the drum clutches, two the post brakes, one reverses, and one handles the throttle. There is in addition automatic gear to prevent running too high and a dish foot brake which puts on two extra brakes in emergency. Dial indicators show position of the cages. Signalling is by whistle. A 1¼ inch cable is used and handles a three ton skip. The rated capacity of the engine is 1,000 h.p., capable of lifting four tons 2000 feet vertically per minute.

The other hoist is also a direct acting double drum engine, made by the Vulcan Iron Works, Wilkesbarre. It has 20″ bv 42″ cylinders, and is handled by five auxiliary engines, using air, two handling clutches, two brakes, and one reversing. The throttle is handled direct. Drums are 6′ diam., 3′ face. It also has indicator dials, but to distinguish from ore hoist its signals are by bell. A 1⅛″ cable is used. Either engine may run single or balanced.

ELECTRIC PLANT.

Electricity as power has proved economical, but liable to break-downs. It is not at present used to any great extent in the Le Roi. Even the sorting mill dynamo is being replaced by an engine. For lighting purposes, however, a large quantity is always in use, being received from the Bonnington Falls Co., 38 miles away. It is used mainly near the shaft.

MACHINE SHOPS.

The machine shop, smithy, and framing shed are built at the mouth of the Black Bear tunnel. The machine shop already comprises large and small lathes, drills, thread cutters, etc., and is being enlarged and remodelled. The smithy comprises six forges, two air drills used like steam hammers, and one large steam hammer. Twelve smiths and a foreman are usually at work, the largest proportion of the work being the sharpening of drill steel. Car tracks and overhead tackle are used to handle heavy pieces. The framing shed comprises full equipment for the advantageous handling of timber, as all framing is done on the surface. An arrangement of saws, two vertical, two horizontal, frames tenon joints at the rate of two per minute. A second similar saw was installed this summer.

FIG. IV.—Le Roi Mine—another view.

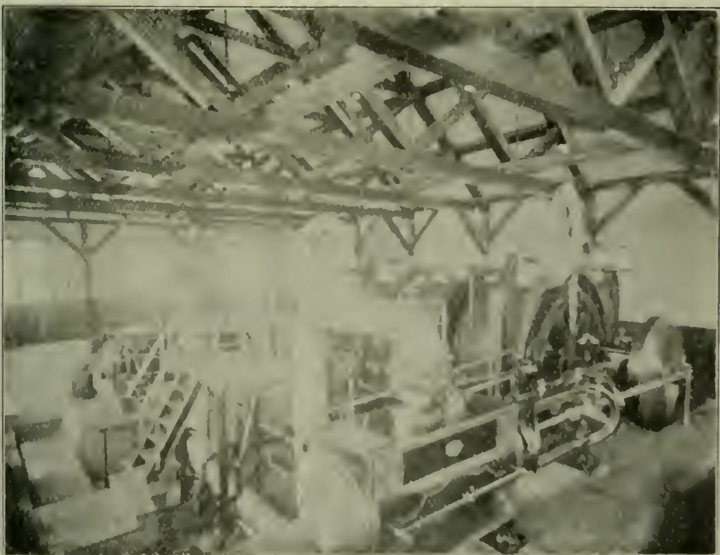


FIG. V.—Le Roi Engines.

STORES.

There are two mine stores, the larger on the Black Bear, the smaller at the top. Each keeps a full stock of mine supplies. The demand for drill steel, powder. candles, shovels, hammers, etc., is constant. The mine uses alone a car of nails alone per month A full stock of drill parts is always on hand, pistons in the rough being machined to suit.

THE ORE HOUSE.

The new or combination shaft is surmounted by a fine head frame 85′ high. The ore, automatically dumped from the skip, falls on a 3″ grizzly of reversed steel rails inclined at 45°. This feeds directly into a Gates crusher of 100 tons' capacity per hour. Ore falling through this grizzly falls on a second 2″ one. The rock is thus divided into three classes under 2″, between 2″ and 3″, and the crusher product, coarse. These fall into bins and thence are fed by eccentric jigs on to picking belts, 100 feet long, travelling 45′ per minute. Six to twelve ore sorters pick out the waste as it passes up. A series of grizzlies, ore chutes, crushers, and rolls reduce all to a maximum shipping size. An automatic sampler is also attached. Seventy-five tons per hour can be handled.

TRANSPORTATION.

From the top ore is carried by a gravity tram down to the Black Bear bunkers. This aerial line runs automatically. Ore is carried by 26 buckets, each of 1000 pounds capacity. These are fixed to a ¾″ travelling cable, and run on pulleys over a 1¼″ stationary cable. The whole is given a constant grade by trust supports, each end being braced by crib work. The gate of the upper ore bin opens into a bucket, which, engaging with the tram, is carried along, automatically dumping and returning in time to fill and engage the next tram bucket. The buckets passing around the lower end engage an arm and automatically dump. The three ore bunkers at the Black Bear have a capacity of 1000 tons.

UNDERGROUND.

Le Roi uses, as do most similar mines in America where the ore body is massive and wide, the method of square sets, first used in the

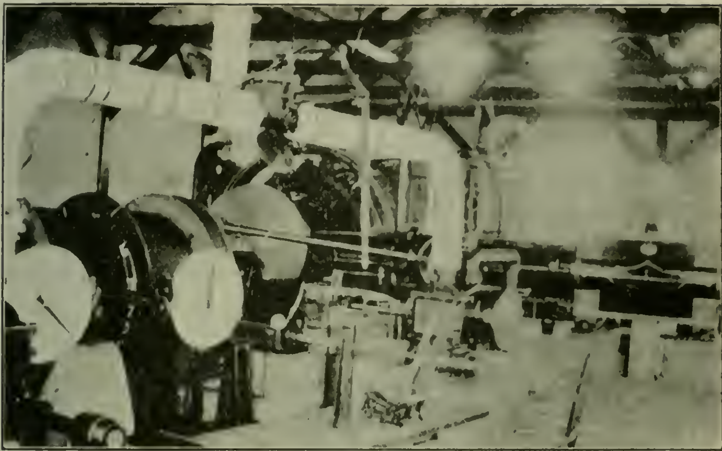


Fig. VI.—Another view of Le Roi Engines.

Fig. VII.—Ore Sorting at the Le Roi Mine.

Comstock. As it is only economical to work with gravity, the ore body is worked from below upward. The shaft sunk, stations are made every 100 feet or so. From the station drifts are run along the vein and crosscuts driven to locate its extent. This done a stope is started. The rock face of a drift is attacked and, the muck removed, the sill floor is laid plumb in every respect. The first sets are put in, lagged with planks, and the rock attacked from this floor. A second floor is made and machines started on this. Thus the bıeast of the rock is advanced and raised until there is a mass of square sets and floors, machines advancing the breast on each floor and timber following up to hold the hanging wall. Thus a stope is formed. Many of the Le Roi stopes, especially the main, are immense.

DRILLING.

Le Roi uses Rand, Ingersoll-Sergeant, and Sullivan rock drills. Practical results and records of repair expenses have predisposed the Le Roi management in favor of the Sullivan, the hardness of the rock

FIG. VIII.—The Top of the Tram.

requiring a heavy machine. Many contractors prefer the Rand, as it is lighter and more easily handled. Rand repairs, however, ran for a time as high as $35.00 a month per machine. Of the 36 drills now in the mine thirty are Sullivans, and the total repair biil is about $500.00 a month. A 375 lb. Sullivan with a 3⅝″ piston, rating 12 h.p., seems to meet Le Roi's needs. The steel is in the form of starters, four, five, six, seven, and eight foot lengths. The bit is of ribbed steel welded to

FIG. IX.—Ore Bins at the Le Roi Mine.

a shank. Ten to twenty drills are dulled per shift. Two nippers look after the drill supply. Drilling starts with the morning shift at seven. The machine men bar down any dangerous rock, level the muck pile, and set up the bar, wedge and jack it in a position best adapted to reach the rock. The machine set up, drilling commences, and continues during morning and afternoon shift. At 11 p.m. drilling is stopped, the machine taken down, and everything left ready for blasting.

THE CONTRACT SYSTEM.

Rossland mine managers in 1900 became dissatisfied with the results of day labor in drilling and introduced a system by contract. There are two methods of payment, per foot of hole drilled, and per foot of advance. Usually in the stopes payment is per foot of hole drilled, the result of morning and afternoon drilling being measured by the blasting crew when it comes on at eleven. From 27 to 33 cents is paid per foot. In places such as drifts, raises, and shafts payment is per linear foot of advance. For drifts or cross-cuts $6.00 to $7.00 is paid, for raises $7.50 to $8.00. Contracts are verbal, and the size of

Fig. X.—The Beginning of a Stope.
(Photo taken in Old Ironsides Mine.)

the raise or drift is not usually specified. Rock will not blast to advantage less than 8 feet in width. Miners also understand that speed at the expense of good work means dismissal. In the War Eagle costs decreased from $8.65 to $4.17 in stope work, and from $11.64 to $8 79 for work paid per foot of advance. Crosscutting advanced from 50.8 to 97.5 feet per month. Le Roi costs are considerably lower, and 110 feet in 22 shifts was considered average cross-cutting. The new shaft was this summer being advanced 60 feet a month by a contract gang of

Fig. XI.—A Difficult Set-up.

27 men, working 9 on a shift. They were getting $59 00 per foot for the entire work, doing their own drilling, blasting, and timbering in order when ready. They were using two sinking buckets. Under the contract system the average wage rose from $3.50 to $4.25 per day. In difficult ground a miner may still choose day wages.

BLASTING.

As the result of blasting is the aim of drilling it is of course essential that all holes be of such a length and so placed in both position and direction as to accomplish a clean break with a minimum of ex-

FIG. XII.—The Ore Skips at the top.

plosive. The respective arrangements differ in drifts, raises, and stopes. Cartridges of about 1″ diam., 10″ long, made of nitroglycerine packed in sawdust or cornmeal, 40 to 70 per cent being nitroglycerine, are used. The paper wrapper is slit, cartridge thrust in drill hole, and packed lightly with a wooden rod. Holes run usually from 3 to 7 feet, and explosive required is proportional. Wrapping paper if at hand and necessary is used for tamping. Forty per cent. powder is used where rock is easily broken, stronger where it is harder. The combustion cap of a six foot fuse is thrust into the centre of the last cartridge. After all the holes have been thus charged, the fuses are cut so as to time their explosions by their lengths. This requires care and experience. The holes must break in an order. They must, of course, always break towards space. In drifts the cut holes break first, blasting out a wedge; the breast holes follow, the lifters being usually last,

FIG. XIII. —A New Three Deck Cage.

to make an even floor and hoist the muck as far back as possible. Blasts in raises are similar, the orders being, cut holes, seconds, side holes. In the stopes there is usually space below. The rock should break in order downward. If breaking is freer to right or left allowance is made. Misfires may result from defective explosive, but are more often the result of the premature explosion of one set of holes cutting the fuse of a second set before the fire has entered the rock. Judg-

27

ment and care are especially necessary. This is accomplished by having a few picked men do the blasting during the night shift. At this time few men are in the mine. The element of danger is lessened and no time is lost waiting for the smoke to clear. Contractors paid per foot of advance blast when ready. They are usually in a raise or cross-cut at a distance from other work. Powder supplies in the mine are kept scattered in small quantities stored in unused cross-cuts.

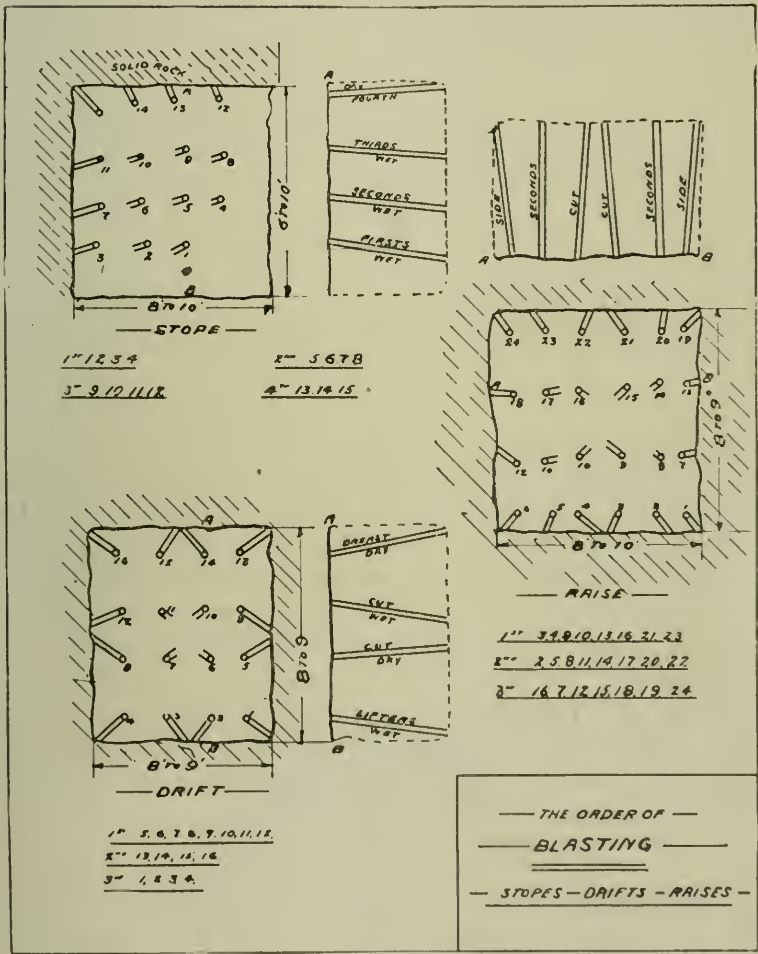
TIMBERING.

The erection of square sets is of course the main timbering work. The posts, collar braces, and caps are exactly tenon-jointed on the surface, and need only to be set exactly in place below. The posts of

FIG. XIV.—A New Shaft at the Black Bear Tunnel.

course must be set vertical, plumb one above the other. The caps, bearing the tremendous lateral pressure of the hanging wall, touch end to end and form practically a continuous post between the walls. The collar braces running along the vein are smaller, and have only one or two inches of shoulder resting on the posts. All are barked, and the caps are flattened above to receive the 3″ floors. The whole mass of square sets must be set plumb from sill floor to the next level. Butt

LE ROI MINE.


SOLID ROCK
8' TO 10'
STOPE
1st 1.2.3.4
2nd 5.6.7.8
3rd 9.10.11.12
4th 13.14.15
FOURTH
THIRDS WET
SECONDS WET
BLASTS WET
SIDE
SECONDS
CUT
CUT
SECONDS
SIDE
8' TO 10'
RAISE
1st 3.4.9.10.13.16.21.23
2nd 2.5.8.11.14.17.20.22
3rd 16.7.12.15.18.19.24
8' TO 9'
DRIFT
1st 5. 6. 7. 8. 9. 10. 11. 12.
2nd 13. 14. 15. 16
3rd 1. 2. 3. 4.
BREAST DRY
CUT WET
CUT DRY
LIFTERS WET
THE ORDER OF
BLASTING
STOPES — DRIFTS — RAISES

caps must meet the walls square. To catch up the level above when two do not meet post to post parts must be bulk-headed. In fact whenever especially heavy pressure is expected bulkheads are put in. A system of ladderways and chutes is built up through the sets. Wherever a post would be in the way, as in a car track, the pressure from above is taken up by a saddle back. Braces are used if sets tend to lean.

Shaft timbering requires even more care than square sets do. The first set, called the mud set, is put in place perfectly plumb, projecting outside of the shaft to give it foundation. The footwall plate is hung by rods and swung into place, the posts are inserted and the whole tightened up. The wall plate is similarly suspended, the caps put in place and the whole tightened up by the rods. It is then spragged in every direction, so that pressure is entirely lateral. The rods are taken out and used to put in the next set, and so on down.

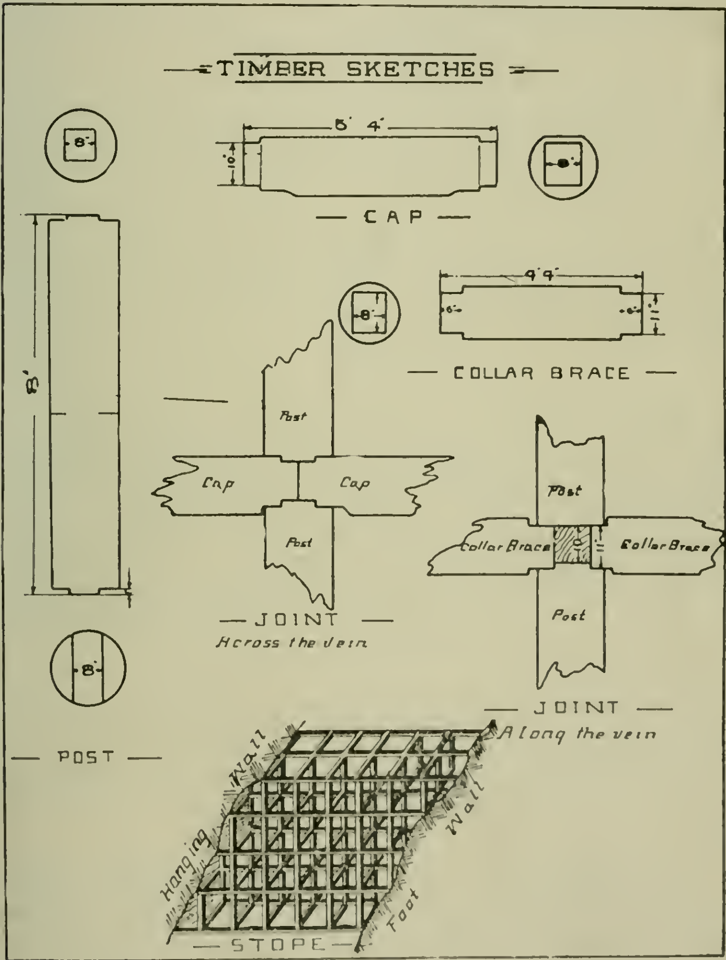
HAULAGE.

The haulage system that lands the ore at the surface is very complete. Tracks of 12 and 15 lb. rails, 18″ guage, follow up all work on the sill floor. Temporary ones are laid on ties, more permanent ones on the lagging of the sill floor. The ore from the floors above by a system of chutes, runs down below the first floor and is liberated by gates into the ore cars. The carmen shove these around and dump them into large ore pockets at the stations. The pocket below 700 holds 300 tons. The skips are filled from these by pneumatic gates in a few seconds. They rest on chairs while filling. Ore is hoisted from the 700 and 800 levels a skip a minute. Various styles of ore cars are used but all are very similar. The Anaconda axle is being introduced, and is now on nearly all the cars in the mine.

PIPES AND PUMPS.

The air and water pipes of the mine pass down the ladder way of the shaft. Thence they branch to all the workings. There is pure drinking water on every level, and, as far as possible, on every floor. Pipes are carried on iron hangers driven into wood, wedged in the rock. One or two condensers are placed on each level to collect the

LE ROI MINE.


TIMBER SKETCHES
5' 4"
10"
8"
CAP
9' 9"
6"
11"
8"
COLLAR BRACE
8'
8"
Post
Cap
Cap
Post
JOINT
Across the vein
Post
Collar Brace
Collar Brace
Post
JOINT
Along the vein
8"
POST
Hanging Wall
Foot Wall
STOPE

moisture of the air. All the mine water runs or is pumped by small pumps so that it will run down into a sump 42′ x 18′ x 16′ below the ninth level. Drifts, etc., are given a grade of about ½″ in 12′. Two pumps, a Cornish and a Northey, pump the water to the Black Bear tunnel, through which it flows out.

A NEW METHOD OF STOPING.

In a few places indicated by a star on sketch map, Le Roi is using the method of caving to mine her ore. Square sets are raised two floors and made doubly strong. The roof is blasted downward. Broken rock is allowed to accumulate sufficiently to allow the machine to be set up always between it and the roof. Rock broken occupies two-fifths more space than in the solid, and that portion can always be removed broken down onto the first floor and thrown into the chutes. It is safe only in narrow vertical veins.

FILLING.

Le Roi is now filling her main stope above seven hundred with waste. Under former management the ore was sorted in the mine, but the waste left on the floors. The weight accumulated dead until the inevitable happened ; 400 feet of stopes, 50 feet wide, gave way from 200 down to 500, and was only caught below by solid bulkheads. Under the system at present in use two to three hundred tons of waste per day is hoisted up to the sixth level. There it is dumped into a raise and runs down by a series of chutes into seven. The first floor of seven was bulkheaded and doubly lagged. Above this, as the stopes fill up, the lagging is removed and waste is allowed to fill up. One solid mass is thus formed, supporting the sets and wedging itself laterally. When needed this will be let down into eight and later into nine.

The official force of Le Roi comprises a manager, assistant-manager, superintendent, mine foreman, seven shift bosses, a master mechanic, a blacksmith foreman, a boss timberman, and a yard foreman. The clerical force includes a book-keeper, time-keeper, and store-keeper. One surveyor and helper surveys all the B.A.C. Mines. Two to three draughtsmen are usually at work. A sampler takes samples of each blast. Assaying is mainly done at the smelter at Northport, whence all the Le Roi ore is shipped.

The miners are of the best class, mainly from Canada and the Western States. There are, however, men from all parts of the world, as miners are wanderers. On morning shift, the men get their checks at 6.30, are at work by seven, quitting at 3.30, half an hour being taken for lunch. Afternoon shift takes up the running and continues until 12 p.m. Night or blasting shift comes down at eleven, gets up at seven. Wages are $2.50 for shovellers and carmen, $3 50 for timber and machine men. Many of the miners belong to a branch of the Western Federation of Miners. There has been friction between men and management for some time, and in July the Union ordered a strike. They demanded $3.00 for shovellers, a settlement with the Northport Union, and the adjustment of other grievances. Recent developments have altered conditions, and the strike has been called off. Once more the mine is at full blast.

In concluding this paper I cannot refrain from mentioning the uniform kindness and courtesy with which the McGill men, including myself, were treated both by men and management. The utmost was done to explain difficulties, and give us every opportunity to get practical experience. This paper is based only on a beginner's observation and inquiries, and must of necessity be somewhat inaccurate. This said, it is respectfully submitted.

Mine Timbering in the Old Ironsides and Knob Hill Mines.

By H. P. De Pencier, McGill University, Montreal.

The Old Ironsides and Knob Hill mines are situated at Phœnix, in the Boundary Creek District in British Columbia, at the summit of the watershed of the Kettle River. The accompanying photograph shows the Old Ironsides head works on the left.

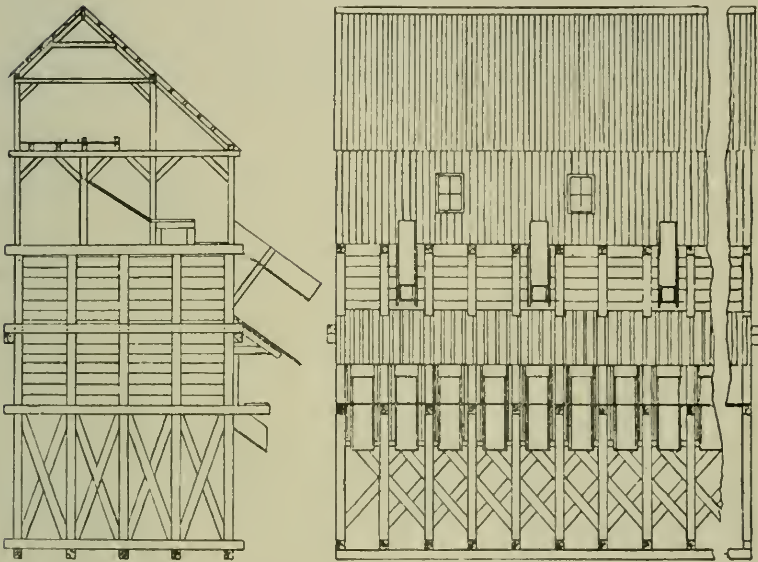
The ore bodies in these mines are very large, as will be seen from the accompanying blue print, which was kindly furnished me by the Superintendent, Mr. W. Y. Williams. This fact necessitates an extensive and thorough system of timbering the lower levels of these mines. The boundaries of these ore bodies have not yet been well ascertained, the ore appears to extend over 2,000 feet in length, while the width is not determined, though crosscuts from the footwall have been run for upwards of 300 feet.

The Old Ironsides has been prospected and developed by a system of shafts and drifts, showing the ore to extend down 400 feet, though work is not being carried on below the 300-ft. level. Stoping ground on the 200-ft. and 300-ft. levels has been opened up exposing blocks of ore running as high as 280 feet in width by 200 feet long; also, in an intermediate level, the 250-ft., ground 160 feet by 40 feet has been blocked out and is being stoped.

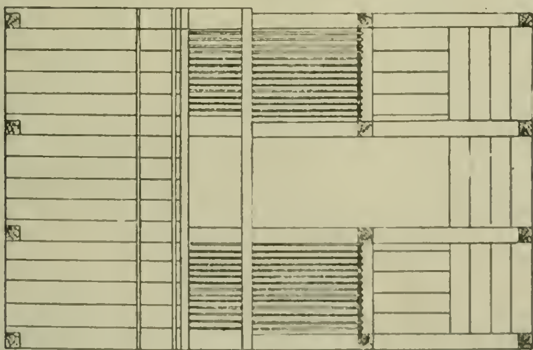
The Knob Hill is worked through a long adit tunnel, along which three blocks of ore 200 feet square are blocked out on at least three sides. On the surface, 150 feet above the level of this tunnel, an open cut or quarry is operated, and delivers ore to the tram system in the tunnel by means of shafts or shutes in the solid rock.

The foregoing brief description of these mines is merely intended to convey some idea of the immense size of the ore bodies, and hence the need for timbering when the ore is removed.

The ore in this wide mineralized zone does not form a very strong rock, though where (as in the Knob Hill) there is not much water and it has not been shattered, it forms a fairly safe roof for drifts and crosscuts.



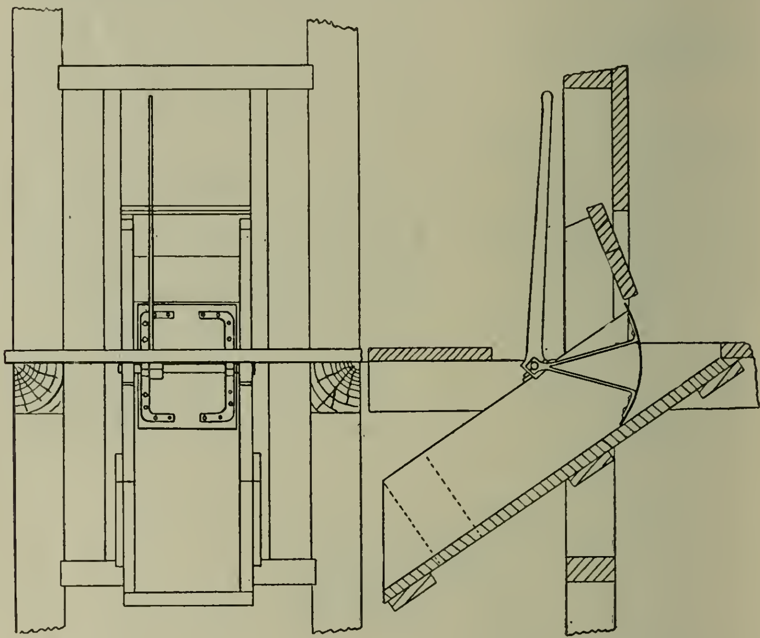
End Elevation   Scale 1" = 10'   Side Elevation



Plan of Grizzly.   Scale 1" = 5'

Fig. 1

A large part of the timber used at both mines has been obtained on the claims, the country here being rather heavily wooded. The principal kinds of woods are pine, spruce, tamarac and Douglas fir; the three latter are regarded as of nearly equal value, the fir being the strongest and all three being stronger than pine, which, however, has the advant-



Front Elevation *Section through Centre*

LOADING SHUTE FOR ORE BIN.
Scale 1" = 2'

Fig. 2.

age of being softer and crushing more easily, so as to take up the load more evenly; for this reason pine is much used for making wedges.

Most of the timber on the claims has now been used and the supply for the future is being brought in by railway from outside points.

Posts and caps are cut from round timber, which has the bark peeled off to lessen the decay caused by moisture retained on the

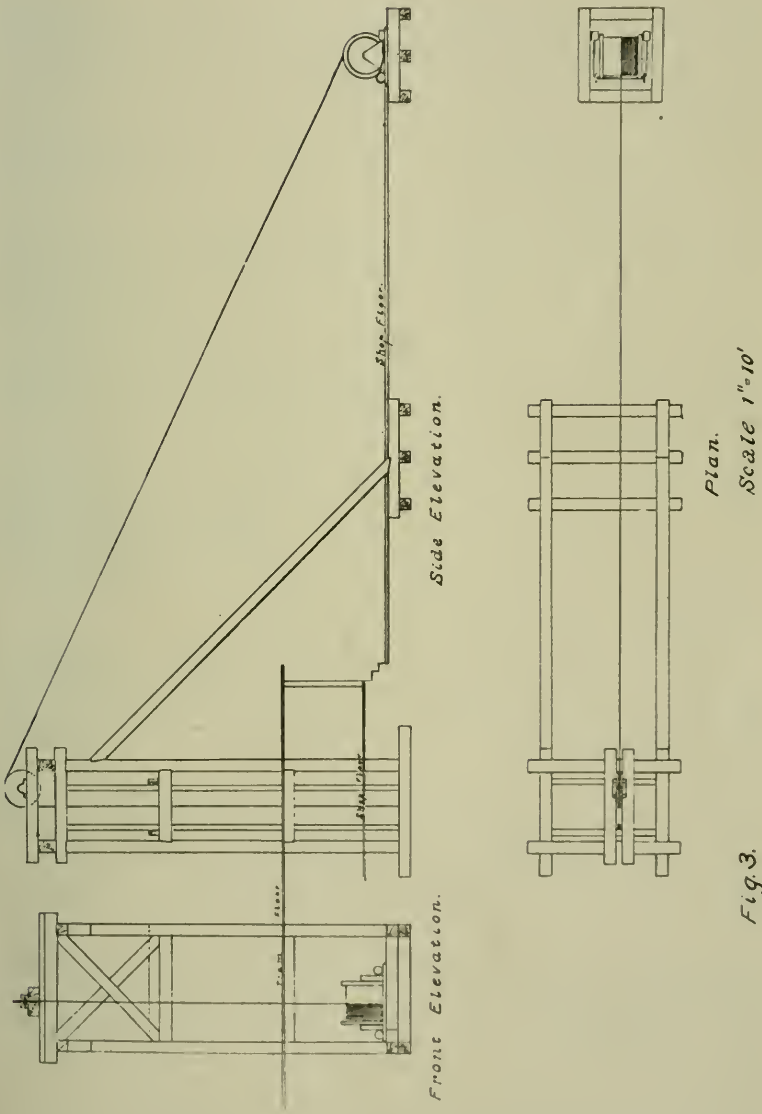


Fig. 3.

surface and below the bark when it is left on; this round timber is 10 inches and upwards in diameter, the posts being generally 15 inches up to 24 inches in diameter, while caps are smaller, the thickness across the flats at the post being 9 inches. Lagging poles are 5 to 10 inches in diameter.

Sawn timber is used in the construction of ore bins, hoists, and in the lining of shafts and shutes.

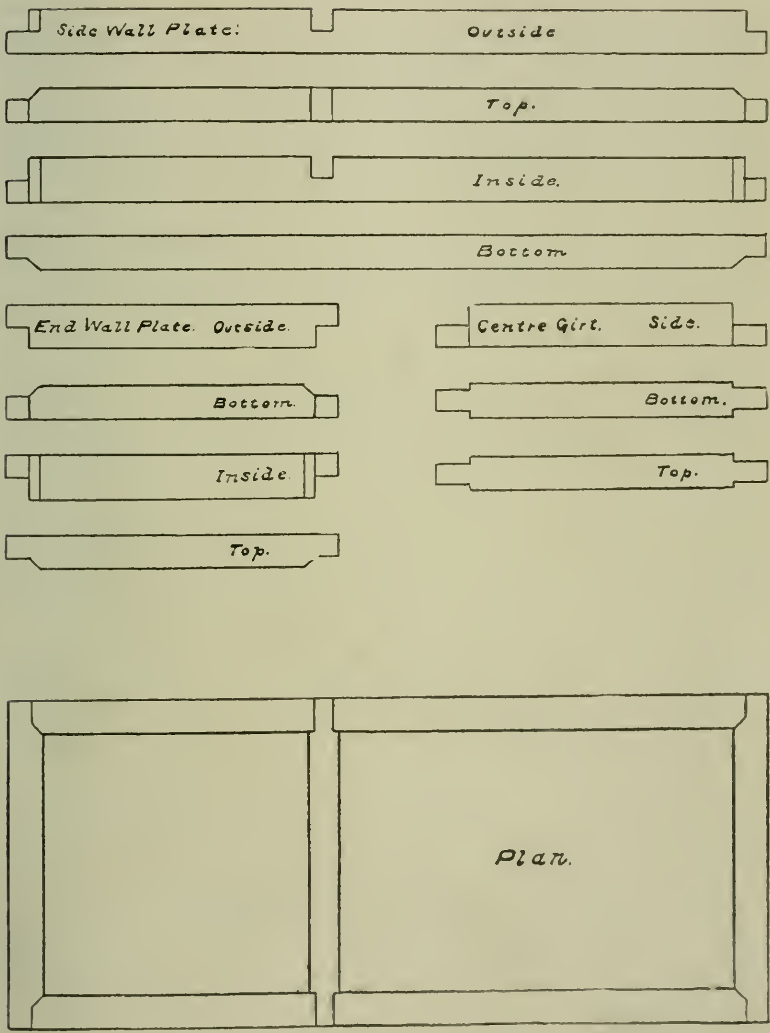
On the surface at both mines considerable timber has been used to build retaining walls to hold second grade ore and for making ground about the shafts and buildings. Round timber with the bark on is used for this; it is built into a wall by means of cross-pieces, forming cribs; these pieces are notched to fit the notches cut in the logs of the wall, and are run back into the bank where the weight of material resting against them holds the whole crib firmly in place.

Both mines are equipped with ore bins capable of holding from 5,000 to 10,000 tons and intended for the storage of ore and its easy delivery from the mine to the railway cars. The general arrangement of them is the same and is shown in Fig. 1. The foundation is made of 12-inch square timber made into bents and resting on mudsills of the same timber; these rest on the solid rock.

The bents run crosswise of the bin at a distance of 5 feet from centre to centre and are strongly braced, the direction of the braces being changed in successive bents, while the bents are tied together by braces crossing three bents.

The floor of the bin comes directly on top of the bents; it is flat and horizontal; the ore takes the angle necessary for its removal.

The floor and sides of the bin proper are made of 4-inch plank, spiked solidly to the 12-inch square timber frame arranged as shown in Sketch 1; also 1 inch iron tie rods are freely used in addition. Along the front side of the bin a railway track is built, and above this on the bin a platform extends from which the cars are loaded by means of a series of shutes placed 5 feet apart from centre to centre. The details of these shutes are shown in Fig. 2; the gate is made of heavy iron 26 inches wide, it is pivoted as shown on an axle and opened by a long iron lever; two movable planks above the iron gate permit the attendant to bar out large rocks if they should stick in the mouth of the shute.



Scale 2" = 1'.

Fig. 4.

Above the main bin compartment proper the grizzlies and breaking and sorting platforms are built—a plan of these is shown in the lower sketch in Fig. 1. The grizzlies are made of 25-lb. mine rails cut to the desired length and strung, bottom upwards, on iron rods at each end, pieces of pipe placed between them on the rods make the desired space between them, about 2¼ inches. There are two such grizzlies, each 5 feet wide, with an open space between them, in each 15 feet of the length of the bin. This open space is used for dumping ore directly into bin when it does not require sorting or breaking; or by means of a shute a low-grade ore can be thrown out of bin at the back.

Above the grizzlies is the tram car level; the cars come from the shafts to the centre of the bins and turn either way on a steel turn-plate and are run to the desired compartment and dumped. A beam 4 inches square, running parallel to the track, about 2 feet from it, prevents the cars being overturned into the bin.

The whole structure is roofed with 1 inch boards to keep out rain and snow, which are abundant in this locality. The bin sketched is a small one with a capacity of about 18,000 cubic feet if full, or say 1,000 tons. There are in addition two others of much greater capacity.

The shafts in operation on the Old Ironsides are the original prospecting shafts and the "gallows frames" are not elaborate. Fig. 3 shows the plan and elevations of the one at No. 1 shaft. It is built of 12 inch square fir timber arranged as shown. Men and timber are taken on the cage at the shop floor level, while ore or waste is hoisted to the tram floor level to be taken to the ore bin or waste dump. As the hoisting engine is quite small, an elaborate hoisting frame is not required. The frame at No. 2 shaft is somewhat similar.

Both shafts have two compartments, one being for hoisting ore, &c., and the other for ladders, pipes, &c. Owing to the fact that they are lagged inside with 2-inch plank, I have not got full details of the timber in them.

Shaft No. 1 is cribbed for a part of the way down and Fig. 4 shows a method of framing timber for cribbing which is employed in British Columbia; it is a halved joint combined with a bevelled hitch on the inside to resist lateral pressure; it is improved if side and end plates are made to break joints so as to prevent one set slipping over the next.

The lower part of No. 1 shaft and all of No. 2 shaft is timbered with square shaft sets. Fig. 5 shows timbers cut for this purpose, with a halved joint and bevelled hitch, and the posts resting at top and bottom in a hitch to prevent them being forced inwards. The centre girt or divider is supported by a tenon and mortice joint; and centre posts are provided. The lagging in bad ground is placed outside of

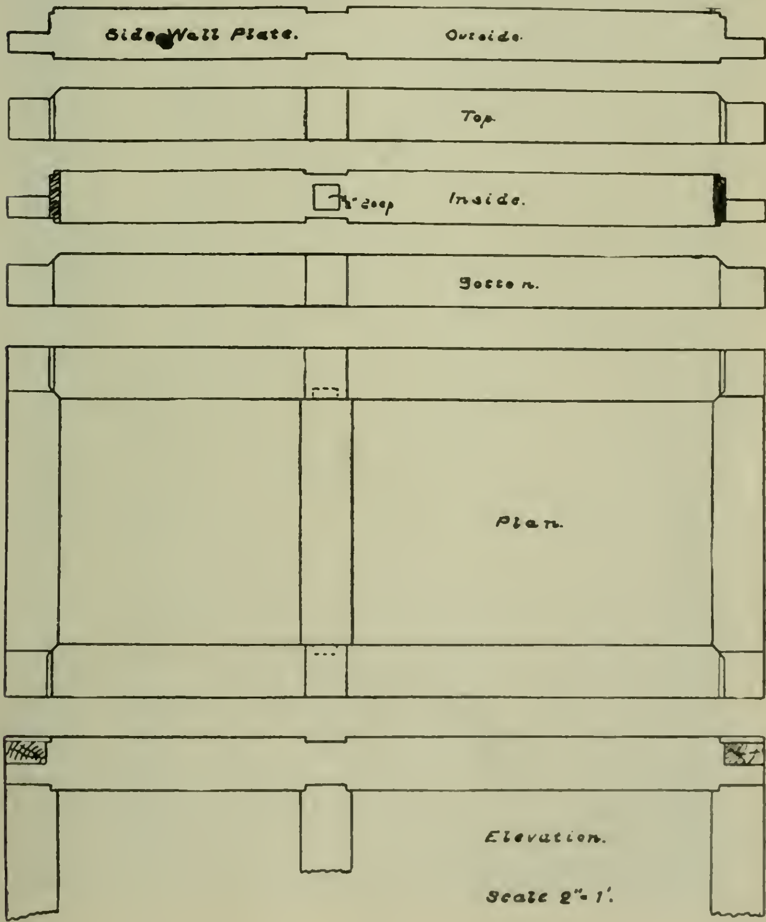


Fig. 5.

the timber and is supported on strips spiked to the plates; in safer ground the lagging is placed on the inside, being intended to prevent small rocks from falling in.

As the shafts are only prospecting ones the level stations are simple. Posts about 15 feet long are put in the shaft at the station and the upper end wall plates are run across the station a distance of about 20 ft., with suitable supporting posts and dividers or cap pieces; the lower end plates are also extended to form part of the sills for carrying the floor and steel turn-table plates.

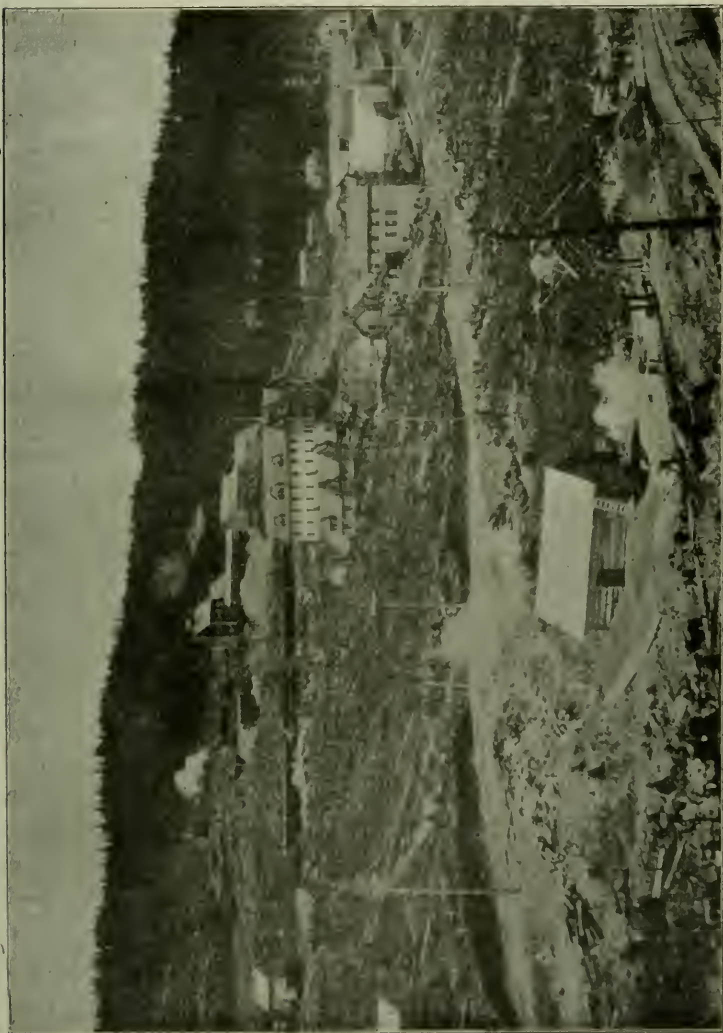
Both mines are equipped with a track system. The rails are carried on wooden ties placed about 18 inches apart; these ties are flat on two sides and are 3 in. x 4 in., and 30 inches long.

The main haulage roads are lighted with incandescent lights; the wires are carried on small round timbers about 4 inches thick, wedged across the top of the drifts like a horizontal stull. Where there are tunnel or stope sets they are used to carry the wires.

The method of mining the ore in the Old Ironsides may be briefly said to be by overhand stoping. The stopes thus formed are filled with square sets of timber, and this timbering constitutes the most important item in the timbering of the mine.

The square sets are of round timber 8 feet in height placed 5 feet apart with cap pieces to hold them in their relative positions laterally. These posts and caps are securely wedged into place to carry any pressure resulting from settling or breaking loose of rock. Fig. 6 shows the shapes of the timbers; they are all round timbers except the bottom sills in each stope, which are 6 in. x 12 in. sawn timber. The sketches at the top of Fig. 7 shows the method of framing joints; in the drawing square timber is used for convenience in drawing. The lower drawing in Fig. 7 shows a number of sets put together; in it the posts are represented as being too small to allow of cutting the small shoulder for catching up the whole cap. This occurs sometimes with the round timber.

It will be noted that the framing of this timber is especially designed to carry vertical pressures,—the tenon on the end of the posts ensuring the position of the posts in the different floors of the stopes being directly above the corresponding post in the floor below.



General View of the Knob Hill and Old Ironsides Mines, Boundary District, B.C.

It will also be noted that this system of timbering is very elastic and can be applied to ore deposits of almost any shape and size.

This timber is all framed on the surface by special carpenters. Fig. 8 shows the framing platform which is situated in a convenient place above the shafts and below a spur of the railway from which the timber can be unloaded and rolled direct onto the platform, framed, and rolled off onto piles near the shafts.

It is cut up into caps and posts to the best advantage. Fig. 6, *a*, *b*, *c*, show templates, straight edges and squares used by the framing carpenters. All timber should be marked off and measured from a centre line. It may be mentioned that this method is about to be abandoned at this mine and the timber framed by machinery.

The timber is transported to the shafts on a 30 inch gauge track and lowered into the mine by the " muckers " of the night shift; and stored in convenient places near the shaft stations. In this connection it may be noted that it is advisable to store it in as dry a place as possible, as the drier and lighter it is the more easily and expeditiously the heavy pieces can be handled.

From the stores underground the men of the day timber crew take it as required to the various parts of the mine on small timber trucks running on the ordinary mine tracks.

If the timber is being put in on the bottom of the stope, the first operation is to get the 6 x 12 inch sill accurately in place. This may be done by the engineer giving level and location with his instrument, or it may be placed by reference to the adjacent timber, if there is any, by levelling and measuring across from the sills. When the sill is tamped accurately to its true position the sill posts are set in position in the open mortices in the sill, then the caps are put on and the whole is " spragged," or braced and wedged securely in place. It is usual to brace and wedge caps and posts from the adjacent walls, and the roof also in the case of the caps by a large vertical sprag set on top of the caps meeting at a post. The accompanying photograph gives some idea of the arrangement of the bottom square sets and the spragging. The secure bracing of the timber requires both judgment and experience, and is a good test of the timberman's ability.

Next the lagging of round poles is laid on top of the caps; the

Photo showing arrangement of the Bottom Square Sets and Spragging at the Knob Hill and Old Ironsides Mines, B.C.

lagging poles are from 4 to 10 inches in diameter, 10 feet long and have the bark left on. Not more than four square sets of lagging is laid in the same direction, *i.e.*, a square 10 feet on the side; the adjacent lagging is laid at right angles to this to give a better support to the ends.

If the timber is to be used on floors above the track level it must

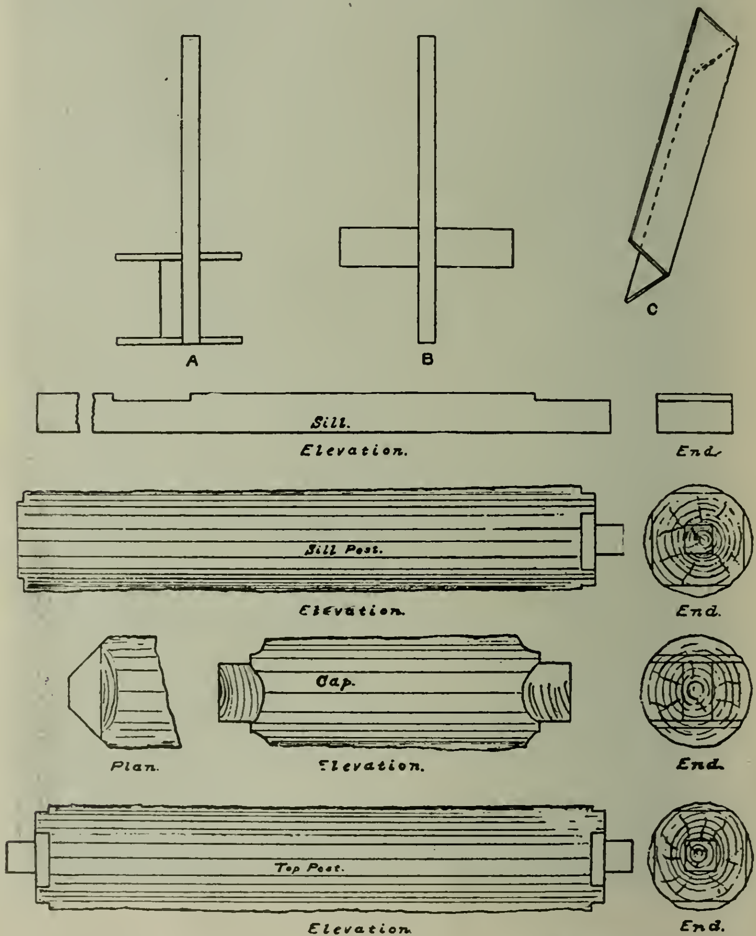


Fig. 6. Scale 3″=4′.

be hoisted from the level; to do this shutes are built through the lower floors—they are made either of plank spiked to the lagging, or of lagging, the top being spiked to the cap and the bottom ends resting on

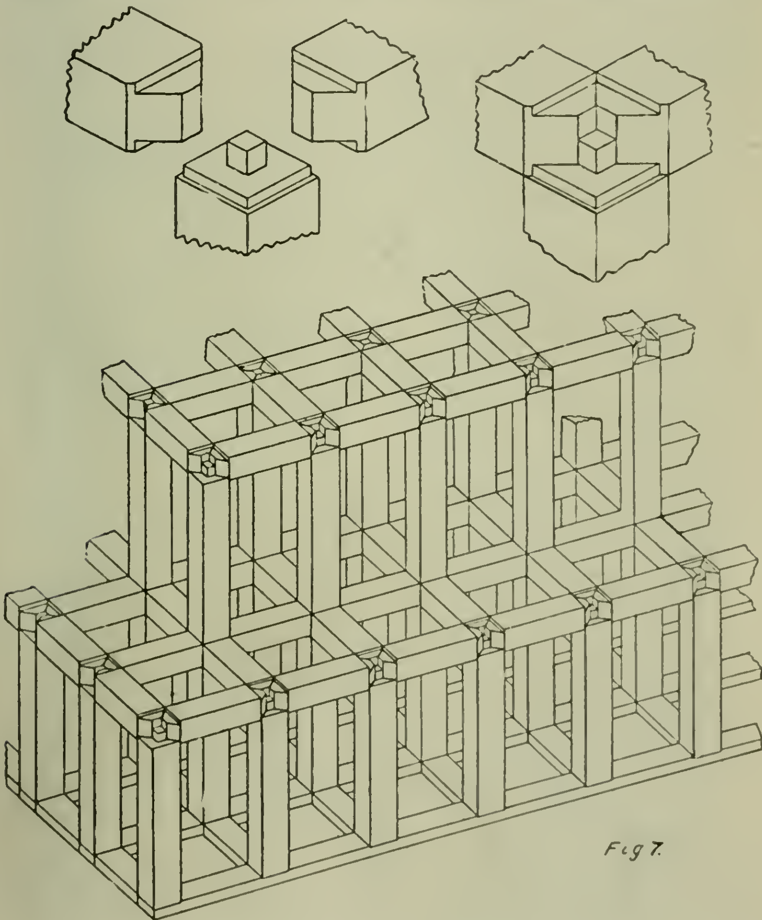


Fig 7.

the next lower floor behind the caps so as to be out of the way of the timber being hoisted.

The hoisting engine used is shown in Fig. 9, a photograph from the maker's catalogue; it is driven by compressed air from the mine mains. This engine is in common use in British Columbia for this purpose. It is made in two sizes with double cylinders 5 and 6 inches in diameter, and drums 12 x 21 inches and 14 x 24 inches respectively. The 5 inch engine is said to be capable of lifting 1,400 lbs. 100 feet per minute. The pistons are of the trunk type, there being no crosshead or slides; the crank discs are carried on the small shaft at the top; this shaft is geared to the larger shaft on which the drum is loose and is

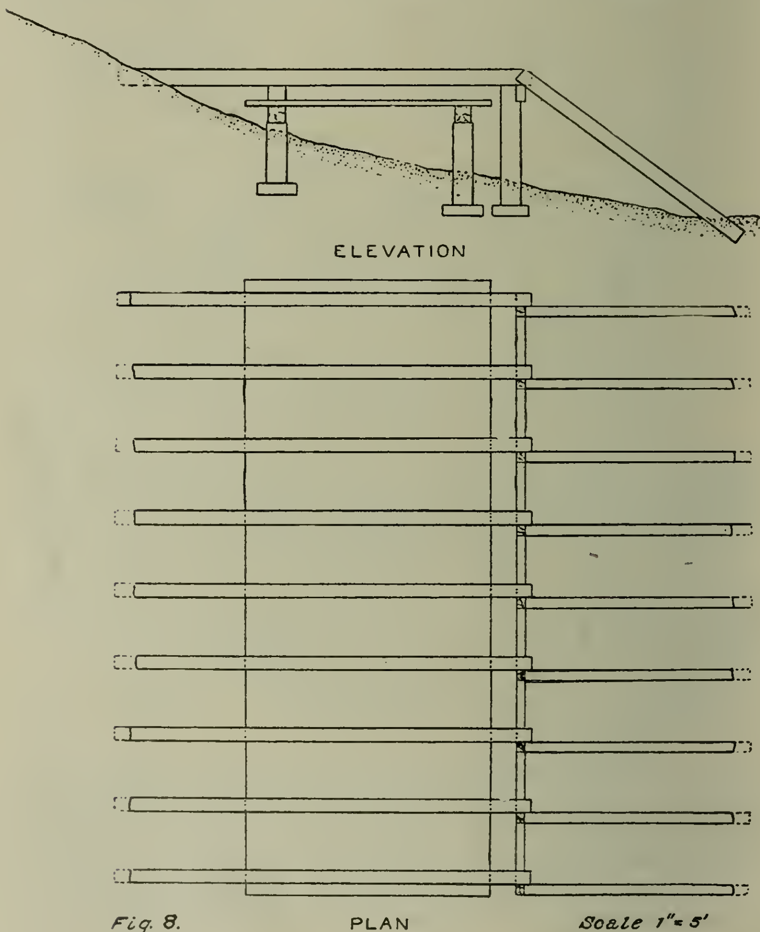


Fig. 8.

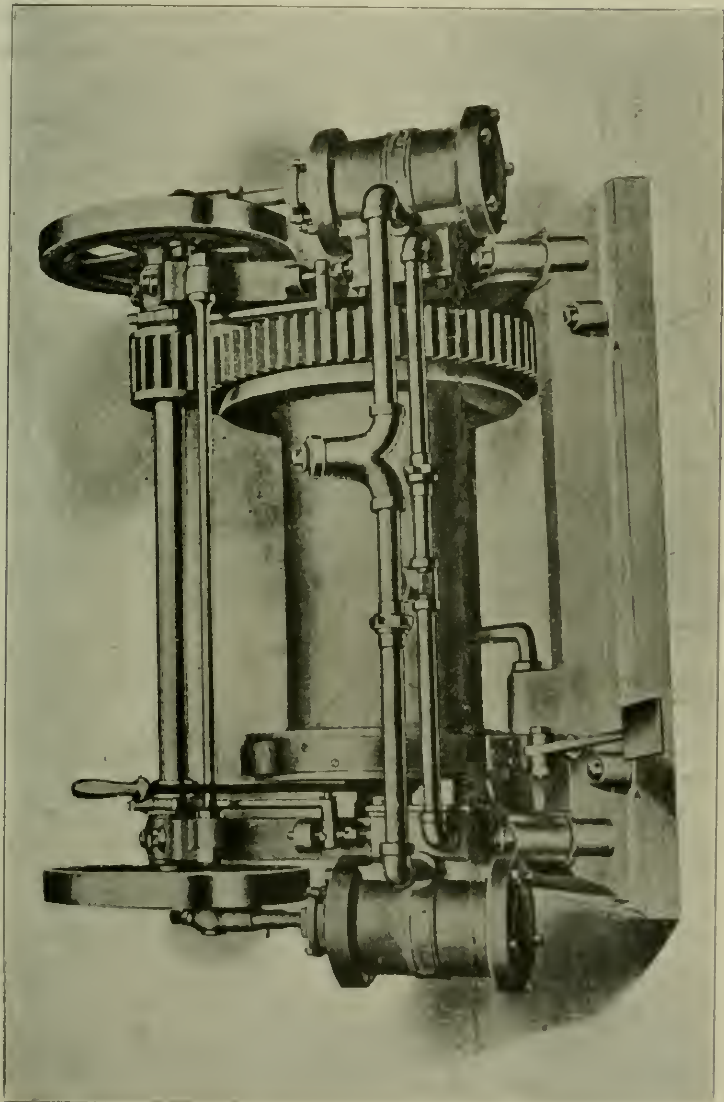


FIG. 9—Type of Hoisting Engine in service at the Knob Hill and Ironsides Mines, B.C.

connected by a V friction between the drum and the large gear when running. This engine is mounted on nine car wheels for transportation underground and braced securely to walls and timber when used. Each engine should be equipped with air hose, wrench, and oil can.

One inch manilla rope is used on the drum, with a single pulley block fastened to the timber of the upper floor, the end of the rope is fitted with a pair of steel hooks for hoisting caps and posts; lagging is tied together and hoisted in lots.

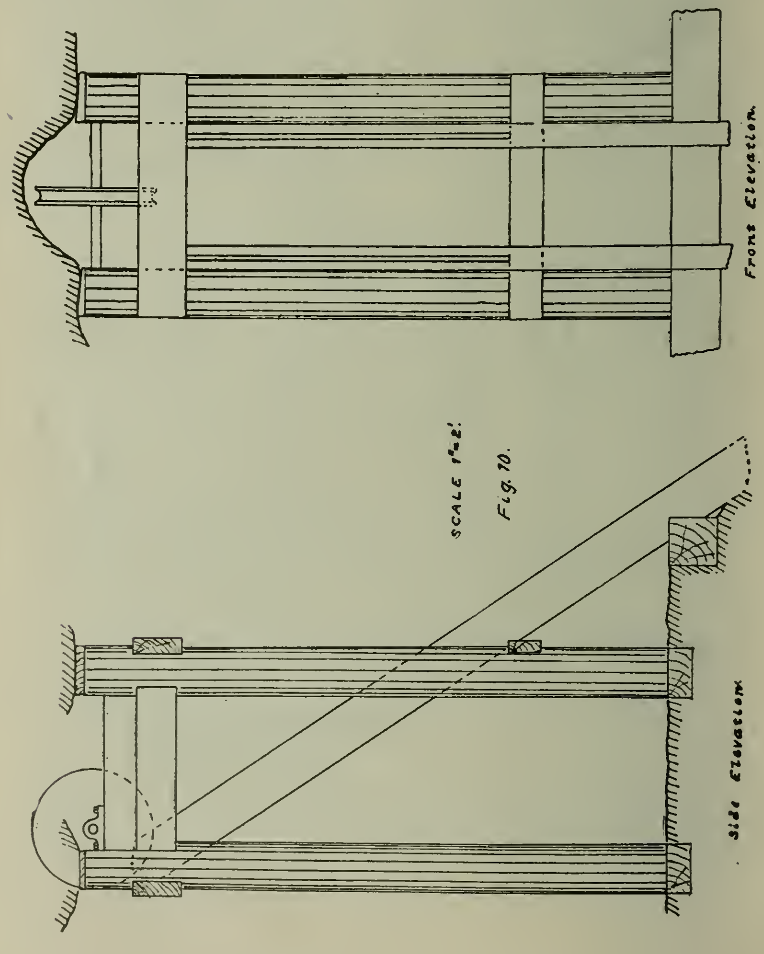


Fig. 10.

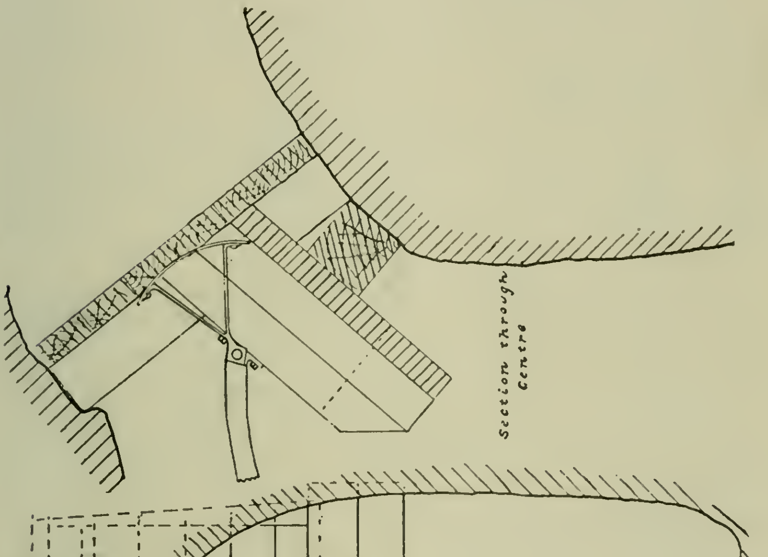


Fig 11.

Timber is moved about the upper floors by means of a pair of steel tongs like ice tongs.

As yet no reinforcing sets have been used. Heavy ground is held by putting in diagonal braces, or by extra spragging and cribbing with solid timber cribs built in between the rock and the regular sets to prevent a fall beginning.

In the centre of the large stopes cribs filled with waste rock or, in some cases, with ore are carried from the bottom level up with the timber; this is intended to steady the timbering in the stope. This filling pillar is usually 15 or 20 feet square and is retained by large lagging split and placed behind the posts.

Where a turntable is put in the track in the bottoms of stopes a post is left out at opposite corners to allow of long timbers being turned; an 8 x 8 inch upright is bedded on rock beside the adjacent posts and a 12 inch square timber on top of these supports the regular caps.

On the bottom of the stopes shutes for drawing the ore from the floor above to the mine cars are built in every 15 or 20 feet along the tracks; they are built of 6 inch plank, the mouth is 5 feet above the track and is 26 inches wide.

Very little timber is used in drifts and crosscuts, only a few square tunnel sets resting on sills and measuring 4 x 7½ feet are used.

In winzes and raises stulls are placed across in the usual way to support the platforms and ladders. Ladders are 10 feet long, sides 2 x 4 inches, rungs 4 x 1½ inches, 18 inches long, and 14 inches apart.

Fig. 10 shows the head frame used in sinking an inclined winze with a bucket, the posts are wedged solid to the rock so that no bracing is required.

Fig. 11 shows a very strong shute placed on the 300-ft. level to draw ore from the 250-ft. level stopes. Similar shutes are used in the Knob Hill at the bottom of the shafts from the surface quarry.

Fig. 12 shows a plan and elevation of an underground station in the Knob Hill from which a vertical shaft over 200 feet deep has been sunk. The frame is made made of 8 x 8 inch and round timber; the posts of the gallows frame are 12 inch square timber, no braces are required as the tops rest against the rock. The station is lagged with

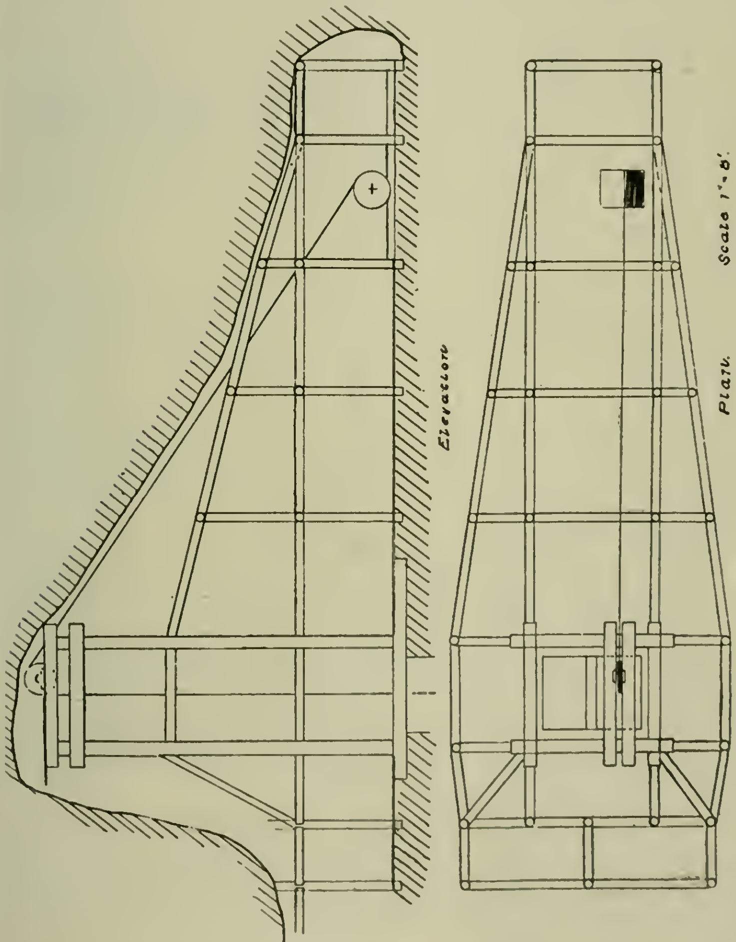


Fig. 12.

2 x 12 inch plank. The foundations are mudsills with two long sills beneath the hoist. The chamber is dry and no better roof is required.

Fig. 13 shows a hoisting arrangement used on the surface of Knob Hill for loading ore into the railway cars direct from the surface.

A small car is used running on a 30 inch gauge track, and a small hoist run by air pulls it up the incline, when at the proper place it dumps its load automatically into the moveable shute below which throws it into the railway car standing alongside. The whole hoist rests on mudsills and can be turned to face different parts of the bank from which the ore is being taken. It is steadied by guy ropes reaching from the top to any convenient anchor.

On the whole very little timber is used in the Knob Hill, a few tunnel sets being practically all outside of the winzes, shutes and underground station. The tunnel sets are 10 feet wide by 7½ feet high, California sets.

Timber used in the Knob Hill may be used repeatedly until worn out; but the life of timber in the Old Ironsides is not expected to be more than three or four years on account of the water and great quantities of powder smoke.

A timber crew in the Old Ironsides consists of four men, of whom two at least should be experienced men, the others may be laborers, but more expeditious work can be done if they also have had some experience. The speed of erecting stope timbers depends on the location and the condition of the place where they are being put up, if far from the timber stores or near, and whether there is much rock in the way or not. Generally from 6 to 12 square sets of three pieces are put up by each crew in 8 hours.

Tools required by a crew consist of: 2 sharp axes, 2 older axes, 6-ft. crosscut saw, hooks, crowbars, hammers, picks, shovels, spirit level, straight edge, and a few drills, besides tools used about hoisting engine.

The framing carpenters on the surface require cant-hooks, 8-ft. crosscut saws, hand saws, adzes, axes, squares, templates, straight edges, plumb bobs, chalk lines, grindstone and whetstone. As a rule the underground tools are sent to the surface to be sharpened.

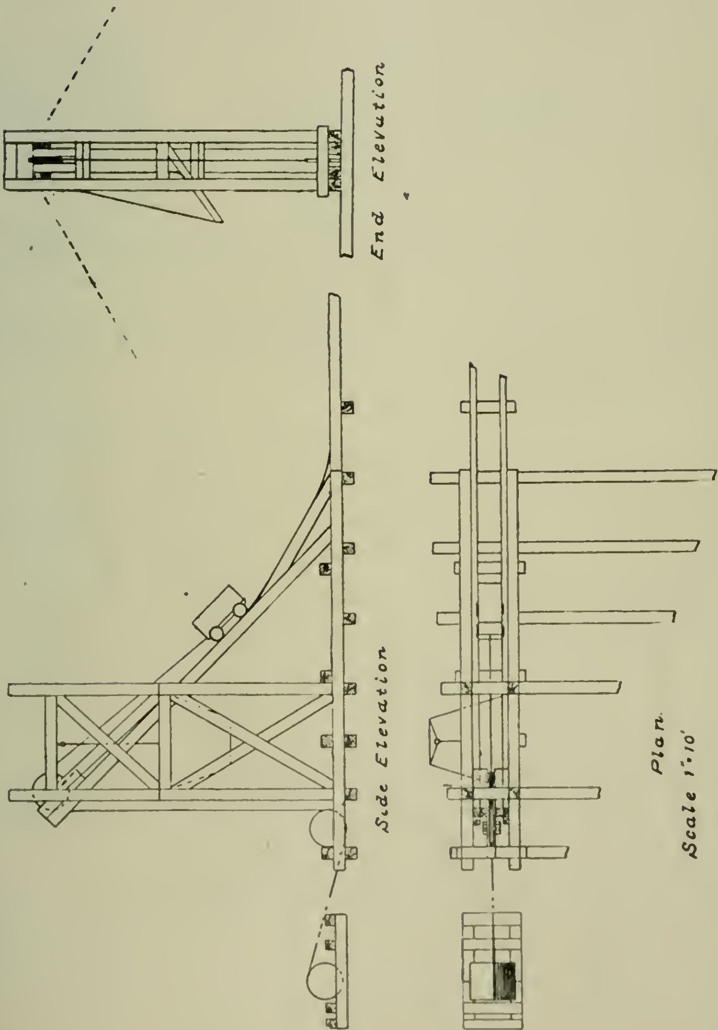


Fig. 13.

The regular timbermen get $3.50 for 8 hours shift, laborers $3.00; and the foreman who looks after all the crews gets $4.00. The framing carpenters get $4.00 per day, but work 10 hours per day.

Figures of the cost of mining have not been made public. Any attempt to figure the cost of timbering in a mine must be made from figures got during a period when the conditions have been very nearly the same; as this has not been the case here owing to changes in the labor and in the source from which the timber has been got the figures would be of little use.

The drawings of timber from which the accompanying photographs were taken were made by the writer from measurements and notes taken by him at the mine.

The paper refers to the state of affairs at these mines in June, 1901.

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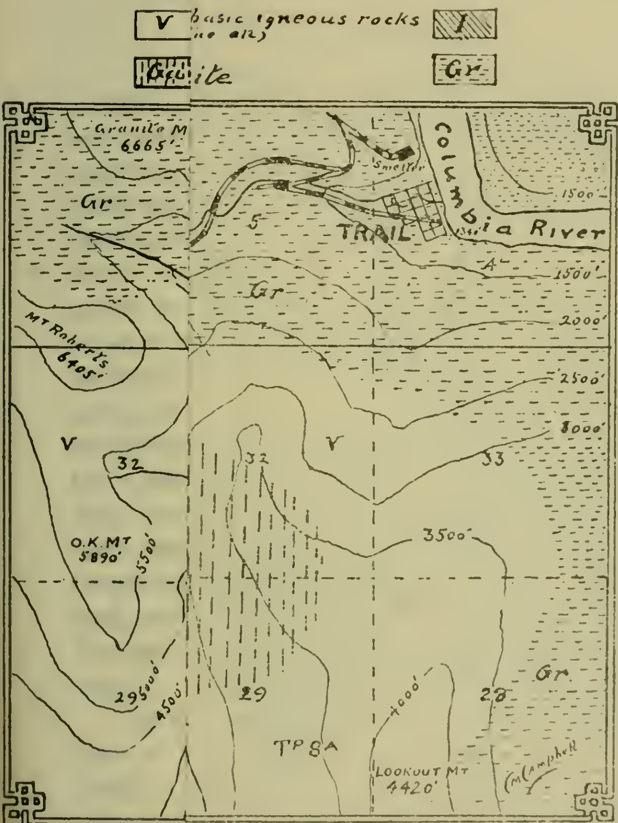

C. M. Campbell.

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Mining in the Rossland District.

By C. M. CAMPBELL, McGill University, Montreal.

This paper will deal chiefly with the mining practice in the Rossland district. The history of the district will be briefly sketched and its geology noted at some length. The larger part of the information herein contained I gathered last summer, in Rossland and the surrounding country, during the stay of the McGill Summer School in that district ; and later, while engaged as pipeman's helper and as machine man in the Centre Star and Le Roi mines. In addition to this I have drawn on an article by Mr. Brinsmeade, B.S., M.E., in "Mines and Minerels" for March, 1901, for much additional information. For the geology of the district I am indebted to a geological excursion with the McGill party under Dr. Adams, to the Government reports, and also to the expert evidence of Mr. Clarence King in the Centre Star–Iron Mask law suit. The negatives from which the micro photos were taken were kindly loaned by Mr. O. E. Le Roy, B.A., of the McGill Geological Department. The remaining photos I took while in Rossland, and they represent the condition of affairs at that time. The Toronto "Globe" of Feb. 8th, 1896, is my authority for the historical sketch.

By the Rossland district is meant a piece of territory on both sides of Trail creek, about three miles wide and eight long. Trail Creek is an average sized mountain stream which flows into the Columbia River from the west, six miles north of the International Boundary. The creek was known to placer miners in the early sixties, as the celebrated Dewdney trail followed its course from mouth to source, but it is not known whether these early pioneers ever found evidences of the richness of the camp or not. In 1889 a French Canadian named Bordeau made the first location, some distance south of Red Mountain, and next summer two men, Moris and Bourgeois, staked out the Le Roi, War Eagle, Centre Star, Iron Mask, and Virginius claims. Every one of these claims has since been made a mine except Virginius, upon which little or no work has been done. Things went slowly until 1895, when there were only a few dozen log cabins in the camp. Then the boom struck the place, and the population went up to 2,500 in the course of a year. Since then the growth has been steady, and Rossland has now a population of over 7000. It is entirely a mining town, the people being completely dependent on the mines.

GEOLOGY. (SEE MAP.)

Many ore deposits, such as the famous Cripple Creek deposits, are situated on deeply eroded volcanoes. At Rossland we have another

Phenocryst of Augite in Monzonite from boulder near War Eagle Stairs.

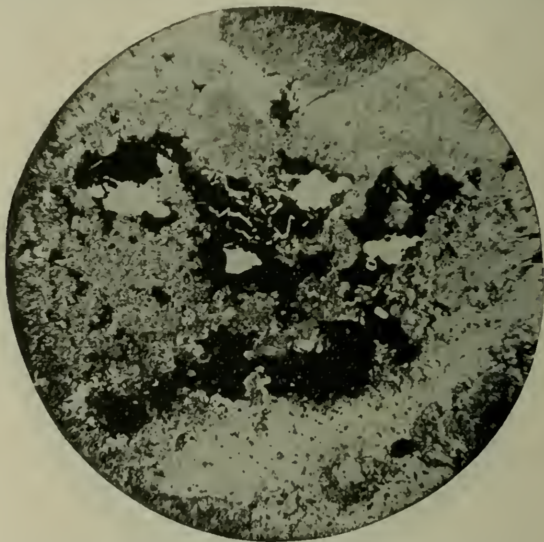
example of this. Here we have an igneous core, on the sides of which we find piles of ashes and lavas, all very much compacted.

The rocks of the igneous core are of different types. One, which forms the greater proportion of the mass, and is the country rock of most of the mines, is a dark, greenish or gray, tough, fine or coarse grained rock consisting of black augite crystals and light colored orthoclase and plagioclase feldspars, with usually a little biotite and often magnetite and pyrites. It is an augite diorite, and is the variety known as mongonite. Photo I shows a thin section of this rock magnified. The large crystal is augite, and the dark zone about the edge shows where it is altering to hornblende. The opaque inclusions are magnetite, while the crystal to the left of the augite one is biotite. At the Iron Horse is a darker series of rocks, similar to the above, but without the orthoclase. This rock is gabbro, and in this locality shows a somewhat banded structure, due to the dissolving out of the dark augite or hornblende constituents, and the deposition of silica in their place. This is shown in Photo V, the upper lighter portion of the photo being

Ash Rock from California Mine.

the silicified part, while the lower half consists of the original mineral. A still further type of rock is that known as augite syenite, and an exposure is to be found at the big cutting at the west end of Columbia Avenue.

Outside this igneous core is the zone of fragmental and volcanic rocks. The fragmental ash rock is a greyish, fine grained, quartzitic looking material, showing a stratified structure due to different depositions of ashes. These features are brought out in Photo II. The volcanic rocks are those known as augite and uralite porphyrites. The passage from the porphyrites to the gabbros is nowhere sharply defined, and the two rocks have apparently originated from the same magma, but have cooled under different conditions. The gabbros and bordering porphyrites are important from an economic standpoint as most of the ore bodies at present being worked are situated either on or close to their line of junction. Photo III represents a specimen of augite porphyrite taken from this junction. It shows where the dark gray



Augite Porphyrite from War Eagle, showing replacement of Hornblende by Pyrrhotite.

hornblende has been dissolved, and its place taken by the black opaque pyrrhotite. Photo IV shows another section of the same rock as it appears under polarized light. Several twinned augite and feldspar crystals are noticeable.

Beds of impure limestone on Sophie Mountain containing corals and ashes interstratified have been found, and indicate a carboniferous age for the volcano. The whole district is underlain by granites containing beds of limestone and known as the Shuswap series.

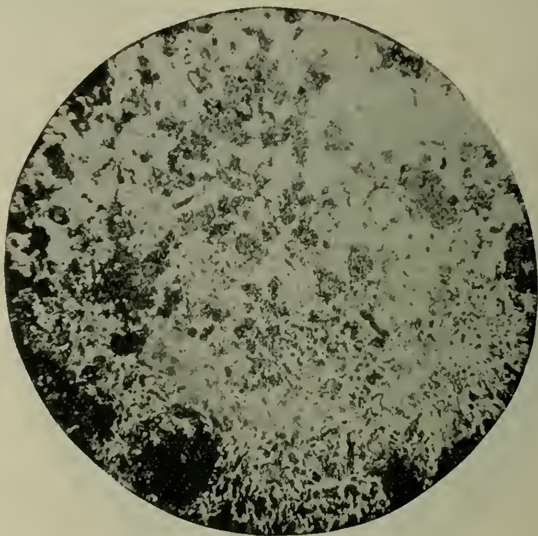
The mineral bearing veins are characteristic fissure veins and some of the larger are known as "shear zone" fissures. Instead of being an indefinite amount of parallel fissures extending into the country an undiscoverable distance it is always a zone of a discoverable and limited collection. The mineral deposit may lie on one plane, or they may eat up the rock between the planes and deposit another in its place, or they may occupy the whole zone, or mineralize one particular fissure and travel on that, and so on. The exterior boundary is assign-

Augite Porphyrite from War Eagle crossed Nicols.

able if you crosscut. These veins are of enormous extent in some places, such as 100 or 200 ft. in width in the shattered mineralized zone.

The ores consist principally of sulphides of various metals. Of these pyrrhotite is by far the most abundant. It is found as a rule in a massive condition, ranging in texture from a fine to medium grain, but is also disseminated through the country rock. The massive variety usually holds blebs of quartz and grains and irregular patches of other sulphides. The pyrrhotite contains gold and silver in varying quantities, a small percentage of nickel, and traces of cobalt. The gold contents are exceedingly irregular ranging from traces up to several ounces to the ton, and the silver from traces to four or five ounces to the ton.

The pyrrhotite is usually accompanied by a certain amount of copper pyrites, intimately commingled with it. The copper pyrites is extremely irregular in its distribution, in some places constituting a considerable portion of the ore body, and in others occurring only as



Altered Wall Rock from Iron Horse.

isolated and occasional grains and patches. It is nowhere seen in large masses. It is auriferous, and holds apparently about the same percentage of gold as the enclosing pyrrhotite.

Molybdenite, galena, and blende also occur in some places in small quantities, while iron pyrite is met with in greater or less quantities nearly everywhere. The ores are usually oxidized on the surface, but the alteration seldom extends downward for more than a few feet.

DEVELOPMENT.

The mines have been developed by running inclines along the dip of the vein, and from these inclines driving horizontal drifts at 100 foot intervals along the strike and usually within the walls of the vein. These drifts are afterwards enlarged, sill floors put in, timbered, and the ore in this way worked out to the next higher level.

DIAMOND DRILLING.

In the big mine diamond drill outfits are constantly kept at work exposing the deposit. Two sizes of drills are used, one with a bit of 2⅛ in. outside and 1⅜ in. inside diameter, and the other with 1½ in.

Le Roi. Gertrude. War Eagle. Centre Star.

Rossland.

outside and 15/16 in. inside diameter. In starting the drill, especially from those drifts in which tramming is being pursued, a short crosscut is first made by the percussion drills to give a space for the machine and the proper handling of the rods. The rods are square threaded at the ends and come in five foot lengths. They are pulled in lengths of 5 to 20 feet, according to the space available behind the drill.

The holes are cored throughout. The core barrel is 5 feet long, and the frequent slips and small seams in the country rock, permit the cores procured to be easily broken off by the usual choker device. The average length of the pieces of core is 5 to 8 inches. In careful sampling the core barrel is sometimes pulled out for every six inches advanced. The drilling engines are screw fed, and fitted for 300, 700, and 1000 revolutions per inch of advance. Their ordinary speed is 300 revolutions per minute. The water is pumped through the drill rod by a small independent pump run by compressed air. The average progress is 8 feet in an eight hour shift, with a record of 18 ft. 9 in.

Rossland from O.K. Mountain.

The core is broken up and assayed, after a careful examination by the mine superintendent While drilling in ore, sludge samples are taken by running the discharged water for a fraction of the time into a tin pail, in which the sludge settles out.

The Rossland rock is very hard on diamonds. The War Eagle and Centre Star companies employ a skilled bit setter to keep the bits in running order. For the smaller sized bits eight diamonds are used, six on the face and two on the outside. Those on the face are set so that half of them have a cutting edge extending to the outside of the face, while the other half cut the inside clearance for the core to pass up. Whenever the drill is withdrawn from the hole the bit is always carefuliy examined, and if any of the diamonds are found to be loose or the metal worn away, the metal is recaulked around them. When the bit is so badly worn that the diamonds are greatly exposed, they are cut out and reset in a new metal blank.

The wear of carbons is somewhat less than 1/64 karat per foot of hole drilled. Each bit will only drill about 12 feet before resetting.

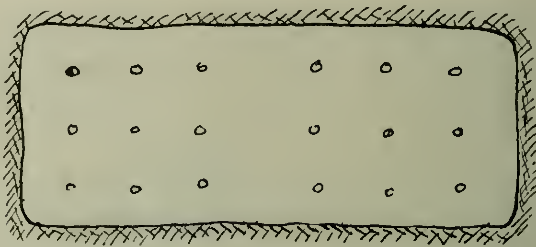
Le Roi Offices.

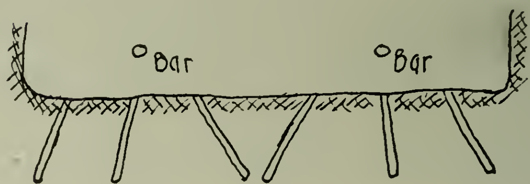
To remove a bit that has been broken off in the hole, it is sometimes necessary, if other devices fail, to ream out the whole with a new bit, large enough to enclose the stuck bit and recover it in the core barrel.

SHAFT SINKING.

The Centre Star shaft is 18 ft. 4 in. x 7 ft., outside to outside of timbers, and is on an incline of nearly 70°. The accompanying figure shows the position of the drill holes for sinking. The whole round is drilled before any blasting is done, the machine drills being set up as shown by the location of the two bars. Four men work the two machines, and it usually takes two shifts to drill the round of 18 holes. The machine men do their own loading and blasting, as it is impracticable to have a separate gang for blasting in the shaft as in the stopes and drifts.

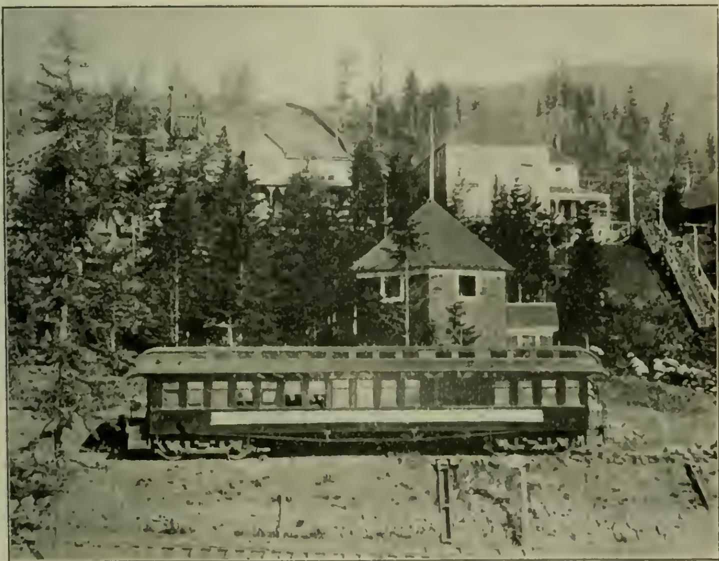
In the Centre Star shaft the rock is hoisted, during sinking, by a bucket let down from a sheave in the ladder compartment by a small Ottumwa Ironworks Company's friction hoist in the station above. An iron bucket is used, 42 in. long and 36 in. greatest diameter. The bale is made of 1 in. round iron with a loop for the clamp hook. A couple of lugs of 1 in. round iron, spread out at the end into a square plate,





are riveted to opposite sides of the bucket near the bottom. The bucket runs on skids about 20 in. to 24 in. apart, on which strips of greased strap iron are nailed with the flat side tangent to the bucket at point of contact.

Near the point of dumping two outside skids are placed a little farther apart than the diameter of the bucket, and take the place of the other skids. These catch the lugs on the bucket and straighten it up. At the point of dumping two depressions are made in the skids and the bucket is only hoisted high enough for the lugs to catch in the depressions. The engine is reversed, lowering the top of the bucket, which falls backward and dumps. The bucket is then hoisted a foot or so above the depressions, and is lowered, the lugs catching on swinging irons which swing forward by the weight of the bucket, carrying the lugs over the depression. The bucket is then lowered to the bottom and refilled. The plan of the 600 level shows the position of the hoist and the shaft. The bucket is dumped backward into a car standing on the track behind the shaft. Two bucket loads fill the car, which is



War Eagle Tram. Manager's Residence. W.E. and C.S. Offices. Reservoir.

Offices War Eagle and Centre Star.

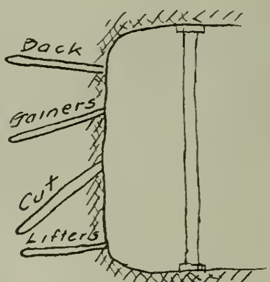
then wheeled around to the front of the shaft, and the contents dumped into a skip.

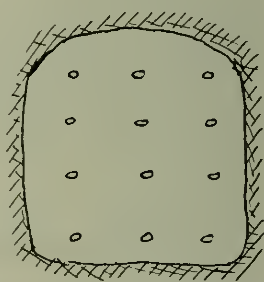
The old rock bulkhead method has been abandoned in favor of the timber bulkhead. By this method the timbering goes on contemporaneously with the sinking, sufficient space being left to keep the lowest set from being injured by the heavy blasts. This clearance is usually 20 to 23 feet.

The shaft sets are of sawed pine, framed on the surface, and are placed 5 ft. apart, being separated by posts. The way in which the different parts fit together is shown in the timber drawings. Hangers are employed to support the sets as the work progresses, the posts serving to keep the sets properly spaced, while the hangers keep the sets tight against the posts. They are not left on permanently, but are removed after several sets have been completed and properly wedged in position.

DRIFTING.

Where possible the drifts are driven along the hanging wall so as to have one free face to break from. The sketch shows the position of drill holes in drifting. The advance per round of holes is about 3½ feet. The powder used is 60% dynamite for primer cartridges and 50% for the balance of the explosive ; 40% is used if soft rock is struck.





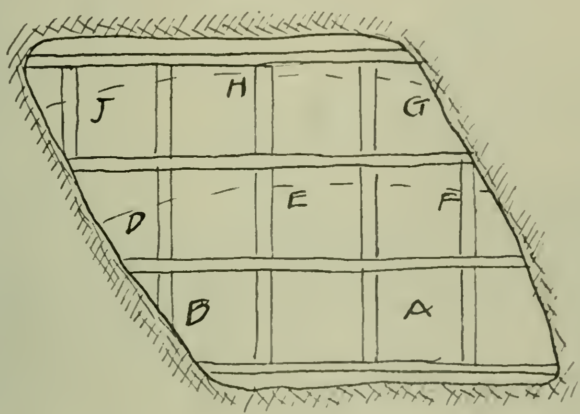
Ten and a half pounds of powder was the average consumption for one foot advance for a recent period. In Rossland the muckers and trammers receive $2.50 per day, and the machine men $3.50, when working by the day. It is, therefore, more economical to keep the machine men constantly drilling, and leave the loading and tramming to the muckers, and this arrangement is followed out.

RAISING.

The raises are put in at irregular intervals. In the Centre Star there are not half a dozen, all told. They usually have two compartments, one a man-way and the other a chute.

TIMBERING.

The square set method has been adopted, and is worked as shown in the sketch The drift A having been driven, the breast stope A–B is then completed to the height of the curve D–E–F. Sills and then square sets, framed on the surface, are put in and floored over by four inch plank. This timbering is shown in detail in the drawing. The drill columns are then set up and stoping is pursued to the curve J.H.G. when the next floor of square set timbers are inserted. Enough space is always first excavated above last floor put in to give room for drilling. The broken rock is taken by wheelbarrows to chutes boxed in among



the sets at 50 foot intervals along the foot wall. The method of timbering a tunnel is shown in the photo of the abandoned Mugwump mine.

BLASTING.

For cleaning out downward drill holes for loading, a straight blow-pipe made of one inch pipe is used. This pipe is connected to the air supply, and thus makes an efficient tool. Powder is kept in a powder house near at hand. A thawing temperature is maintained by hot water pipes heated by a stove in an adjoining cabin. A powder-man watches the powder-house and keeps account of the powder distribution In the mine workings above the lowest tunnel it is, in winter, nearly as cold as on the surface, and the powder, if left long before firing, would soon freeze again.

TRAMMING.

Three types of stations are in use (See drawings of shaft stations). One with a shaft bin; one with a chute which discharges the ore directly into the skip; and one where the cars are dumped directly into the skip. The wooden hopper used in this case usually prevents the rock from falling outside the skip when dumping the car. A lessening of the number of cars required for tramming is one of the benefits gained by the installation of the station bins. This method is

Shaft House Engine House.
Aerial Tramway. Bins.
Air Compressors. Black Bear Tunnel. Boiler House. Ore Cars.

Surface Plant Le Roi.

used altogether at the Le Roi and works very satisfactorily. Here the bins are much larger than those at the Centre Star, the one on the 700 level holding 350 tons of ore. The gates of these bins are worked by compressed air cylinders. By this method the skips can be loaded much faster and less dangerously.

The tracks are 15 lbs. per yard, and are spiked, in the drifts, to ties 2½ feet apart. Various types of switches, in and about the mine, are shown in the sketches.

The mine car in use in the chief mines is 2 ft. 11½ in. from track to top of body, and has a capacity of 16 cubic feet of rock. The turn-table on the truck allows it to be dumped in any direction.

The axles are of the Anaconda type. In this type the axle is divided in the centre, mainly to allow for variation of travel in passing around curves, also to enable the wheels to be pressed separately on

Le Roi Ore Bins.

each half axle. This construction simplifies repairs, does away with nuts and caps on the outside, and necessitates oiling only once in three or four weeks.

HOISTING.

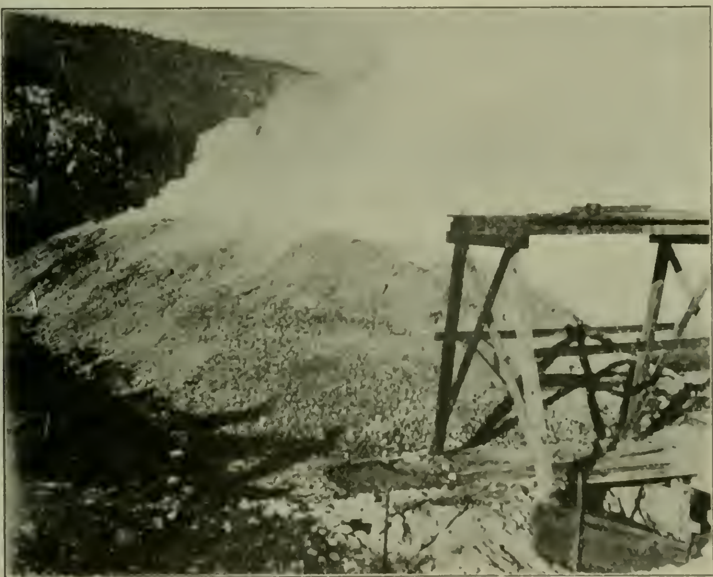
At the Centre Star shaft there is installed a steam hoist made by Webster Camp and Lane, of Akron, Ohio, with two drums, each 6 ft. x 3 ft., with a capacity of 1700 ft. of rope of ⅞ in. diameter. The average winding speed is 800 ft. per minute, with a maximum of 1200 ft. All the motions are controlled by hand levers except the steam drum brake. This consists of a governor which is connected with the shaft. When the wheel goes too fast, the governor allows compressed air to enter a cylinder, which causes a brake to press on the wheel. When the speed passes 900 ft. per minute this mechanism comes into play. The engines are 14 in. x 18 in. stroke, with a Stevenson reversing gear. A Lane friction clutch permits of either drum being run independently of the other; a necessary thing when there are several levels from which hoisting is done. The War Eagle has a duplicate of

War Eagle. Josie. Le Roi.

Looking East from Le Roi Flume.

this engine in its main shaft. The round rope is prevented from cutting the foot wall shaft timbers by rollers on the wall plate at long intervals.

The skip used in the Centre Star and War Eagle Mines is detailed in the drawing, and is also shown in the photo of the Centre Star shaft at the surface. It runs on a 30 lb. per yard steel track spiked to the footwall plates in the shaft. The shaft guides are chiefly for safety purposes, for the skip dogs will grip them in case of accident to the rope. The guides also serve to keep the skip steady, as the skip body is only fastened to the frame on the rear axle. The weight of the skip is 2,400 lbs., and as it carries a load of 4,600 lbs. the total weight of the loaded skip, without the rope, is 7000 lbs. It is proposed to increase the hoisting capacity when it becomes necessary by attaching a cage under the skip. The skips in these mines are equipped with a Humber safety clutch, the working of which is seen on reference to the drawing. The clutch is designed to prevent accident due to overwinding of hoisting rope, which may occur from carelessness of the engineer or derange-



Roast Heap Trail Smelter.

ment of the engine. Without this hook the cage may be drawn up to the head sheave, causing the rope and possibly the sheave to break. Figure 1 of this drawing shows the hook closed at the top, as it would enter the stationery safety-stop when overwinding occurs. Figure 2 illustrates the action. Having, by overwinding the hoisting rope, come in contact with the safety stop, the spreading plates, one of which is shaded in the drawing, close at bottom, causing their upper portions to open like scissors, releasing the rope. At the same moment the plates spreading at the top, drop, and rest on the safety stop, thus suspending the cage until the runaway rope is again attached.

The War Eagle steam hoist replaced a 300-h.p. electric hoist run by the current brought from Bonnington Falls, 30 miles away. The electric hoist was a failure, owing to bad design and faulty construction. A good example, however, to show that an electiic hoist of correct construction will work acceptably, is the one recently installed at the Josie

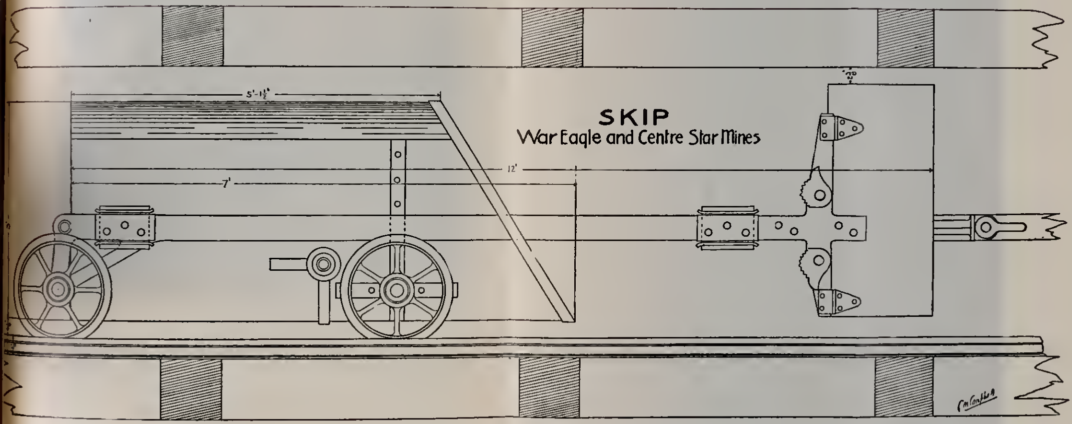
Lumber Yard. Bins. Carpenter Shop. Boiler House. Shaft House. W.E. Tram.

Surface Plant Centre Star.

shaft, made by the Denver Engineering Co. It is a 150-h.p. machine, with an average consumption for counterbalanced hoisting of 60 h p. It works at a potential of 250 volts with a three phase motor ; and has two drums, each holding 1000 feet of rope.

In the Le Roi five compartment shaft two of the compartments are used for hoisting ore. The skips in use are much the same as above described, but as men are not hoisted in them the bonnet has been omitted. Below the surface these two compartments are boarded in. Cages, with two decks, are used for hoisting the men, and these run in

464 a



Illustrating paper by Mr. C. M. Campbell.

two other compartments, the fifth compartment being the ladder way. Before long, cages with three decks will be used. One of these is shown in a photo. It is lying outside the entrance to the Black Bear tunnel, prior to being mounted in shaft. Separate engines are used for

Old Surface Works Centre Star.

the ore and man skips. The hoisting signals are a combination of pull rope and electric bell.

In most of the large mines there is a telephone connection at each level with the surface. This is found to be a very great convenience.

VENTILATION.

This is chiefly natural. In long drifts ventilation is produced by means of a Root blower. This is on the surface, is usually worked by a motor and blows a positive current down a main set in the ladder-way of the shaft. This main is round, of galvanized steel, and is riveted and soldered with telescopic joints Branches of smaller piping are taken off at each level where necessary and led into the working faces.

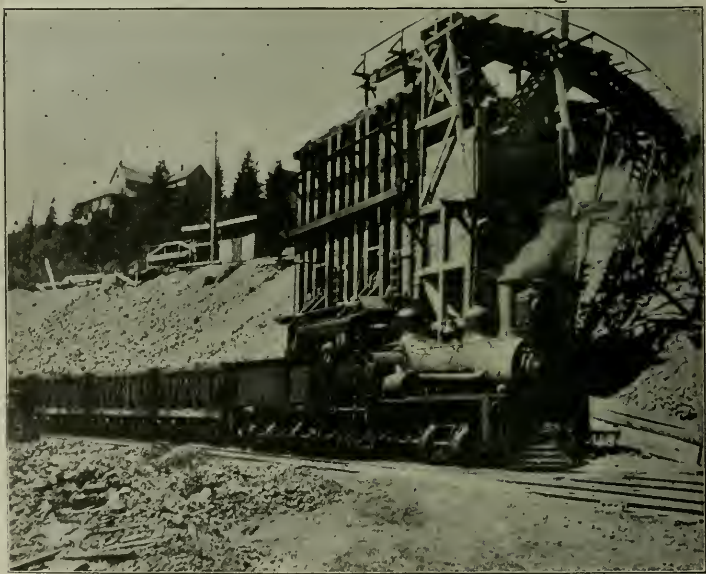
30

PUMPING.

As yet the water encountered in most of the mines is insignificant. In the Centre Star the water which accumulates on the 200 level is run out of the tunnel on this level. The water of the 300 and 400 levels runs into the sump on the 500 level, and from there an overflow pipe takes it to the 600 level, from where it is pumped by a Cameron sinking pump to the 200 and from there runs out the tunnel.

BLACKSMITHING.

There is no hand drilling, except by the timbermen to cut hitches for placing stulls, or by the pipemen when a hole is needed in the



Shay Locomotive at War Eagle Bins.

rock for a hanger to support pipes. The hardness of the rocks renders picks of little use. There remains little to be sharpened but machine bits, which are made by welding a star steel point to an octagon steel shank. Each machine drill uses from 20 to 30 bits in eight hours.

LIGHTING.

Tunnels and stations are lit with 16-candle-power lamps, furnished with horizontal tin reflectors painted white inside. At the working faces candles are used.

HEAD FRAMES.

At the War Eagle is a large structural steel headframe, very expensive, as it was imported from Eastern United States, necessitating

Shaft House. Air Compressor. Iron Mask Gulch.
Nickel Plate Mine.

heavy freightage and duty. Hence the new frames at the Centre Star and Le Roi are built of timber, the native woods being peculiarly adapted for this purpose. In the Centre Star the hoisting engine is set on the hang wall side of the inclined shaft ; this simplifies the head frame, as the posts in the direction of the shaft act as back braces for the frame.

The Le Roi head frame is much larger than either the War Eagle or Centre Star. This is due to the fact that the Le Roi has a larger shaft, and that the building is used for other purposes. The ore from the skip passes over a large grizzly to a large sized Comet crusher. From this it is discharged on an iron travelling picking belt. The useless rock is thrown into the chutes along the side of the belt, while the good ore goes to the bin beside the loading end of the tramway.

SURFACE TRAMS.

To transport the ore from the main shaft to the shipping bins at the railroad, the War Eagle employs a double track gravity tram. This tram is set for nearly its whole length on a trestle, not to save

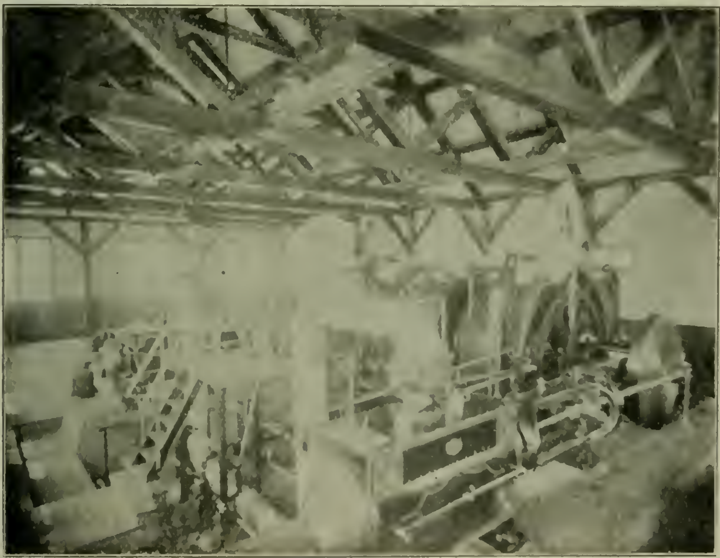
Mugwump Tunnel (abandoned).

grading, but to escape the snowfall. The tram has a fall of 350 feet in a total length of 1300 feet, and in profile has a concave and convex curve. The rope is kept down on the concave side by a pulley in an overhead frame, and kept up on the convex curve by a sheave of 4 ft. diameter set between the tracks. The tram car holds five tons of ore, and is dumped automatically at the lower end of the tram.

This end of the tramway is moveable, and can be so swung that the end is over the bin into which the ore should be dumped.

The tramway at the Le Roi is an aerial one, about 2000 feet long. One man only is employed at the loading end. At the other end the buckets drop their ore into the bins automatically. From the bins the ore runs into the cars below through iron chutes, the gates of which are worked by compressed air cylinders.

In the Centre Star the ore is trammed in the ordinary manner from the bins in the head frame to the bins along the railroad track,

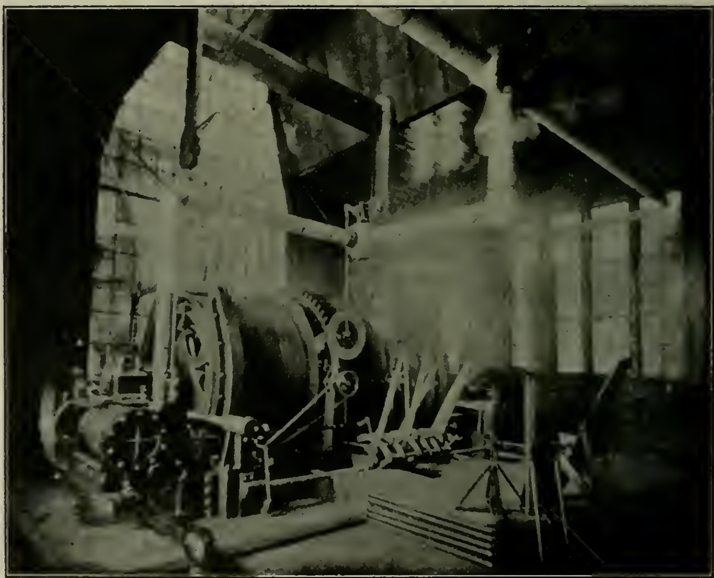


Hoisting Engines, Le Roi.

through a covered double tracked passage way a distance of 200 ft. This arrangement is temporary, as it is expected that a concentrator will be erected in the rear of the present head frame, when other loading arrangements will be made.

THE WAR EAGLE STEAM LINE.

Steam is transmitted through a six inch pipe from the boiler house of the Centre Star up the slope of the hill to the War Eagle shaft house. A section of the wood box enclosing the pipe is shown in a drawing. The pipe is set well above the bottom, to allow for drainage and packing. The packing used is dry coal ashes. When on the surface the box is naked; but for part of its length it lies underground, and is there enclosed in a wooden conduit large enough to permit the



Hoisting Engine, Centre Star.

free entrance of a man. Considerable steam is no doubt wasted in this length of pipe, but it is certainly cheaper than the difficult transportation of coal to a separate boiler plant.

STEAM PIPES IN BLACK BEAR TUNNEL.

In this tunnel two pipes, 8 in. and 6 in. diameter, convey the steam 3000 ft. from the boiler-house to the Le Roi head works above. The temperature of the steam inside is 480°, but the insulation is so good that the outside is only warm. To bring this about several layers of packing were used—first, air cell asbestos covering, with air cells rnnning lengthwise, then ½in. strips of wood set at right angles. This gives an air space of ½in. Then same type of covering as first, except that air cells run around the pipe, and finally, a thorough coat of lime whitewash to close the pores. As expansion and contraction amount to considerable in a pipe line like this, siphon joints are in-

Shaft at Surface, Centre Star.

serted every 200 feet. These are well packed, and will allow a lengthening of 14 in.. though only about one-third of that is ever used.

SURFACE PLANT.

A short description of the Centre Star surface plant might be introduced here. The chief difference between the one at the Centre Star and the one at the Le Roi is that the latter is slightly larger, otherwise they are very similar. As for the War Eagle, most of the surface work required is done in the Centre Star shops.

CARPENTER SHOP.

To the east of the shaft house is the carpenter shop. This building is equipped with a 40-inch swinging cut-off saw, run by a 30 h.p. electric motor placed overhead on the turntable from which the saw hangs. It is arranged to turn by a pinion and gear, and to cut bevels of any angle so that timbers do not need to be moved. A speed of

Shaft at Surface, Le Roi.

1800 revolutions per minute is obtained by using the motor. Below the saw is a roller table which runs to a carriage. This takes the timber past four saws which cut a tenon on each end. This machine is driven off a counter shaft, and will cut up 100 sets of timber per day, the work of 50 carpenters by the old method. Square 10 in. x 10 in. timber is used. Some of it is obtained from Nelson, and some from a mill four miles distant. Wedges are cut from 4 in. plank by a solid-toothed buzz saw 24 in. diameter, running 1800 r.p.m. This saw will cut 2200 wedges in 4½ hours. Formerly $25 per thousand was paid for them. Sixty horse-power is used for the shop. Adjoining is a lumber yard, where a well ordered supply of timber is kept on hand.

MACHINE SHOP.

This building is west of the shaft house, and is equipped with a large planer 29 ft. x 24 in., two large 14 ft. 28 in. lathes, and one of smaller dimensions, a Barnet drill and a radial drill with a 6 ft, arm.

Shaft at Black Bear Tunnel, Le Roi.

A travelling crane of 3 tons capacity commands the shop. The master mechanic's office with a drafting table, and the engine room, adjoin the shop. Partitioned off in another corner is the drill and air hose repair shop. This is also a supply room for drills, bars, and drill parts.

BOILER HOUSE.

Eight boilers are installed here. Four aje of 80 h.p. each, and have separate smoke stacks. The remaining and somewhat larger boilers have a smokestack for each pair. Crow's Nest coal costing $5 per ton is used.

AIR COMPRESSORS.

One end of the boiler house is used for air compressors. Here five compressors of 7 drill capacity each are stored. They were in use before the large new compressor was bought, and are still used in emergencies.

The new compressor is a Rand compound condensing machine. It is a 200 h.p. 40-drill compressor, and can be run either with elec-

Three Deck Cage, Le Roi.

tricity or steam. At present it is run by steam. The air is compressed to 35 lbs. in the low pressure cylinder, passed through an intercooler, and then to the high pressure cylinder, where it is further compressed to 90 lbs. The water from the intercooler is passed over a cooling tower, which consists of a series of horizontal troughs (of wood and galvanized steel) that expose the water in thin sheets for partial evaporation in the atmosphere, by which the residue is cooled. This takes the water at 212° and cools it to 90°. Twenty-five gallons per minute are cooled, and the tower is used on account of the scarcity of water.

LE ROI WATER SUPPLY.

The Le Roi Company have a supply of their own. The east fork of Little Sheep Creek has been inverted near the Jumbo Mine by

Picking Belt, Le Roi.

means of a dam and flume, and the water thus taken to the mine is used for the required purposes and then turned into Trail Creek at its head quarters on the Black Bear mineral claim.

DRY ROOMS.

Here the men change their clothes before going in, and when coming out of, the mine. In the Centre Star dry room the trough containing the washing water has a steam pipe running along the bottom. Apertures in this allow the steam to escape and warm the water.

The Le Roi building is somewhat more pretentious. Hot water is supplied in large quantity, and each man can have a wash basin of of his own. The room has a cement floor, and a small stream of water runs along a trough in the floor, carrying off all impurities. Each pair of men can have an apartment to themselves.

BUILDINGS.

The head offices and other buildings of the mining companies are very tastefully built and are surrounded by well kept gronnds. This

Mt. Roberts. Le Roi Flume.

is rather the exception in mining camps, and deserves favorable comment.

WORKING COSTS.

The War Eagle and Centre Star issue a detailed report annually to their shareholders. In this report are shown the general financial balance sheets, the condition of the mine as to ore reserves, and the itemized cost of each branch of work. From the report of 1899 we learn that during the year the total cost of mining per ton of ore stoped was $5.86. To this must be added the transportation charges to the different smelters and the cost of smelting, bringing the total cost up to nearly $11.00.

The Le Roi ore is smelted at their own smelter at Northport. The rest of the Rossland ore goes to Trail, where it is roasted before

Dry Room, Le Roi.

being treated in the furnaces. The grade to Trail is very steep, and a specially constructed and very powerful stay locomotive is used on the route.

OUPUT OF THE MINES.

For the six months ending June 30 the output has been as follows:

January–June,	1897	30,008 tons
"	1898	39,395 "
"	1899	66,576 "
"	1900	72,080 "
"	1901	204,500 "

The output for the first six months of 1901 was divided as follows:

Le Roi	104,298
Le Roi No. 2	20,270
Centre Star	51,918
War Eagle	19,050
Great Western	8,058
Iron Mask	2,233
I.X.L	189
Monte Cristo	20
Spitzee	80
Velvet	586
Evening Star	74

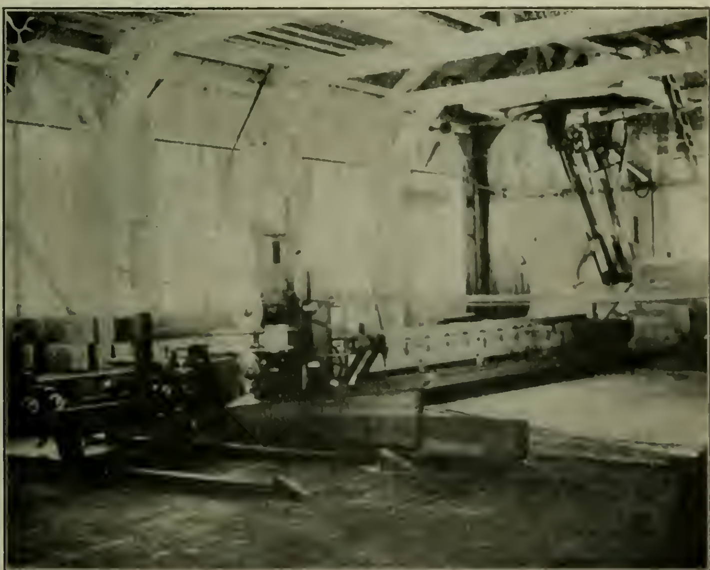
LABOR CONDITIONS.

Rossland is a union town, the local miners' union being a branch of the Western Federation of Miners. The scale of wages for the leading positions has been :

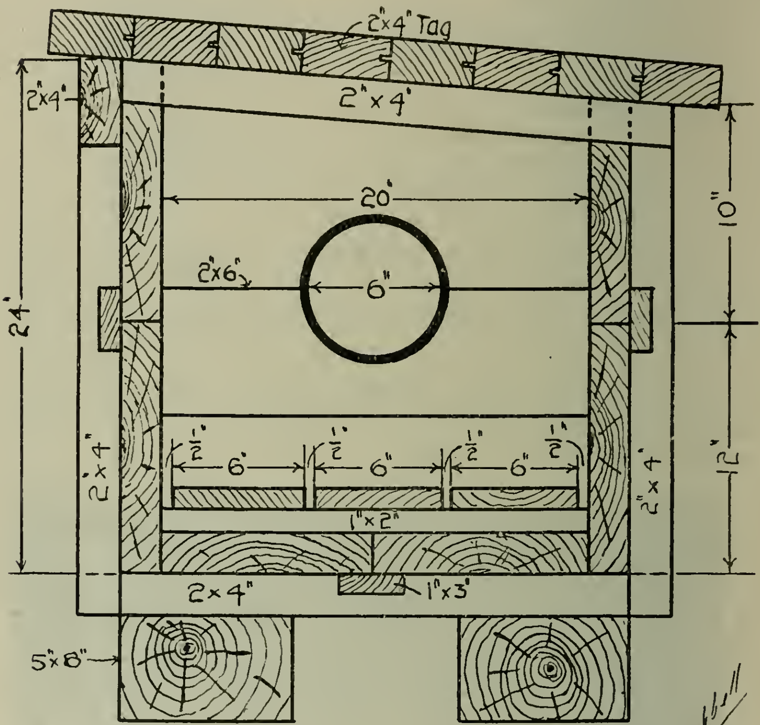
Dry Room, Centre Star.

Shift boss	$5.00
Shaft men	$4.00
Machine men	$3.50
Timber men	$3.00 to $3.50
Shovellers and car men	$2.50
Carpenters	$3.50
Machinists	$4.00
Blacksmiths	$4.00
Blacksmiths' helpers	$3.00
Hoisting Engineers	$3.00 to $4.00
Powder and tool boys	$2.50
Surface laborers	$2.50

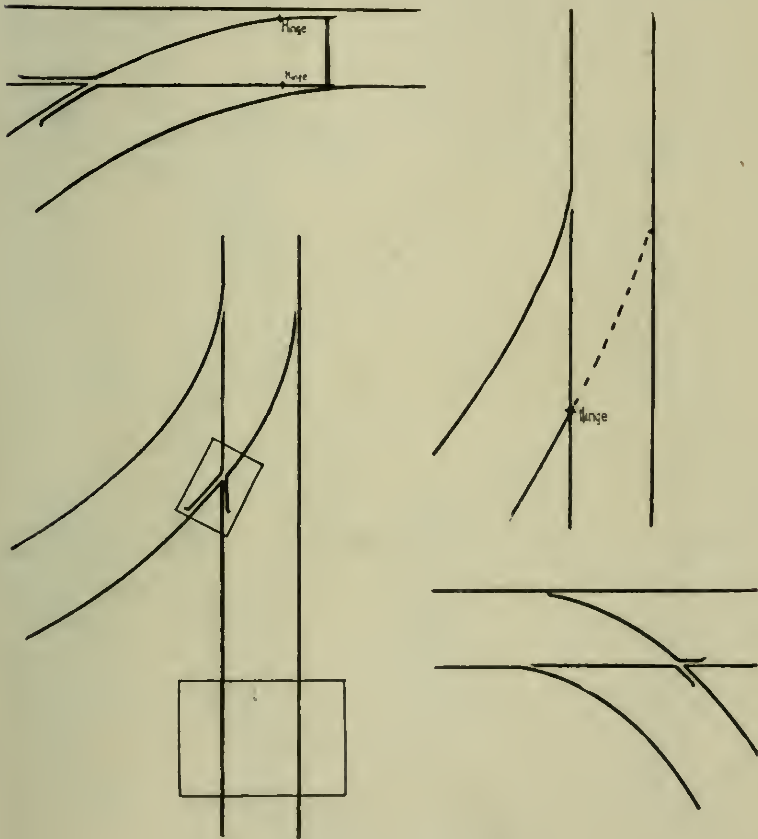
Machine men, however, usually work by contract, and are paid according to the total length of holes drilled. Contracts are verbal. Parties are fixed and contracts let at the beginning of each month. The men are provided with a box of tools and a two compartment box for dull and sharp steel. Better wages are usually made by this method, the average being from $4.00 to $4.25. In most cases it is more satisfactory to the employer.



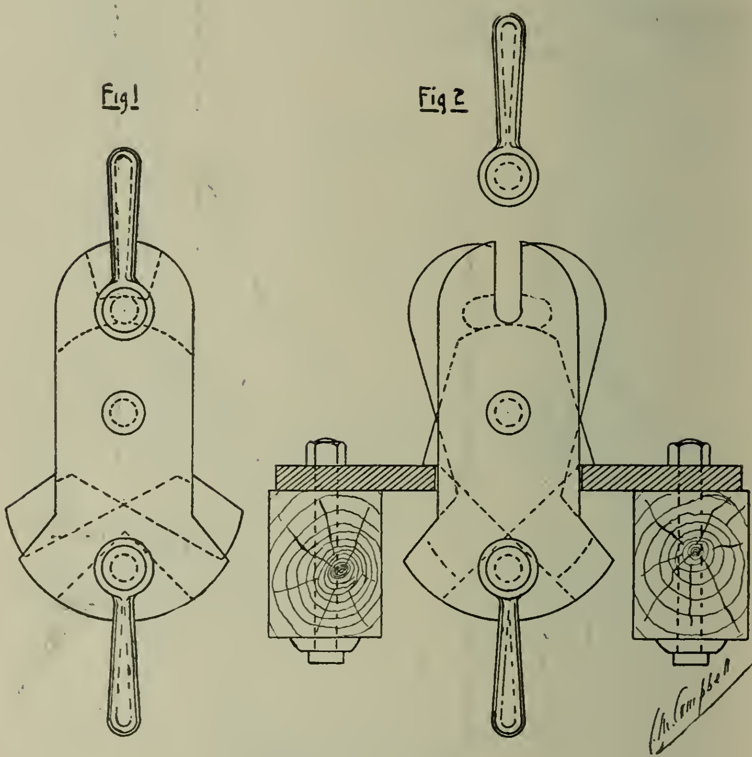
Carpenter Shop, Centre Star.



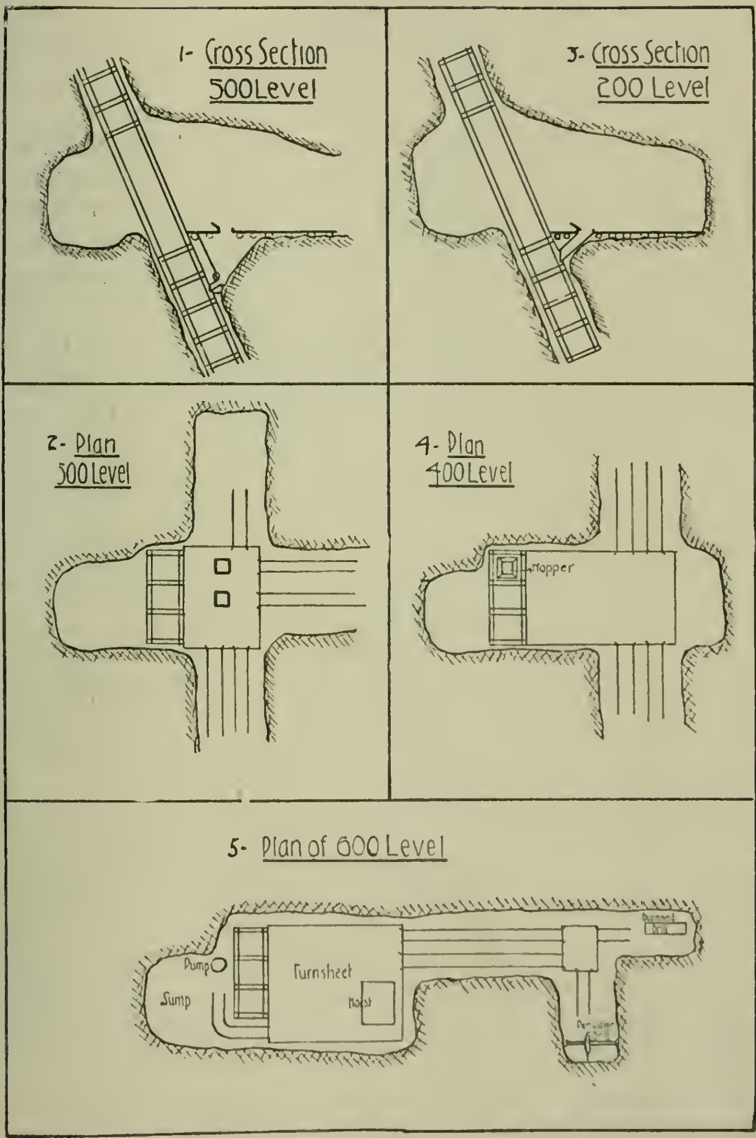
Cross Section of
Wood Box
enclosing
Steam Pipe
from Centre Star to War Eagle Mine



Mine Roads and Tracks



SAFETY HOOK



Stations in Centre Star Mine

Power Drills.

By Mr. C. C. Hansen, Montreal.

In opening this discussion about power drills I will, with your permission, give a short description of a few of the better known types.

We find in all cases that the power drill consists of the following parts: The cylinder, piston, rotating mechanism, and valve. These constitute the working parts of the drill, and are mounted in a frame or shell, provided with means for feeding it ahead as the drilling progresses.

For work on the surface, the drill is usually supported on a tripod, which is placed over the spot where the hole is to be drilled, and when the desired depth is reached the whole apparatus is moved to the next place, usually a few feet distant. For underground work, such as shaft sinking or drifting, a column or bar is used, as several holes can be drilled from the same position of the bar, and a tripod is difficult to handle under ground where the room is confined. The drill is fastened to the mounting or support in such a way that nearly all the space can be reached and the holes drilled in any desired direction.

In the end of the piston that extends outside the cylinder, provision is made for fastening a drill steel or bit, which must be changed for an average size drill say every two feet in depth, which is the extent of the feed, or oftener, according to the time it takes to wear of the cutting edges on the drill steel.

The work of a power drill consists in the piston travelling forward and backward in the cylinder, actuated by the pressure from steam or air, according to what is available. The number of double strokes or blows will vary between 250 to 500 per minute. The forward stroke against the rack is uncushioned, that is, the drill steel fastened in the piston must take the full force of the blow, but the force of the backward stroke is taken up in a cushion by admitting the pressure into the back end of the cylinder before the backward stroke is completed. The work of the piston is controlled by the valve mechanism, which alternately admits the pressure at the top and exhausts it at the bottom.

In this valve mechanism, or the means for controlling the forward

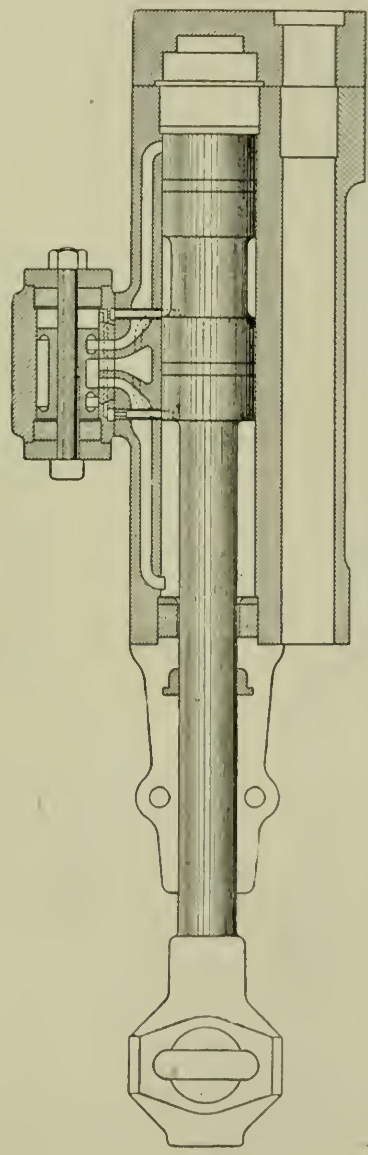


Fig. 1.

and backward strokes of the piston, we find the greatest difference in the various types of power drills, which I will show you later.

An important feature of the power drills is the rotating of the piston during the work. If the position of the drill steel remained the same during a number of blows, the consequence would be that the steel would wedge fast in a very short time, the hole would not be round, but the shape of the bit, and power wasted. It is therefore necessary to rotate the bit a small part of the circle between each blow. This is accomplished by boring out the back end of the piston to give room for a " rifle bar," which is part of the rotating mechanism. The usual thing is to place a ratchet ring in the back end of the cylinder, supported between washers, the one on the inside having a hole in the centre for the rifle bar to pass through. In the inside circumference of this ratchet ring are a number of teeth or ratchets. The head of the rifle bar contains two or more pawls that will engage the teeth or ratchet in the ring, when the rifle bar is turned in one direction, but pass over the ratchets when turned in the opposite direction. Each rifle on the bar is a screw-thread that will make a revolution in about 60″ and the bar contains, usually, five or more rifles In the end of the piston is placed a nut that fits the rifles in the bar. This mechanism is so arranged that on the forward stroke the pawls will pass over the ratchets, and allow the rifle bar to turn, but on the backward stroke the pawls will hold the rifle bar fast and the piston will turn a small part of a circle. As the stroke of an average size drill is about 6½″, the piston will describe a revolution in about nine strokes, so that the force of the blow is fairly well distributed over the bottom of the hole.

Fig. 1.—This sketch shows one type of power drill in which the valve is operated by the reduced part of the piston proper, alternately covering and uncovering two parts connected with the respective end of the valve chest. The position of the valve is for admitting pressure to the back end of the piston for the forward stroke. The space between the cylinder and the reduced part of the piston is always in connection with the atmosphere through ports leading to the exhaust. As the piston travels forward until this port is covered, all the pressure on this side of the valve will be exhausted and the small amount of pressure

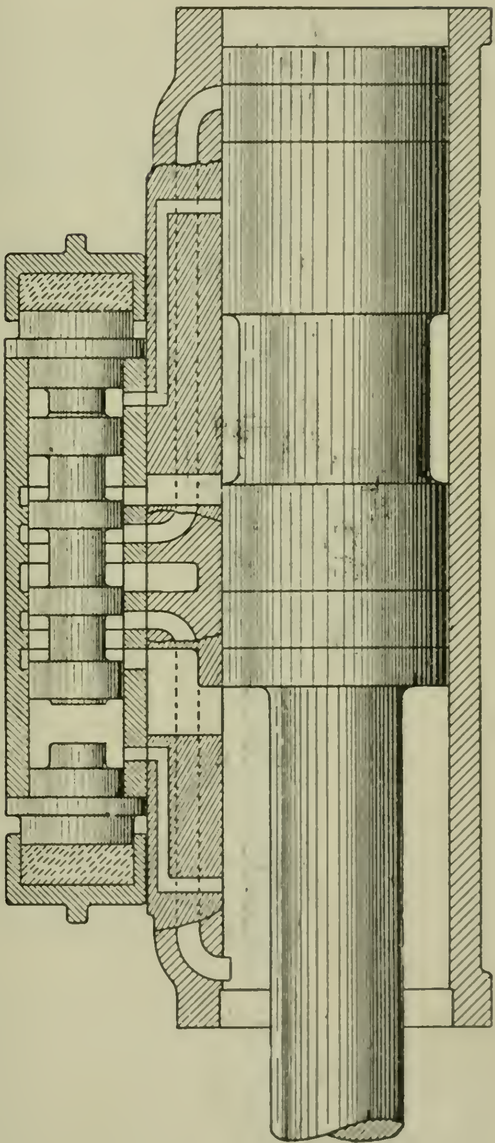


Fig. 2.

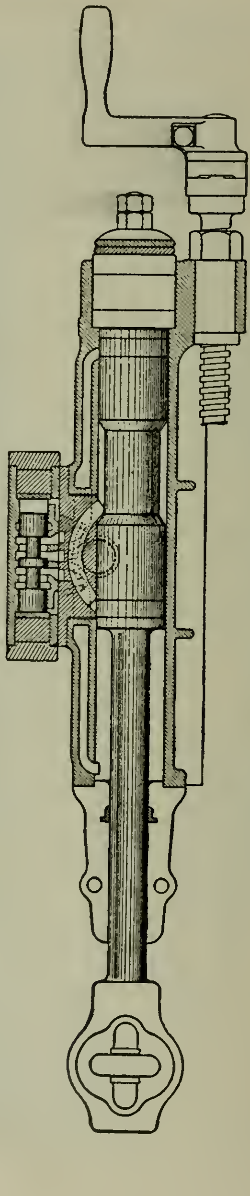


Fig. 3.

that will pass by the solid part of the valve is sufficient to hold it in place, as the piston travels farther on the forward stroke the port connected with the back end of the valve will be opened to the atmosphere and the pressure on this side exhausted, which will shift the valve to the opposite position from that shown.

Here you see the cylinder which contains the ports to each end of the valve chest, the piston, consisting of the piston proper, the piston rod or shank and the chuck for clamping the drill steel. The rotating mechanism and the valve and chest.

Fig. 2.—This sketch shows another type also operated by a floating valve which is again actuated by small ports covered and uncovered by the reduced part of the piston. This sketch shows the cylinder, valve mechanism and part of piston only.

Fig. 3.—This sketch shows some departure from the previous described types in regard to the valve. We find still the floating valve controlling the piston, but this valve is actuated by an auxiliary valve, which is again operated by the piston. This auxiliary valve is really nothing else but a slide valve, which alternately admits and exhausts the pressure at the respective ends of the floating valve with which it is connected by means of small ports. The auxiliary valve is made in the shape of an arc of a circle, and is moved by the reduced part of the piston. The space between the reduced part of the piston and the cylinder walls is filled with pressure and not, as in the previous cases, open to the exhaust.

Fig. 4.—Here the result has been accomplished in a different way. The valve is a plain D slide valve, which is operated by a tappet or rocker supported on a pin that passes through the cylinder wall. The high parts of the piston will strike one or the other of the two arms and allow the other to go down in the reduced space of the piston, and the third arm will move the valve.

Fig. 5.—Here we find another "tappet" only much the same as the one previously described. The valve, you will notice, is part of an arc on the face, with the pin supporting the tappet for centre.

The amount of work done by a power drill is usually measured in lineal feet of hole drilled in a given time. This again depends on the

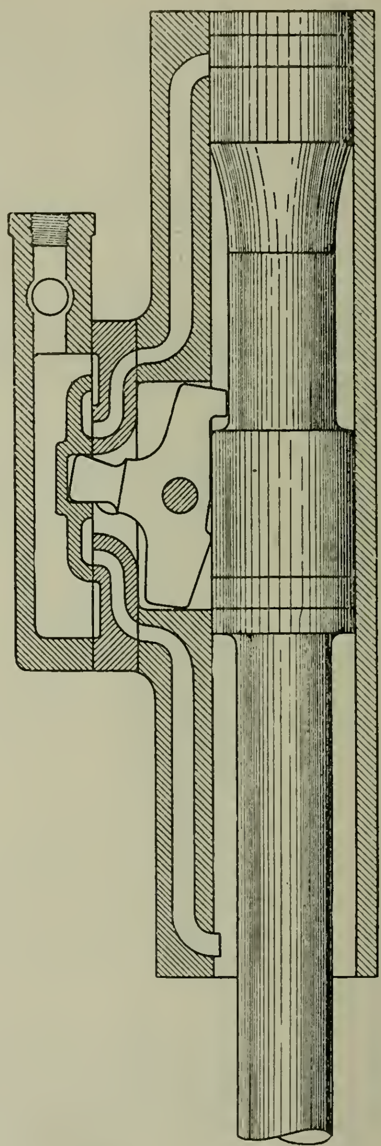


Fig. 4.

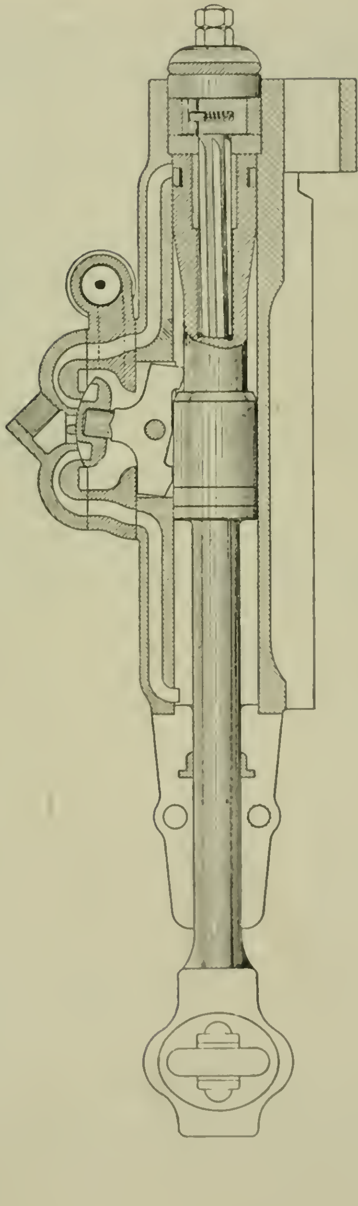


Fig. 5.

kind of rock, the depth to which the holes are drilled, troubles that may be caused from seamy rock, when it is difficult to keep the hole straight, and last, but not least, the drill runner. Comparison is, therefore, difficult if not impossible. I know cases where twenty lineal feet drilled in eight hours would be considered good work, and other cases where from three to four times this amount would only be considered fair.

In some of the Western mining camps drilling matches are held, usually on the Fourth of July and Labor Day, the manager putting up a prize for the winner. It is useful in more ways than one, because it gives an idea of what a man can do, and has a tendency to keep up a spirit of competition between the men, for it is considered quite an honor to be the best drill runner in the camp. The drill runner is no doubt a very important factor in the amount of work that can be done with a power drill, for experience counts here as well as in most other things, but, as stated, the condition of the rock and work has a large influence. From my experience I should say that from twenty to eighty lineal feet may be drilled in a day. Sometimes this is exceeded, as proved by an instance where one man and a helper drilled 218 feet in a little over nine hours. This was done with a 3½ inch drill mounted on tripod and in an open cut.

The Ore Deposits of Copper Mountain, Similkameen District, B.C.

By O. N. SCOTT, School of Mining, Kingston, Ont.

LOCATION.

Copper Mountain is about 13 miles south of Princeton on the east side of the Similkameen River, in the Similkameen sub-mining district, which embraces the great south-eastern portion of the Yale District, B.C., and is drained by the Similkameen River and its tributaries.

This district contains many large deposits of low grade copper ores, some of which have been prospected considerably, but lack of transportation facilities has hindered that development which would be necessary to determine more exactly the value and extent of these deposits.

However, on Copper Mountain are to be found large surface outcrops of copper ore, and on the deposits development work has been carried on, to a limited extent, but yet more than in any other part of the district.

It is to the description and characteristics of the ore deposits of Copper Mountain (on the Sunset and H.H. Gardner mines) that I wish to draw the attention of the members of the Institute, from observations made by myself in July of last summer.

GEOLOGY OF COPPER MOUNTAIN.

Copper Mountain rises abruptly from the Similkameen valley to a height of about 2000′ or 2300′ above the valley, and covers several square miles.

It consists chiefly of masses of volcanic rocks, which probably are pre-tertiary, although in altitude they are found above the tertiary coal seams in the valley bottom.

The explanation of this is that these tertiary rocks occupy an original depression in which they have been protected from denundation by the surrounding more resistant rocks. They probably form part of a series which once covered the whole surface of the country, but which, owing to denundation, now appear merely as isolated remnants, resting on the older rocks.

These are comparable to the tertiary of the Kamloops district, described by Dr. Dawson,* and the tertiary outlines of the Kettle River, mentioned by Mr. R. W. Brock in the summary report of the Geological Survey in 1900.

On the accompanying diagram "A" I have sketched part of the volcanic areas which are associated with the ore bodies of the "Sunset," "Helen H. Gardner," "Sunrise," and other properties lying on the summit and western slope of the mountain ; a cross section of same is shown in "B."

The green colored band (No. 2) is an area of basic volcanic rock, greenish in color, and of fine texture.

Its analysis is given in "B."

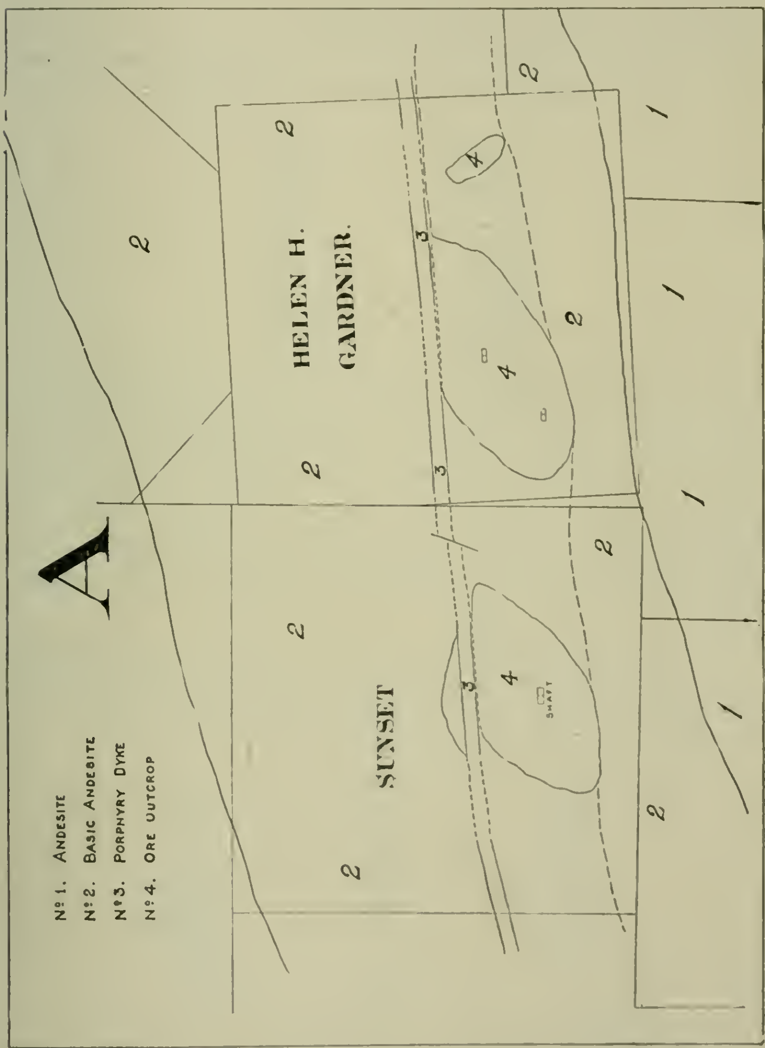
	B	C	D
Locality	Copper Mt.	Japan.	Nevada.
SiO_2	50.48	50.87	50.38
Al_2O_3	13.92	21.98	19.83
Fe_2O_3	15.04	10.94	8.05
MnO_2	.0088	1.45	.....
CaO	11.28	9.12	10.33
MgO	4.083	1.38	5.36
K_2O	.0355	.02	1.76
Na_2O	3.611	2.85	2.15
S	1.1083	.....	.....
	99.5666		
Sp. Gr.	2.8571		

Under the microscrope a thin section showed it to be considerably altered and decomposed, but consisting of plagioclase feldspar, augite, and biotite.

It also shows a microscopic brecciated structure. According to its analysis, chemical and microscopic, I have classed it as a "basic andesite," although on account of its age, following the German petrographers, we might speak of it as a "porphyrite."

In comparison with an audite andesite (C) from Japan mentioned by Rosenbusch, it shows a striking similarity in chemical composition when we group the ferro-magnesian constituents and silica content.

* Geological Survey Report, 1894, part B.


A
No. 1. Andesite
No. 2. Basic Andesite
No. 3. Porphyry Dyke
No. 4. Ore Outcrop
HELEN H. GARDNER.
SUNSET
SHAFT

This basic andesite shows in chemical analysis a similarity to the basalt of Richmond Mt., Eureka district, Nevada, given under "D," described in Kemp's "Handbook of Rocks."

The part colored in brown, No. 1, represents the area of fine-grained greyish-looking rock of the following composition : —

A—

SiO_2	52.33
Al_2O_3	18.80
Fe_2O_3	10.21
MnO_2	none
CaO	8.22
MgO	4.189
K_2O	3.62
Na_2O	3.842
Total	101.211

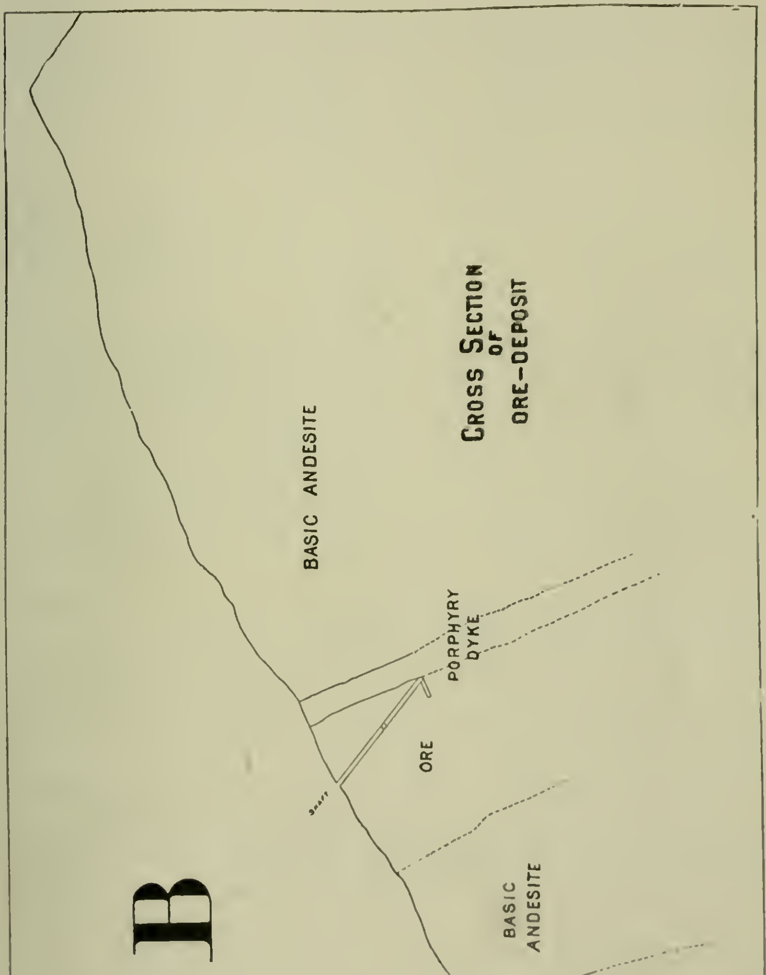
A thin section under the microscope shows its chief constituents to be plagioclase feldspar, also smaller quantities of orthoclase feldspar with crystals of augite and biotite. The constituents are well crystallized and do not show alteration or decomposition. I have classed this as an "augite andesite" according to the above microscopic and chemical analysis. This andesite is evidently a later intrusion in the "Basic Andesite," since a well-defined "Salband" occurs along the contact.

The pink colored parts, No. 3, represent a series of quartz porphyry and porphyry dykes that strike in an easterly and westerly direction, cutting through the basic andesite and dipping into the mountain.

The analysis of two samples ran :—

	E	F
SiO_2	72.5	71.65
Al_2O_3	11.51	14.10
Fe_2O_3	5.25	4.42
CaO	.44	.51
MgO	traces	traces
K_2O	5.252	4.542
Na_2O	6.012	6.644
MnO_2	.....	traces
	101.03	101.866
Sp. Gr.	2.571	2.510

Under the microscope, a thin section of this porphyry shows quartz of distinct crystal outline, in a ground-mass of orthoclase feldspar.


B
CROSS SECTION
OF
ORE-DEPOSIT
BASIC ANDESITE
PORPHYRY
DYKE
ORE
BASIC
ANDESITE
ANDESITE

The quartz porphyry is of fine texture, and is a hard brittle rock.

"F" is an analysis of a porphyry outcrop in the "Helen H. Gardner," not showing similar characteristics in hand specimens—that is, absence of quartz crystals—but the chemical analysis is close to "E." It is therefore probable that it belongs to the same dyke or series of faulted dykes as that which occurs on the Sunset property.

THE ORE BODY.

The ore body on the "Sunset" and "Helen H. Gardner," which are adjoining claims, is roughly defined on the north by this quartz porphyry dyke, which has a width of about 75 feet, and forms the hanging wall. Contiguous to the dyke is the copper ore, not occurring in a well-defined vein, but in the form of bornite and chalcopyrite, impregnated and disseminated through the basic andesite, forming a large deposit that can be traced in an easterly and westerly direction for over 3000′, and varying in width from 50′ up to 250′.

This mineralization of the basic andesite with copper pyrites extends from the dyke outwards, becoming less and less mineralized till the ore gradually gives way to country rock.

This country rock (the altered basic andesite), forms a contact with the coarser grained andesite on the south.

The ore from this deposit is most interesting in its character. In appearance it resembles closely the barren basic andesite, with the exception that it is cupriferous.

The bornite and copper pyrites are at times disseminated through the gangue (basic andesite) in small veins or veinlets, which look like a highly shattered mass cemented together with copper pyrites. These veinlets are quite irregular in their course, in fact, crossing and recrossing each other in intricate confusion, forming enrichments at contacts and again widening out into seams ranging from a fraction of an inch up to 6″ or 7″ in width, of solid bornite and copper pyrites

Associated with the sulphides of copper is calcite, as a gangue in filaments along the facets or again forming considerable seams. Very often the calcite and sulphides are intimately mixed.

By analysis I found an average sample of the ore to contain :—

G—

Cu	4.66
Au	20c. to $1.50 per ton
Ag	traces
SiO_2	42.25
Al_2O_3	9.26
Fe_2O_3	9.37
$CaCO_3$	34.74
S	1.65
	101.93
Sp. Gr.	3.0

ORIGIN OF DEPOSIT.

On a careful examination of the many hand specimens which were selected from different parts of the ore belt, one is impressed with the fact that the characteristic feature of the copper is its occurrence in small veinlets and seams through the gangue (basic andesite).

Under the hammer specimens would invariably break along these vein fractures.

That occurrence suggested to my mind that the ore deposit was of aqueous origin.

These fissures and cross-fissures would serve as channels for ascending copper-bearing solutions, which, it would seem, deposited their metallic contents in these veins.

Under the action of circulating water, the veins have been widened and adjacent country rock replaced with copper sulphides, by metasomatic action.

It is reasonable to suppose that a basic rock would undego decomposition under the influence of ascending mineral waters under pressure and probably containing CO_2, which would accelerate its solvent power.

In comparing the chemical analysis of the ore (G) to the basic andesite (B) it will be observed that the ore shows much lower percentages of ferro-magnesian and SiO_2 constituents and total absence of alkalies than the basic andesite, indicating that the augite and feldspars have yielded to a solvent.

Also under the microscope a thin section of the mineralized country rock showed the feldspar kaolinized and in places surrounding crystals of pyrites. Also, the ferro-magnesian mineral augite had undergone decomposition and was replaced in part by crystals of pyrite; thus the microscopic and chemical analyses prove directly the replacement of the feldspar by the pyrite.

Again, the fact that calcite occurs as a gangue in these fissures in connection with the copper sulphides would indicate deposition from solution.

If we seek for an explanation of the genesis of the deposit in an igneous theory, it must be explained why the sulphides are not more or less evenly disseminated through a gangue or segregated in solid masses; whereas quite the reverse is a case for Copper Mountain ores.

Here the bornite and chalcopyrite are deposited chiefly along fissure lines, leaving the country rock quite recognizable.

The origin of the mineral contents of the deposit was not local, that is, the material was not brought in and deposited by "lateral secretions," because the analyses show there is no concentration of the iron from the surrounding rocks, and that these rocks have not been leached, so that the material must have come from depth.

Referring to the accompanying sketch, you will notice that I have indicated the quartz porphyry dykes in pink color.

These dykes follow the general course of the ore bodies, that is, east and west, and usually form the hanging wall, although one case was found where ore occurred on both sides of the dyke.

In these rugged mountainous regions, where the process of tilting and folding has been active, eruptive dykes have caused further rupturing and fissuring of the country rock, which probably may have been accelerated later by earthquakes, etc., etc., so that I attribute the formation of the intricate fissuring which extends from the dykes outward into the country rock to the forcing of the quartz porphyry through the basic andesite. At least the later fine fissuring was due to this.

I shall further try to show that the porphyry dykes have a relation to the ore deposit, a relation which is chiefly mechanical and not chemical.

The chemical analysis of two specimens shows them to be highly siliceous rocks, so that they would be highly insoluble compared to the contiguous basic andesite.

A thin section under the microscope showed that its constituents were not altered or decomposed, indicating also its impermeability to circulating solutions. Therefore, these fine-grained acidic eruptives were impervious to ascending solutions, but acted as a barrier to horizontal circulation and directed the course of mineral-bearing solutions upward along the lines of dislocation and fissures.

In that way the permeable basic andesite was brought under the influence of ascending mineral solutions, which, by their dissolving power, would readily attack the feldspar and ferro-magnesian constituents of basic rocks, enlarging the already existing fissures in such lines of decision and depositing their metallic contents.

The augite andesite (No. 1) does not show mineralization on account of its compactness, lack of fissures, and absence of porphyry dykes.

In the Similkameen district quartz porphyry dykes should cause the prospector to thoroughly examine the contiguous rock for ore deposits or indications of such.

In the Boundary country, 150 miles east, I have noticed somewhat similar acidic dyke rock in the B.C. mine (Summit Camp) in contact with the rich Cu. sulphide ores, also at the "Rathmullen" and "Blue Bird" mines in the same camp, so that the relationship of the dyke to the ore bodies in the Similkameen may be applicable to the low grade deposits of the Boundary country, which may also owe their genesis to ascending mineral solutions.

If the genesis of the ore is attributed to ascending solutions, their source must have been deep-seated, hence a favourable indication of the continuance of the ore in depth.

SURFACE INDICATIONS.

Copper Mountain ore deposits are generally covered or partly covered with "detritus" or wash, and since the copper ore does not contain a high percentage of iron, heavy gossans (or insol. iron oxides) do not occur to indicate bodies of sulphides below.

Ar the surface of the "Sunset," "Helen H. Gardner," "Sunrise," and other Copper Mountain ore deposits, the soluble copper content has been leached out by surface waters, aided by the oxidizing action of the atmosphere changing the upper part of the deposit to a barren or lean copper ore, and in the lower regions forming enrichments.

In the upper parts of the deposits carbonates of copper form blue and green stains in the rock, the well-known surface indications of copper ores, although when no wash covers the outcrop very little carbonate stain may be left owing to its contact with the rains and atmospheric agencies.

MINING AND TREATMENT.

The Copper Mountain ores are of a type common to the whole district. The large deposits of low grade copper ore, averaging from two and a half to seven per cent. Cu, and small amounts of Au and Ag, which vary in width from 40′ to 250′ and, showing good indications of permanency in depth, are comparable to the Boundary district ores.

In the Boundary some of the large deposits are quarried, giving a large production at a low cost per ton. Copper Mountain deposits, lying on a sloping mountain side, would afford favourable conditions to cheap mining by a system of quarrying.

The Boundary ores are self fluxing and smelted at a low cost. Copper Mountain ores should offer no great difficulty in being smelted at as low, or nearly as low a figure as these. The aluminium contact is somewhat high, but not high enough to cause serious trouble in the furnace.

Within the last month, reports have come from Princeton of the discovery of a 10′ bed of bituminous coal, which is said to be of a good coking quality. It is less than ten miles from Copper Mountain ores, and should furnish a cheap fuel for the smelting of ores of the whole district.

Therefore, under competent management, and a careful development of the deposits, together with a local supply of fuel, these ore bodies bid to become valuable copper producers in the near future.

Notes on the Geology and a Few Ore Deposits of South Eastern British Columbia.

By C. V. Corless, McGill.

PREFACE.

The underlying idea of the following notes, which at first sight appear to be perfectly disconnected, is, that the ore bodies treated of form part of a related group, suggesting that, probably, veins formed in a similar way over a still wider area may be similarly related, owing to the derivation of their metals, mainly, if not altogether, from the deeper part of the zone of rock fracture, and from igneous masses intruding into this zone. Should veins so formed be found generally thus related, particularly where, as in the present instance, the surface geological conditions are very diverse, it would furnish strong evidence in favor of considerable depth of origin of the metals carried by mineralizing solutions.

While the data collected are much too insufficient to prove the truth of any hypothesis, it is felt that such evidence as they furnish at least points towards this explanation.

To complete the present notes, some special deposits of Ainsworth and Goat River mining divisions should be described, but as no mine was visited in either, the former is passed over by a few general remarks, while the latter is not mentioned.

The notes on the ore deposits were made during the mining tour of the McGill Summer School for 1901. The notes on the geology were gleaned from the various sources given, and while they are a mere repetition of facts generally known or easily obtainable, the rude outline of the geology of the district was felt to be of too great importance in relation to the ore deposits to permit of its omission.

The provincial reports for 1897, 1899, and 1900 have been freely consulted for confirmation of observations and for additional details in the case of certain deposits. Also current mining magazines have been appealed to, where articles were available, for additional confirmation and for an occasional detail.

While considerable care has been exercised in compiling the notes, nevertheless, that errors should creep in, in so hasty a visit to each mine, seems unavoidable. It is hoped, however, that such will prove to be few.

Thanks are due to the several mine managers and superintendents for their great courtesy and kindness in granting permission to the class to examine the several deposits as well as the surface plants, and for valuable information, which was very freely given; they are due also to Dr. Porter, under whose guidance the mines were visited, and to Dr. Adams for many valuable suggestions, and for kindly checking the notes on certain of the mines.

Professor Kemp's work on the "Ore Deposits of the United States and Canada" was freely consulted in drawing comparisons between this group and certain others in the Rocky Mountain region.

C. V. CORLESS.

SUMMARY.

I. Introduction and Description of District.

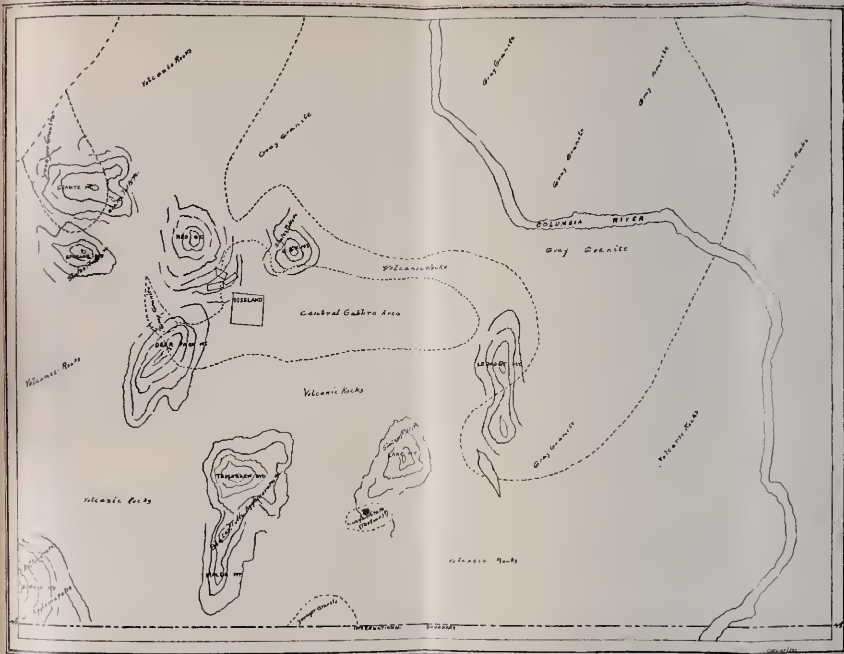
II. General Geography of the District.

III. General Geology of the District—
- (a) Sedimentary rocks.
- (b) Igneous rocks.

IV. Ore Deposits—

Classification—
- (A) Silver-lead deposits.
  - Ex. 1. The Slocan Star vein.
  - Ex. 2. The St. Eugene.
  - Ex. 3. The North Star.
  - General notes on silver-lead deposits.
- (B) Gold-bearing copper deposits.
  1. Of the Boundary.
     - (a) Local geology.
     - (b) The ore-bodies.
     - Ex. 4. The Mother Lode.
     - Ex. 5. Knob Hill and Old Ironsides.
  2. Of Rossland district.
     - (a) Local geology.
     - (b) Ex. 6. The Rossland ore bodies.
     - General notes on gold-copper deposits.
- (C) Free-milling deposits of Nelson, M.D.
  - Ex. 7. Ymir.

V. Conclusion.



GEOLOGY
of
ROSSLAND DISTRICT
Scale 1 mile to inch

Plane Survey by Mr. McConnell, B.A.

Plate illustrating paper by Mr. C. V. Corless.

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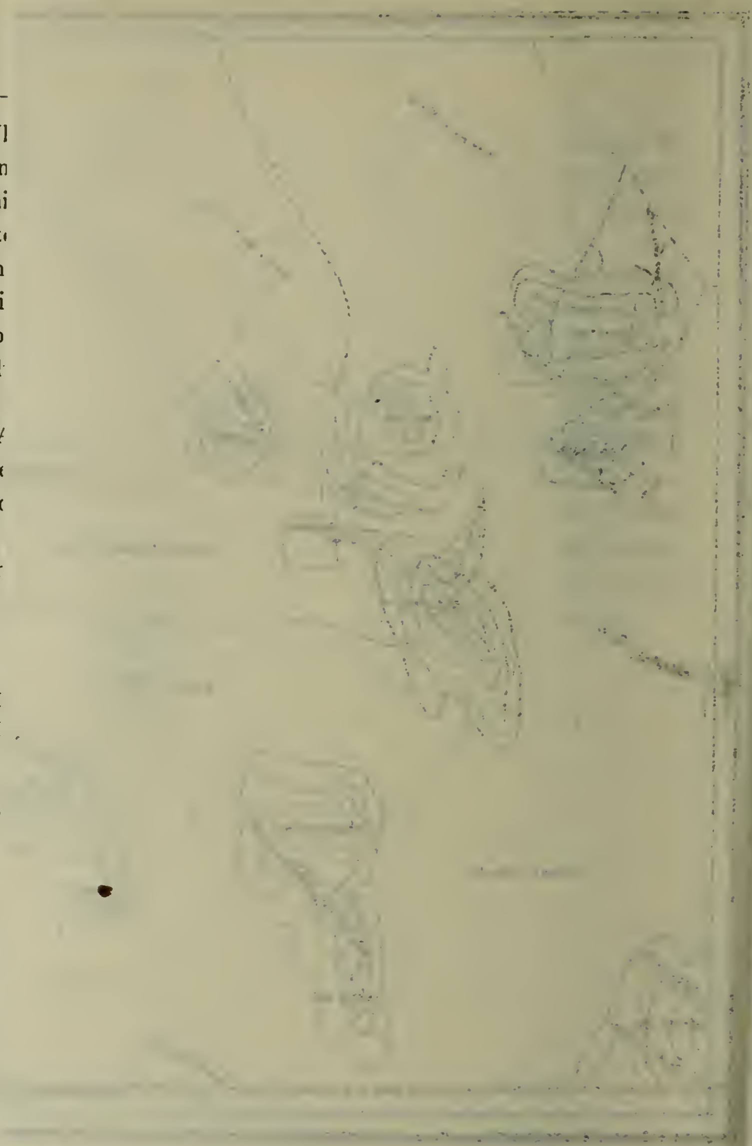


I.
II
II

IV

V

INTRODUCTION.

In that part of the basin of the Columbia River which lies between the forty-ninth parallel of latitude and the Canadian Pacific Railway, important developments in mining have been made in recent years. Here have been discovered a number of remarkable ore deposits, the development of which is making south eastern British Columbia famous as a mining district. To the west, in the drainage area of the Kettle river, are found the deposits of the "Boundary Country," now attracting so much attention. Next east lies Trail, with Rossland as a centre, these two districts being remarkable for their large deposits of low-grade auriferous copper ore. Eastward again, is Nelson district, with its well-known free-milling gold and silver-bearing deposits, while to the north and east are found the argentiferous galena ores of the Slocan, Ainsworth, and Fort Steele mining divisions. Lying in the last mentioned mining division, and of very great importance to the development of the smelting propositions, are the practically inexhaustible Crow's Nest coal seams.

It is the purpose of the present paper to present some brief notes on the geology and a few of the ore deposits of the region roughly outlined above.

GENERAL GEOGRAPHY.

This region is very mountainous and rugged. The Upper Columbia and its tributary, the Kootenay, into which flows the Slocan, have their courses largely formed by long and relatively narrow lakes, which, being navigable, have greatly aided in the development of the mines in this otherwise difficultly accessible district. The Kootenay drains the Kootenay and Upper Kootenay lakes; the Slocan rises in Slocan lake, lying to the west; the Columbia widens out into the Upper and Lower Arrow lakes, west of this; while, to the west again, the Kettle river, a western tributary of the Columbia, receives the waters of Christina lake.

All these, as shown by the accompanying sketch map, lie mainly in north and south valleys, and receive the discharge of the smaller streams from the generally precipitous slopes lying to the east and west. Along these creeks the veins have generally been located.

Grand Forks mining division surrounds Christina lake. Trail and Nelson embrace the west and the east bank, respectively, of the Columbia as it leaves Canada, Nelson occupying the basin of the Salmon river and extending north-eastward to Kootenay lake. Slocan extends from east of the Arrow lakes beyond Slocan lake. Ainsworth surrounds Upper Kootenay lake and the north end of Kootenay lake, while Fort Steele, occupying the south-east corner of British Columbia, embraces both banks of the Kootenay as it enters Montana.

GENERAL GEOLOGY.

Of the geology of the district outlined, comparatively little is known. The following brief notes have been gleaned mainly from papers and reports by Mr. Carlyle, Mr. McConnell, Mr. Brock and Dr. G. M. Dawson.

The principal series of sedimentary rocks that have been recognized are as follows :—(See sketch-map.)

1. The Shuswap series, consisting of mica schists, gneisses, quartzites, and marbles, of Archean age. These rocks occur typically developed in a narrow strip bordering Kootenay lake, north of the west arm. They are also found north of Slocan lake.

2. The Nisconlith series, consisting of dark shaly slates, with quartzites, limestones, and dolomites, referred to the Cambrian. It is found bordering the Shuswap, parallel to Kootenay lake, but is more largely developed in the Nelson district. Here a band several miles in width extends from a short distance east of the town of Nelson to the international boundary, widening to fifteen or twenty miles along the Pend d'Oreille, an eastern tributary of the Columbia.

3. The Selkirk series, consisting of schists, quartzites, conglomerates, dolomites, and green eruptive rocks. This series borders the Nisconlith west of Kootenay lake. It is also found on the divide between Kootenay lake and Salmon river, a tributary of the Pend d'Oreille from the north.

4. The Upper Selkirk series of quartz and mica schists. These rocks, overlying the Selkirk series, are found on Summit creek, extending eastward to Kootenay lake.

5. The Slocan series, of dark shales and impure slates and lime-

stones, with tuffs and ash rocks. These rocks are found around the north end of Slocan lake and eastward, with a band extending southward between the Selkirk beds and a great granite mass to the southwest.

6. The Quartzite series, of the Cambrian. East of Kootenay Lake for some distance the formations have not been so carefully made out. Of the region about St. Mary's river, a western tributary of the Kootenay, Mr. Carlyle in the Provincial Report of 1897, says:—

"The mountains in this part of East Kootenay belong to the Purcell Range. . . . Geologically these mountains comprise well stratified quartzite slates, shales and siliceous limestones overlying, apparently, schists and gneisses, and broken through by areas of eruptive rock, from which intrusive sheets lie as if interbedded with sedimentary rocks."

This region about St. Mary's river, together with a belt along the east bank of the Upper Kootenay river, extending to the international boundary and beyond, is of the Quartzite series.

7. The Limestone series of the Devonian and Carboniferous. This is found bordering the Quartzite, extending eastward to the Elk river, an eastern tributary of the Upper Kootenay, and southward beyond the forty-ninth parallel. Other narrower bands of limestone are exposed in the Cretaceous to the east.

8. One or more series of the Cretaceous containing the remarkable Crow's Nest coal seams.

Varied and complex as are the sedimentary rocks described, through the intense folding and denudation of the mountain masses, they have been made vastly more complex by being faulted, dyked and metamorphosed by numberless intrusions of igneous rocks. Doubtless, to this fact is due, in great measure, the vast mineral wealth of this part of British Columbia.

These igneous rocks are of several different groups, including the following:—

1. The Columbia volcanics, of porphyrites, monzonites, gabbros, breccias, tuffs, agglomerates and fine-grained ash-rocks. These rocks occur about Rossland, also across the Columbia to the Salmon River

and northward to the Kootenay River and the West Arm of Kootenay Lake. Probably, too, the volcanics of the Boundary belong to this group.

2. Gray granite, probably the commonest rock in the region described. The granite contains both biotite and hornblende and is usually gray in color. This is found in a large mass southwest of Slocan lake and bordering the Lower Arrow lake. It also occurs along both banks of the Kootenay river from Kootenay lake to its confluence with the Columbia, and following the Columbia southward. It is found also in small areas throughout the entire West Kootenay. It is younger than the other rocks of the district, so far mentioned. It is the granite seen so abundantly at the town of Nelson.

3. The younger eruptives, described by Mr. Brock and grouped by him into—(*a*) the "white dykes" and (*b*) the "black dykes."*

(*a*) The "white dykes," of greatly varying thickness and ranging in composition from rhyolites to diorite porphyries. They are generally light in color, the acid types prevailing, though in some places darker types are met with. The ore deposits appear to be generally closely related to these. Probably the hot solfataric waters following the close of the period of volcanic activity that was accompanied by the intrusion of these dykes, constituted one of the principal factors in the genesis of the ore bodies.

(*b*) The "black dykes" of which Mr. Brock in the paper already alluded to, says :—

"Younger than this system of dykes (the 'white dykes') and the ore bodies, and consequently cutting these, are the 'black dykes,' a group of lamprophyric and basaltic dykes."

ORE DEPOSITS.

Classification.—In this region, the ore bodies to be described may be roughly grouped into three classes. The prevailing type of ore of the Slocan, Ainsworth and Fort Steele mining divisions, to the northeast, is argentiferous galena ; that of Trail and Grand Forks, to the southwest, is auriferous, copper-bearing pyrrhotite ; while Nelson,

*Paper by Mr. Brock in the Journal of the Can. Min. Inst., 1897.

which lies geographically between these, generally produces ores which appear to be mineralogically transitional.

A. *Silver-Lead Deposits.*—In Slocan mining division Mr. Carlyle recognized four classes of veins :—†

1. Those with argentiferous galena, blende and some tetrahedrite, in a gangue of quartz and siderite. These are the most numerous and important veins in the district.

2. Veins of argentiferous tetrahedrite, jamesonite and silver minerals in quartz gangue, but not numerous.

3. Veins carrying argentite with native silver and gold, in quartz gangue.

4. Gold quartz veins, in granite.

In the Ainsworth mining division, the gangue is commonly quartz and calcite and the ores are argentiferous galena, with some blende and pyrite, or silver minerals with some tetrahedrite and other sulphides.

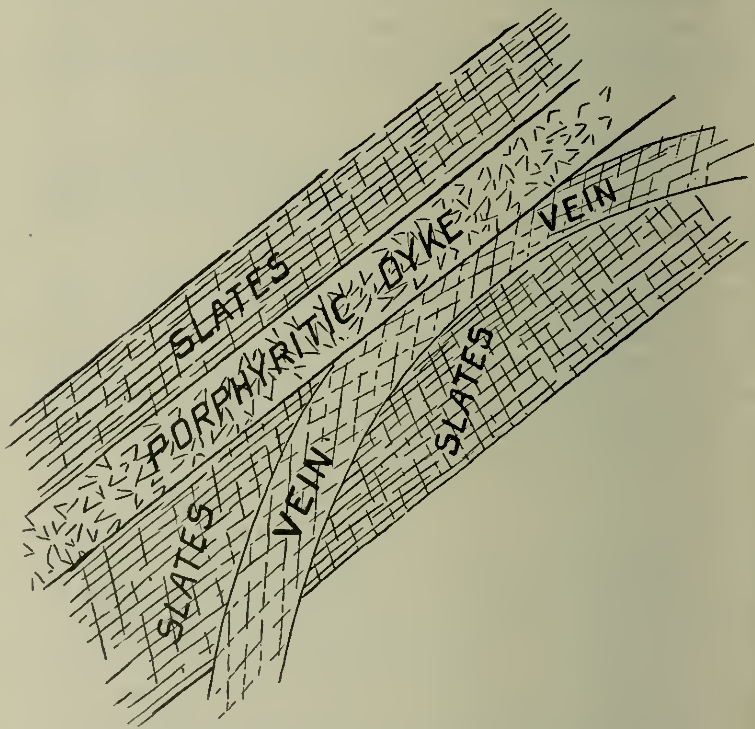
In Fort Steele division the best known veins are of silver-bearing galena in a gangue of calcite and quartz.

Example 1.—The Slocan Star. This vein is situated in Star Mountain at Sandon in the Slocan. It will serve as a type of the large group of veins at Sandon. It appears to be a true fissure vein which, owing to its insoluble walls, cannot have been much enlarged by replacement. The strike is east and west and the dip is south into the mountain at 40° to 60°. The country rock is of slates of the Slocan series. The ore is mainly galena with considerable zinc blende and some tetrahedrite. The oxidized zone extends downward but a few feet except where there are special water channels. The gangue is mainly of quartz, siderite and calcite with a little barite. The vein, so far as exploited, has a width of four to twenty-seven feet, rising to the grass-roots. Values are maintained with depth, but are not markedly increasing. Concentrates and picked ore run from 75 to 150 ounces in silver and 35 per cent. lead. Small picked specimens of tetrahedrite are said to run several thousand ounces in silver. The blende, which is separated from the galena as far as possible in the concentration

†Bulletin III, Bureau of Mines, Victoria, B.C., 1897.

carries high values in silver. The richest part of the vein is generally on the side of the hanging-wall. The hanging-wall is formed for a short distance by a porphyritic dyke from which the vein curves as shown roughly in the sketch. There is no noticeable change in values at the contact.

A large horse 30 feet thick and 130 feet long divides the vein at one point for 300 feet in depth. Values showed considerable increase



Sketch showing suggested origin of the North Star Ore Bodies.

at the union of the two divisions of the vein at either end of this horse. This ore body shows no disturbance of any account through faulting.

The ore body is opened up by adits cross-cutting the country slates, with levels on the strike of the vein. Owing to the increase with depth in the length of the adits, a shaft on the dip is being sunk from the fifth level.

A well-equipped concentrating plant, with an abundant water-supply, is in operation.

Example 2.—The St. Eugene. This vein or group of veins is situated near Moyie lake, a few miles from Cranbrook, in Fort Steele mining division.

In 1900, the Fort Steele mining division made a greater increase in production than any other single mining division in Britlsh Columbia, the value of the mineral output having risen to almost three million dollars, placing this district in total output second only to Nanaimo division. The metalliferous mines produced, in 1900, more than $2,200,000, nearly the whole of which was obtained from the St. Eugene, North Star, and Sullivan mines, in the order named. In the same year, the St. Eugene was the largest single lead producer in British Columbia, its output being nearly as great as the combined production of the mines of the entire Slocan mining division.

The St. Eugene mine includes three or more sets of workings, all on the same vein. This vein occupies a fissure or group of fissures which extend from the summit of the mountain in which it occurs down to the level of Moyie lake, a vertical distance of about 1900 feet The whole vein appears to be mineralized to some extent, but two portions between the principal workings seem at present unproductive.

The upper, or St. Eugene workings extend from the surface to the 400-foot level ; from the 400-foot level to the 800-foot level is unproductive.

The middle, or Moyie, workings extend from the 800-foot level to the 1000-foot level ; from the 1000 foot level to the 1500-foot level is unproductive.

The lower, or lake-shore workings extend from the 1500-foot level to the 1800-foot level, which is about 100 feet above the surface of the lake.

The ore body fills two or more parallel fissures with diagonal gashes between. The width averages ten feet, reaching thirty feet in places. The walls, generally clearly defined, are of the country slates, which lie here in nearly horizontal position. The vein is somewhat difficult to follow next the walls, since it branches out between the strata, leaving tabular pieces of the slates projecting into the ore body. As a result, horses are frequent. At one point one of these tabular pieces of slate projects entirely across the vein. The gangue is mainly the slates of the walls, with some quartz. There is some zinc blende and a little pyrite. The silver values are slightly less in the lower workings than in the upper, being about two-thirds of an ounce of silver to the per cent. of lead in the St. Eugene, or upper workings, and about one-half of an ounce of silver to the per cent. of lead in the lower.

The mine is equipped with a concentrating plant of about 400 tons capacity daily, the rate of concentration being about 4½ : 1, producing a concentrate running 65 to 70 per cent. lead.

This ore body is opened up by a series of tunnels along the principal vein, with cross-cuts to the parallel connected vein, the tunnels of each set of workings being connected by raises. The upper workings are connected with the concentrator by an aerial tramway; the middle, by gravity tram to the 1500 level, thence by mule-tram to the mill; the mule-team also connects the lower workings with the mill.

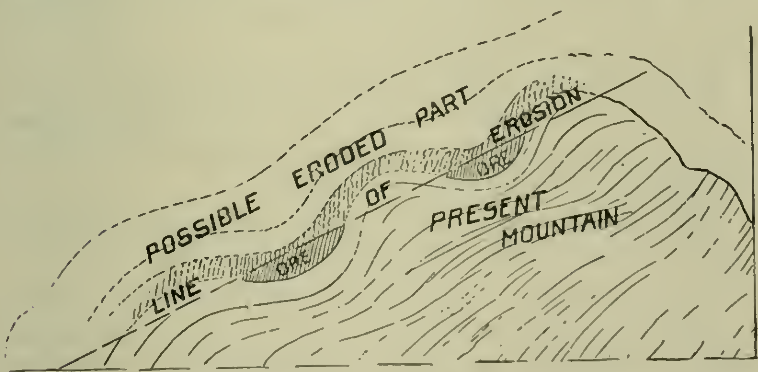
Example 3.—The North Star. This unique ore deposit, situated abont one mile from Kimberley on Mark creek, is reached by the recently constructed branch of the Canadian Pacific Railway from Cranbrook.

The ore body, or rather bodies, are of remarkable form. They occupy two or more approximately parallel, basin-like depressions running diagonally up the mountain side, with clearly-defined limits. These depressions are filled with almost pure galena with associated oxidized ores. So pure is this ore that with only ten to fifteen per cent. rejected as waste, values run about 25 to 30 ounces in silver and 50 to 55 per cent. lead, with only 3 per cent. zinc blende.

The general direction of the ore-bodies is north and south. One reaches a length of 180 feet with 40 feet depth. A cross-cut 70 feet to the west from this, reaches a parallel ore-body of 400 feet length, 70 feet width and 50 feet depth. Both bodies rise to the surface, being merely covered over with drift, which may be considered as the hanging wall—a fact that necessitates very careful timbering.

The country rock has been called metamorphosed felspathic sandstone, by Dr. Dawson. The contact of the ore body with the country rock is generally sharp and well defined. Though the walls generally show no mineralization, in some places they are pyritized, while here and there they are impregnated for a few inches with galena.

Though no dykes have been met with, the ore bodies are possibly related to igneous intrusions, as is apparently indicated by the metamorphosis of the sandstone. This, however, may be due merely to the intense folding which gave rise to the mountain masses. The peculiar form of the ore bodies suggests a folded "blanket vein," from which the summits of the anticlinals have been eroded. Whether



Sketch showing suggested origin of the North Star Ore Bodies.

these peculiar bodies of ore will ultimately be found to be connected with fissures along which the mineralized solutions travelled, seems doubtful. Possibly the usual fissure or fissures were some distance away, and the mineral-bearing solutions followed the strata at this point, being confined by some igneous intrusion now eroded away. The true origin of this remarkable deposit would probably be revealed by a detailed study of the local geological conditions.

GENERAL NOTES ON SILVER-LEAD DEPOSITS.

The above are typical of a large number of silver-lead veins in these districts. These occur mainly in sedimentary rocks and in close relation to igneous intrusions.

A comparison of twenty-four important silver-lead deposits of the Rocky Mountain region, chosen at random, from New Mexico to British Columbia, showed that twenty-one, or 87½ per cent., occur in sedimentary rocks, and of these fifteen, or over 62 per cent., occur in limestones, the remaining six being in quartzites and slates, while, almost without exception, all occur in contact with, or in close proximity to, igneous intrusions. The galena of these deposits is uniformly associated with zinc blende and a gangue, generally of quartz and calcite with barite or siderite at times. This indicates, apparently, a certain uniformity in the minerals associated in the mineralizing solutions to which these veins owe their genesis, and this fact must indicate, in turn, a general uniformity in the geological conditions giving rise to the solutions.

B. *Gold-bearing Copper Deposits.*—1. *Of the Boundary.*—Probably no ore bodies in British Columbia are attracting more attention at present than the enormous low grade, auriferous, copper-bearing deposits of the so-called "boundary country."

Local Geology.—The following brief notes on the local geology are taken from Mr. Carlyle's provincial report for 1897 :

"The preponderant rock formation noticed from the north fork of the Main Kettle river was seen to be very highly metamorphosed Archean sedimentaries or gneisses, schists, quartzites, slates, and perhaps some crystalline limestones, in which are found almost all the gold-bearing veins and veins of high grade silver-gold ore.

Overlying these rocks are seen the fragmentary areas of highly altered limestone, as this region has been subjected to much eruptive action along lines of fracture and eruption running northerly and southerly; and all the formations are traversed by dykes of various eruptives and overlain in part by areas of effusive rock, mostly light to dark green, partly crystalline, fine-grained felspathic rock, the miners' "diorite," which is a very important member, as in this case are all the large zones, impregnated with gold, chalcopyrite, hematite, and sometimes pyrrhotite and iron pyrites. Many of these deposits lie in contact with, or in close proximity to, very crystalline limestones, which generally show a nearly perpendicular plane of contact with the general strike of north and south."

This indicates the much disturbed nature of the district.

The Ore Bodies.—In this district two well-known ore bodies will be described.

Example 4.—The Mother Lode. This deposit is situated about two and a half miles from Greenwood, with which it is connected by a railway spur. The ore body is a zone of fine-grained, greenish volcanic rock, impregnated with a small percentage of chalcopyrite, some iron pyrites, and, in parts, very fine-grained magnetite, with a variety of other, mainly secondary, minerals. The lode can be traced on the surface for 1800 to 2000 feet, with a width varying from 80 to 160 feet, while below, the mineralized zone widens to 200 feet.

The form of the ore body is somewhat crescent. The strike is, roughly, north and south, and the dip, eastward, with the strata at 55 to 65 degrees.

On the surface, 1,100 feet north of the shaft, the vein is cut off by a so-called lime dyke, 500 to 600 feet thick, dipping southward, so that on the 200-ft. level the ore body is cut by it 800 ft. north of the vertical shaft. This so-called lime dyke, really a limestone bed of the country rock, sweeps round to the west, forming the foot-wall. The hanging wall is a greenish rock, said to be a diabase. Thus the mineralized zone lies between the limestone on the west and the fine-grained, massive, eruptive rock on the east.

On the foot-wall side, the transition from barren rock to pay ore is gradual, while on the hanging-wall side it is fairly abrupt. The chemical composition of the hanging-wall and that of the mineralized rock near to it, omitting the pyrites, are the same. There is, besides, in places, some soft gangue, beyond which the wall-rock is not broken. These facts point, possibly, to the existence of a fault here.

Porphyry dykes occur, which, together with the more or less fissured zone accompanying the apparent fault, must have formed a ready means of ingress for mineralizing solutions while the vein was forming, One of these dykes, with a thickness of 16 feet and a dip of 30 degrees. cuts the vein at right angles.

The ores have been grouped roughly, from a metallurgical point of view, into three classes. These are:—

(1) *Calcite Ores*, consisting of calcite, bearing copper and iron sulphides, either massive or scattered, frequently with quartz, garnets, serpentine, or all three, and occasionally with a little zinc blende.

(3) Magnetite ores, consisting of a hard, fine-grained magnetite with quartz and chalcopyrite, but containing very little iron pyrites.

All three classes carry gold, and the calcite and silicate varieties carry one or two ounces of silver as well.

In addition to these three classes, there has been found on the foot-wall side on the 200-ft. level, a little galena and zinc blende in a gangue of calcite. This seems to be a curious incidental confirmation of the tendency above alluded to, viz., of limestone to precipitate and segregate galena out of mineralizing solutions.

The following note on the occurrence of gold and the analyses of typical specimens of the three classes of ore are taken from the Canadian Supplement of the Engineering and Mining Journal of New York, May 18, 1901:—

	Calcite Variety.	Silicate Variety.	Magnetite Variety.
Silica	20.10	44.23	27.33
Iron Oxides	12.00	16.83	51.12
Alumina	1.31	7.46	.....
Ca. and Mg. Oxides	34.00	16.03	10.26

An inspection of these figures shows how admirably the ore is adapted for self-fluxing by mixing the three classes in suitable proportions. Taken as a whole they are too basic for self-fluxing. A curious and probably inexplicable fact has been observed regarding the gold values. As a rule gold increases as copper increases, but not in the same ratio. But the presence of iron pyrites seems necessary for carrying gold, for samples of chalcopyrite with no iron pyrites yield little or no gold. As an illustration, a sample assayed 15 per cent. copper, yielding $16 in gold, while a very rich piece of chalcopyrite with no iron pyrites assayed 28 per cent. copper and only $1.50 gold.

Gold values are increasing slightly with depth.

Another peculiar feature in this body of ore is the occurrence of a body of magnetite, rich in copper, extending downward from the 300 foot level and cutting the vein diagonally.

The mineralized zone on the surface is much decomposed and copper-stained, much of the surface being converted into gossan.

The surface quarries yield ore with about 1¾ per cent. copper, while the levels below run from about 2 to 5 per cent. copper and $2 to $4 in gold. The difference is due probably to leaching.

A considerable variety of minerals occur, among which are calcite, quartz, epidote, garnets, actinolite, magnetite, hematite, pyrite, chalcopyrite, azurite, malachite, galena and zinc blende.

This ore body is opened up by a crosscut tunnel through the limestone wall and by a vertical shaft with levels on the strike, from which raises are made to the surface. The self-fluxing nature of the ore, and the cheap method of mining adopted, viz., the "mill-hole" method, with quarries where the raises meet the surface, have brought a large percentage of this ore-body within the pay limit.

Example 5.—Knob Hill and Old Ironsides. These two mines, together with some adjoining claims, appear to be on the same vast ore body, the exact limits of which are not very clearly known. This body of ore is situated at Phoenix, about three miles from Greenwood, near the summit of the divide between the watersheds of Boundary creek and Fourth of July creek. The strike of the vein is north and south and the dip eastward at 50 degrees. It is thus briefly described in the Provincial Report for 1899:—

"This ore body may be best described as a huge mineralized zone of fine-grained eruptive rock, highly altered, and occurring near a contact with limestone. Through this rock are disseminated yellow copper sulphides, magnetite and magnetic iron pyrites, with small stringers of calcite, while, occasionally, the iron sulphides and oxides become massive."

The vein is of immense size, having been traced on the surface for over a mile in length and for 300 feet or more in width. Below ground a drift was run at one point 400 feet from the foot-wall, across the vein, without reaching the hanging wall. Its width appears to be about 200 feet perpendicular to the dip, but is rather uncertain. Exploitation with the diamond drill has shown that the ore continues at over 1,000 feet of depth. As many thousands of feet of sinking, raising, drifting and cross-cutting have been done, the body of ore may be considered well proven. The ore in this vast body is thus seen to be practically inexhaustible and it has been shown that the grade of ore improves with depth. The deposit is generally very low grade and very uniform, carrying values roughly similar to those at the Mother Lode.

The foot-wall seems mainly silicified volcanic breccia, the hanging-wall being probably a limestone breccia. The foot-wall is generally fairly clearly defined by the presence of three or four feet of selvage, indicating movement. As at the Mother Lode, the limestone wall is more indefinite. Dykes occur but are not frequent. The gangue is mainly calcite, with quartz, hematite and magnetite, epidote, etc. As at the Mother Lode, the ore is self-fluxing. The oxidized zone is generally about 50 feet, but in one instance follows a water-course for 300 feet in depth.

The similarity of this deposit and the Mother Lode in respect to strike, dip, mineralization and contacts is very marked. Probably closer study of the geological conditions in this locality will reveal still closer relationships between these two kindred deposits. Both these veins seem to have been formed by replacement, the highway for the mineralizing solutions having probably been formed by eruptive disturbances of the strata with resulting dykes and fissures.

In their formation along the contact of limestone with igneous rock, these two ore bodies resemble a number of other important veins in the well-known Warren and Globe Districts, Arizona.

2. *Of Rossland District.*—Probably the prosperity of mining in British Columbia during the past few years has been more influenced

by the prosperity of Rossland than by that of any other mining camp in the province. Certainly foreign as well as Canadian capitalists have, for nearly a decade, shown great faith in Rossland Camp, with the result that we now have here a flourishing city whose sole industry is mining.

Local Geology.—The following notes on the geology of the district are gathered from various sources, but mainly from Mr. McConnell's report to the Geological Survey for 1896 :—(See map).

In the district about Rossland, rocks of igneous origin are markedly predominant. The principal rocks occurring are :—

(1) Granites. The granites are gray, and of the same age as those before described as typically developed about Nelson. Here they follow the east bank of the Columbia to a point near but below the mouth of Bear creek (see map). The south eastern edge crosses the Columbia and follows Lookout Mountain ridge for some distance. West of the Columbia the granites occur in a band roughly two miles wide, with an expansion to the west partly surrounding the Kootenay —Columbia mountain. There are, besides, some isolated bosses of granite elsewhere in the district, for example, on the north-west slope of Deer Park mountain.

(2) Gabbros and related rocks. At the central part of the district is a mass of dark, fine-grained rock, with a width of one to one and a half miles north and south, and a length of four to five miles east and west. The rock of this area is of three main types :—

(a) Monzonite, the country rock of the principal mines, Centre Star, eastern part of the Le Roi, War Eagle, etc. This rock is composed mainly of plagioclase and orthoclase feldspars, with augite, and is of a dark greenish-gray color, tough and generally fine-grained. It is transitional between the syenite on the west and the gabbro on the east.

(b) Eastward the monzonite shades into gabbro.

(c) To the west of the above group of mines, near the Josie, syenite occurs. All three are merely differentiations of the same molten magma.

This group of rocks extends from Deer Park mountain to Lookout mountain. The limits are more exactly shown on the accompanying map.

(3) Porphyrites, tuffs, agglomerates, etc. A section made radially from the above central mass "shows a bordering zone of brecciated porphyrites and diabases of varying width, but seldom exceeding a mile, beyond which comes an alternating series of porphyrites, tuffs, and slates, while, still farther away, agglomerates, associated in places with fossiliferous limestone, make their appearance." * The fossils are said to be probably of carboniferous age.

Slates and tuffs, with porphyrites, are found on Kootenay-Columbia mountain, and on Lake and Bald mountains to the south, while these rocks, together with agglomerates, occur on Granite, Spokane, Grouse, and Lookout mountains, the main mass of Sophia mountain being composed of agglomerate alone.

(4) A peculiar patch of conglomerate, of probably tertiary age, occurs on the southern slope of Lake mountain. This is evidently an erosion remnant.

From the roughly concentric arrangement of these rocks and their gradation outward from holocrystalline monzonites, gabbros, etc., through semi-crystalline porphyrites, to volcanic ash rocks and fragments, lying in bedded position, sloping upward to the central mass, it is inferred that Rossland is located on the site of an ancient volcano now much eroded, in this respect resembling Cripple creek.

(5) Dykes. The entire district is much cut up by dykes varying from light acid, to dark basic varieties of rock, and from micro-crystalline to granitic texture. These are due to later upwellings of the molten magma, fissuring the original lavas after consolidation, and filling the fissures.

Example 6.—Rossland Ore Bodies. As might be expected in such a region, there is everywhere evidence, in this district, of dynamic as well as eruptive disturbances, shown in numerous fissures, faults and parallel fissures or shear zones. These shear zones have formed a most favorable means of ingress for mineralizing solutions especially where, as here, dykes exist to direct and concentrate the currents. As

* Report by Mr. McConnell to the C.G.S., 1896.

the fires of the ancient volcano waned gaseous exhalations were abundant and the underground waters, heated both by depth and the proximity of the molten mass, must have had very great solvent power. This resulted in the rapid solution of the walls of the fissures and deposition in their place of part of the burden of minerals held in solution. This interchange of minerals gives rise to "replacement veins."

Probably most so-called "true fissure veins" have had the original fissure much enlarged by replacement. While a "fissure vein" is generally distinguished by clearly defined walls and banded arrangement of minerals, and a replacement vein by impregnation of the walls and by a gradual fading of values into the country rock, we have every possible gradation between the two with the resulting difficulty in classification. With regard to the most important Rossland veins, there seems to be no doubt as to their class. No other veins in British Columbia have given rise to more careful examination and thorough discussion than these and there seems to be a complete consensus of opinion as to their origin. They are considered to be replacement veins along shear zones. At the Iron Horse, replacement of large crystals of augite by pyrite can be seen in every stage of completeness.

A peculiarity of this class of veins is that within the limits of the exterior fissures of the shattered zone, replacement may be along a single fissure, or the whole zone may be mineralized for a short distance and then the solutions may have penetrated through an opening to a fissure some distance away, which they followed upward and along which replacement again occurred. This peculiar distribution of the mineralized parts of the shattered zone brings corresponding difficulties into the mining of such veins. It makes the vein difficult to follow; it renders the limits of the vein obscure, so that the walls of one month may be within the ore body of the next; it makes necessary a large amount of dead-work in the search for possible bodies of ore and in handling large quantities of worthless country rock enclosed between mineralized fissures. If we add to these the extraordinary hardness and toughness of the country rock and the frequent displacements caused by faults and dykes, we have some of the gravest difficulties that mining engineers at Rossland have had to overcome.

The common Rossland ore is pyrrhotite accompanied by chalcopyrite bearing gold and a little silver. The pyrrhotite is generally massive and rather fine-grained, but it is also found disseminated through the country rock. It sometimes bears traces of nickel and cobalt. Gold values vary from traces up to several ounces to the ton; and silver, from traces up to four or five ounces. The chalcopyrite is very irregularly distributed. In some places it constitutes a large percentage of the ore and in others it is found only in isolated patches and grains Besides these minerals iron pyrites is met with in small amount almost everywhere and, in some of the mines of the camp, a little arsenopyrite, molybdenite, galena, zinc blende and free gold have been found. The zone of oxidation seldom exceeds a few feet in depth.

The distribution of the Rossland ore bodies is noteworthy. Most of the important ore bodies so far developed, occur on or close to the line of contact between the central volcanic neck and the surrounding porphyrites and diabases. The Le Roi and Centre Star, the War Eagle, and the Josie veins cross the line of contact on Red mountain. The Nickel Plate, Iron Mask, Virginia, Iron Horse, and Great Western are a short distance within the line. The Deer Park and Monte Christo occur close to it. The Kootenay-Columbia and the Iron Colt occur a few hundred feet to the north of it in a band of porphyrites, while, just beyond the line of contact to the south, in diabases and porphyrites, occur the Homestake and the Crown Point. Not all the ore bodies, however, occur in or near the central area. A few occur in the surrounding ancient lava flows. The general contact location of the principal veins indicates a line of weakness here.

Most of the best known veins, as the Le Roi and Centre Star vein, the War Eagle, the Iron Mask, the Nickel Plate, the Josie, and others, lie in a group on the southern slope of Red mountain, with a roughly east and west strike. These veins dip at high angles and approach and intersect one another in various ways, so that the whole group may be considered, dynamically, as forming one huge shear-zone. The Josie vein crosses the War Eagle claim. The Le Roi and Centre Star mines are on the same vein, which is intersected by the Iron Mask. A huge, dyke-filled fissure, one hundred feet wide, nearly vertical, and with north and south strike, cuts the Le Roi and the Josie. In fact, this whole group of veins, bound together since their formation, by numerous dykes and faults in common, occurring, as they do, in a great crushed and sheared belt, with similar minerals impregnating the walls of fissures that in many cases intersect, must also be very closely related in their origin.

The Rossland veins are cut by a series of dark, fine-grained, lamprophyric dykes. Since the veins must have existed before the dykes, and since the intrusion of the dykes no doubt followed somewhat closely the close of activity of the volcano, it seems probable that the mineralization of the veins occurred very soon after the consolidation of the rock. Doubtless the contraction on cooling opened a great many of the fissures and the solfataric waters caused rapid filling of the fissures with minerals and replacement of the walls. There has also been a more recent second mineralization with quartz, calcite, and zeolites, in veins cutting the previously mineralized rock. It is believed by Mr. Ferrier (geologist of the War Eagle—Centre Star Co.) that a second enrichment in gold occurred during this period. The largest fault has a throw of about four hundred feet.

Briefly summarizing the history of the development of this district we have :—

1. The development of the volcano.

2. The shearing of the monzonites and other volcanic rocks, giving a passage to solfataric waters.

3. Impregnation by metallic sulphides, silica, etc., along the shattered zone.

4. Continuation of the movements causing further faulting and shearing, probably accompanied by a filling of some of the fissures by dykes.

5. A second mineralization along these fissures.

6. Erosion of the volcano to its present level.

These ore bodies are generally being opened up by shafts, either vertical or on the dip, with levels on the strike, and much exploratory cross-cutting. The utility of such cross-cutting in this class of veins is well shown in the Le Roi, where, at one point, in the 700-foot level, the walls have successively receded until the stope has widened from less than 40 feet to more than 150 feet.

As development work to the extent of many miles has been done, and as considerable depths have been reached (in some of the mines one thousand feet and over), both values and size of the ore bodies being generally well maintained, the permanency of mining at Rossland seems assured for many years.

The total ore shipments for the year 1900 from Trail Creek mining division were 217,636 tons, with a gross value of $2,333,125. Of this, the Le Roi shipped 159,734 tons, valued at $1,437,726, and the Centre Star, 40,875 tons, with a gross value of $609,358.75. In other words, two hundred thousand tons of the total two hundred and seventeen thousand tons, or over ninety per cent., was shipped from this one vein.

In their roughly parallel arrangement, in their east and west strike and steep dip, in their igneous wall rock, and in their formation by replacement along fissures that frequently intersect, the group of veins on Red mountain resembles the famous group of copper-bearing veins at Butte.

GENERAL NOTES ON GOLD–COPPER DEPOSITS.

It will be seen that the auriferous copper-bearing ore bodies at Rossland, and those at the "boundary" present certain points in common. In both cases the ore is low grade and bears copper, as sulphide, and gold. Both groups of veins have been formed by replacement, and are large mineralized zones, with values fading into more or less ill-defined walls, rather than veins in the usual sense.

Both sets occur in volcanic regions, and in direct connection with igneous rock ; and all these veins are disturbed and dyked by later igneous intrusions.

A comparison of fifteen of the best known and most important groups of copper veins in the Rocky Mountain region, most, if not all, of which are auriferous, showed that seven of the fifteen groups have igneous rock for one wall or both. In almost every case the district near the veins has been much disturbed by fissures, dykes, and faults. The very common occurrence of these veins in contact with limestones, as was seen to be true in the case of silver-lead deposits, is noteworthy. Probably the strong chemical activity of limestone is an important factor in the deposition of these ore bodies.

C. *Free-milling Deposits of Nelson Mining Division.*—Notes will be given on but one ore deposit in this district.

Example 7.—Ymir. This mine is at present one of the best dividend payers in British Columbia.

It is situated about five miles from Ymir station, on the Nelson and Fort Sheppard railway, with which it is connected by wagon road. It is on Ymir mountain, on the north fork of Wild Horse creek, a tributary of Salmon river.

The vein is a true fissure, with a strike of N. 70° E., and a dip to the north-west of 70 degrees. The vein is in slates, probably of the Nisconlith series, the strata dipping nearly vertically and having a strike nearly due north and south. Alteration is indicated by the presence of incipient staurolite and andalusite.

The horizontal length of the pay chute is about 500 feet. The width at the surface is about 15 feet, and increases considerably with depth. It outcrops at the surface, being merely covered with three or four feet of drift. Surface decomposition appears to extend to a depth of three or four hundred feet.

The walls are clearly defined and uniform. The ore body, which shows a banded structure, consists of galena, pyrite, and zinc blende, with gold and silver values, in a quartz gangue. The ore is free-milling, about two-thirds of the gold and silver values being caught on the amalgam plates, and one-third in concentrates, which are smelted. The values saved run about one and a half per cent. lead, one ounce in silver, and three to four-tenths of an ounce in gold. The galena of the concentrates carries silver, and the pyrite, gold. The vein is widening with depth, and values are being maintained with greater regularity.

A dyke, four to fourteen thick, the rock of which is apparently a minette, after cutting the vein with a slight dip to the east, turns and forms one wall for a short distance. At the 100-foot level, this dyke appears to split, following two fissures to the surface. It does not appear to affect the values in near-lying parts of the vein. Other dykes occur.

This ore body is opened up by adit levels on the strike. From the 300-foot level, with which the other levels are connected by winzes, an aerial tram carries the ore to the mill. At 1,000 feet below the surface outcrop, a cross-cut tunnel was being made at the time of the visit (May, 1901), on a level with the ore-bin at the mill. It was estimated that this tunnel would reach the ore body in 2,200 feet. This tunnel has since then been successfully completed, thus proving the vein to this depth.

From the general form of the vein, from the generally clearly defined and but slightly impregnated walls, and from the frequently banded arrangement of the minerals, this would seem to be the best type of a "true fissure vein" of those described.

CONCLUSION.

As already stated, the general type of ore in the Ymir and other mines in the Nelson District is intermediate between that of the Slocan, Ainsworth and Fort Steele mining divisions to the north and east and that of the Trail and Grand Forks mining divisions to the south-west. To the north-east we find silver, lead and zinc with a little gold. In Nelson, the central district, gold comes in more prominently and there is still a little silver and lead as seen in the Ymir concentrates. To the south-west again, in Rossland and the "Boundary," the ores consist of iron and copper sulphides with gold and but little silver. Galena has almost disappeared. It has been shown that the upper geological formations over this wide district are very diverse. Hence, reasoning back from the uniformly progressive character of the deposits from north-east to south-west, it would seem that the rocks whose constituents enriched the mineralizing solutions that formed these deposits, must be mainly below those formations now exposed. It seems reasonable to suppose that, deeper down, the fundamental igneous rock is fairly uniform in character and that, while varying considerably over wide areas in general composition, the transitions in composition of these rocks from point to point are gradual. Also, the general uniformity in character of the two main igneous intrusions (the "black" and the "white" dykes) seems to indicate that the composition of the residual bodies of molten magma at the time of the intrusions of the dykes was fairly uniform. The close relationship of the deposits to these igneous intrusions was noted above.

It is well known that, on cooling, rock magmas extrude large quantities of water and various gases, carbon dioxide, sulphuretted hydrogen, fluorine, etc., and probably volatile compounds of many of the metals. These, rising through fissures, must mingle with the underground circulating waters and not only enrich them, but also quicken their chemical activity, which owing to heat and pressure is already much increased.

The evidence, therefore, as to the origin of this large group of veins, seems to point strongly to the derivation of their metals, by underground circulation, in part, from the deeper portion of the zone of rock fracture and probably also, in part, from molten igneous masses intruded into the zone of fracture. This evidence seems to be directly in line with the view expressed by Lindgren of the U. S. G. S.:—

* " Where fissures traverse the cooling magmas, and the rocks surrounding them, it is natural that these mineralizing agents (emanations) carrying their load of heavy metals should ascend, at first under pneumatolytic conditions, above the critical temperature. Reaching the zone of circulating atmospheric waters, it is natural that they should mix with these, which probably greatly predominated in quantity. To this combinatien of agencies, found in the ascending waters of such regions of igneous intrusion, the formation of most metalliferous veins is probably due."

* Trans. Am. Inst. Min. Engineers, Vol. 30, p. 692.

The Sulphide Ore Bodies of the Sudbury Region.

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These deposits are unique from many points of view. When discovered first in 1883 they were thought to be enormous deposits of chalcopyrite which were to revolutionize the copper industry. Later they were found to be of more modern dimensions, but to contain good percentages of nickel, a metal worth several times as much as copper, and one for which, though the demand is now considerable, is ever increasing, and in all probability will be very great in the near future. These deposits are now the source of over forty-five per cent. of the total nickel production of the world, which in 1900 amounted to about 7500 metric tons, of which Ontario produced about 3540 tons, and New Caledonia about 3845 tons. They have been found on an area extending on the strike from Lake Wahnapitae to about forty-five miles in a south-westward direction and transversely from the "Soo" branch of the C.P.R. line north-westward for about twenty-five miles to the centre of Levack township. The ore bodies are lenticular in shape, pinching out in both directions, their elongation corresponding to the strike of the Huronian strata. The structure of their downward extension has not yet been proven, though the Evans mine, which was worked in the form of an open pit, was abandoned when down about 800 feet. There have been other mines in the district, which have been abandoned when down to about the same level, though it was not satisfactorily proven that other masses of ore did not lie below these a little off the line. The deposits have a general strike of north-east and south-west which conform both to the strike of the greenstone with which they are intimately associated, and to that of the Huronian series through which the greenstones cut. The presence of the ore bodies is indicated in nearly all cases by rounded hills of gossan, which occur at intervals for miles in a north-east and south-west direction. The gossan is due to the formation of peroxides and hydrate-peroxides of iron from the decomposition of the pyrrhotite mainly, along with some from the decomposition of the chalcopyrite, of which two minerals the ore is chiefly composed.

The ore bodies may be grouped under three general heads :

First. Contact deposits of the sulphides situated between the granites and gneisses and igneous " greenstones," good examples of which are supplied by the Evans, Murray, and Copper Cliff mines. Under this head may also be grouped deposits situated between the greenstones and the quartzites, etc. The latter deposits are few, and their pyrrhotite is now believed to be almost barren.

Second. As impregnations of the pyrrhotite and chalcopyrite through the greenstones, which are often so rich as to be workable deposits, as in the case of McArthur No. 2 and No. 4 mines, the former of which has been worked in the form of a great open pit, 200 ft. long by 150 ft. wide by 300 ft. deep, while 100 ft. below this and connected by a shaft from the surface is a stope 75 ft. deep by about 45 ft. long by 40 ft. wide. The shaft is now down about 500 feet altogether.

Third. As segregation veins, which were filled subsequently to the eruption of the greenstones in which the writer believes the ore to have been first finely disseminated. Such veins are not very common, though portions of the more massive deposits have been dissolved out and redeposited along certain faults and fissures.

PETROGRAPHICAL CHARACTERS.

The greenstones are fine to medium grained eruptives, having a general greenish or greyish green color, from which they get their name. They vary in petrographical characters from a norite or gabbro to diorite or hornblende-granite. The diorite is probably secondary, as the hornblende seems to be derived from one of the members of the pyroxene group, the original rock being perhaps a gabbro. As a rule they show a gradual transition from what Vogt calls a typical pyrrhotite-norite on the one hand to a hornblende-granite on the other.

The writer examined a number of thin sections of the greenstones from around Copper Cliff which varied in petrographical characters as above, though nearly all were fairly acid, showing free quartz and micropegmatitic structure of the quartz and plageoclase, the latter being altered in places to calcite. Considerable orthoclase which was also much altered was found, and contained many inclusions zonally arranged, the outer edges in most cases being free from them. Among the inclusions quartz, mica, and apatite, and in several either pyrrhotite or chalcopyrite were determined. All but the latter seemed to have their longer axes arranged in two definite directions, which the writer believed to correspond to two of the pinnacoid faces. The darker silicates were determined to consist in some cases almost wholly of hornblende, while in others hornblende and hypersthene were closely associated; others again showed enstatite, bronzite, hypersthene, and augite to be present sometimes all in the one section. The hypersthene crystals have light central zones, and contain tabular inclusions assumed to be limenite; several also contain specks of chalcopyrite and pyrrhotite, and those nearer the deposits show stress by their bending and perfect cleavage at right angles to their elongation. Biotite is very abundant, and in some sections seem to invariably have greater or smaller inclusions of ilmenite, which has weathered around its outer edge to loucoxene and sphene. Apatite is also very abundant, and is found included in both the felspar and quartz. Sections within fifty or sixty feet of the deposits show a great deal of pyrrhotite and chalcopyrite to be included, which becomes more abundant as the deposits are approached, till just at the deposits they seem to make up a third or more of the section.

The chemical compositions of three typical samples of greenstone are :

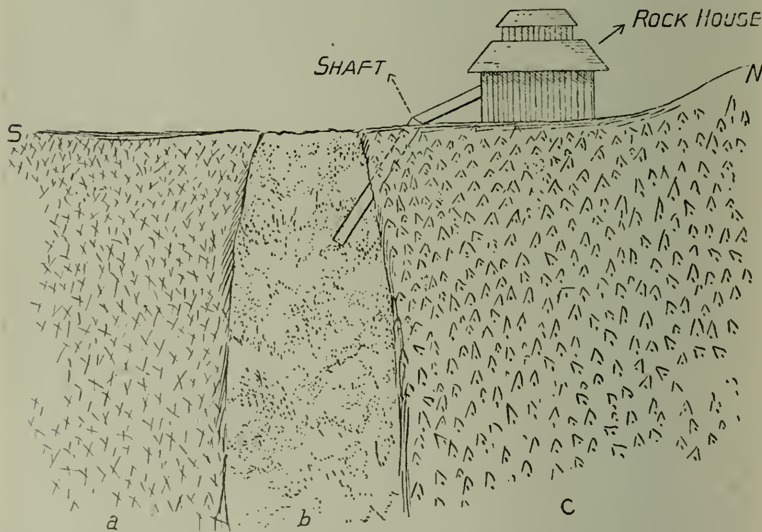
	I		II		III	
$Si\,O_2$	48.95	per cent.	49.83	per cent.	62.75	per cent.
$Al_2\,O_3$	16.21	"	17.28	"	18.21	"
$Fe_2\,O_3$ FeO.	12.15	"	14.85	"	4.64	"
CaO	7.41	"	7.01	"	3.61	"
Mg O	6.25	"	6.01	"	2.91	"
Na_2 O......	3.25	"	1.85	"	3.72	"
K_2 O.......	2.70	"	2.20	"	1.31	"
Total...	96.92	"	99.03	"	97.15	"
Sp. Gr......	2.88		3.01		2.81	

Canadian Copper Company's Froude Mine, five miles from Sudbury, Ont.

The greenstone areas vary in extent from a couple of hundred square yards to square miles, and cut through the rocks of the Huronian series, which are here represented by hornblende schists, quarzites, and slates, associated with which, and younger in age, are granites and gneisses, which, as a rule, bound the greenstones on the south-east and north-west. The deposits in most cases occur at the junction of the greenstones and the granites and gneisses as shown in a section of the Copper Cliff mine below.

The ore bodies consist of masses of chalcopyrite and pyrrhotite, very closely associated, distributed through the greenstone in specks,

SECTION OF COPPER CLIFF MINE.



(a) Greenstones ; (b) Ore-body ; (c) Gran ite.

which near the contact become more concentrated and assume the form of masses or stringers either inclosing or being inclosed by greenstone gangue. The ore, as it is brought from the mine, is mixed with about 50 per cent. gangue, and in the works of the Canadian

Shaft House Creighton Mine, eight miles from Copper Cliff, Ont.

Copper Company is crushed and then hand-picked to get rid of about 25 per cent. of such matter. A number of typical samples taken from each of four different mines now in operation were analysed and the average for each given below.

NO.	COPPER.	NICKEL.
1	5.25 per cent.	3.75 per cent.
2	2.75 "	3.72 "
3	2.68 "	3.62 "
4	2.20 "	1.25 "

In the same way an average of several samples from a property in each of four townships was taken and gave the following:

NO.	COPPER.	NICKEL.
1	0.89 per cent,	2.45 per cent.
2	0.35 "	3.01 "
3	0.60 "	2.05 "
4	2.75 "	2.86 "

Some of the ores run very high in nickel, as was shown by a small quantity of dressed ore shipped from the Worthington mine in 1891, which averaged 30 per cent. of nickel. The ores contain appreciable percentages of cobalt, and also of gold, silver, platinum, and palladium, which are all found in samples of the Bessemer matte of Canadian Copper Co. or the 80 per cent. matte of the Orford works An analysis of a sample of Bessemer matte is given below:

Ni & Co	39.64	per cent.
Cu	42.75	"
Fe	1.03	"
S	14.05	"
Ag	5.30	ounces per ton.
Au	0.75	"
Pt group	0.50	"

The nickel and cobalt in the ore is associated with the pyrrhotite, and up to about 3 or 4 per cent. probably replaces the iron in $Fe_7 S_8$, but in cases where the nickel occurs up to 10 per cent. and over it is probably present as pentlandite or at least has pentlandite distributed through it. This mineral is very abundant in the Crighten mine, and is easily detected by its perfect octahedral cleavage or part-

The Gertrude Nickel Mine of the Consolidated Lake Superior Co., situated thirteen miles from Sudbury, Ontario.

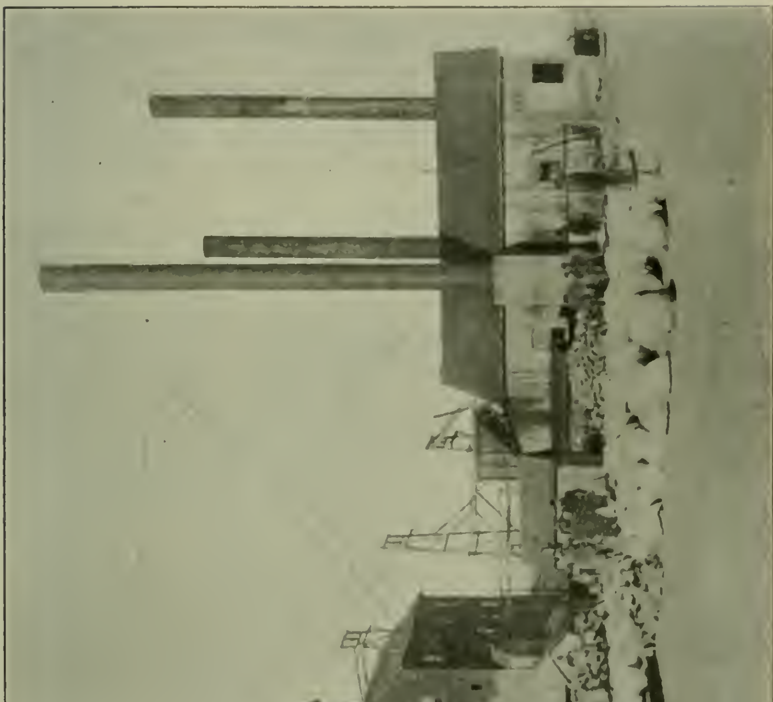
ing and non-magnetic properties. Ferriferous polydymite was also supposed to contribute to the high nickel value in the ore, also millerite, a small quantity of which was found in the Copper Cliff mine. Other nickel minerals found in the region are gersdorffite (Ni As S) and niccolite (Ni As) from secondary quartz veins in the Worthington mine. In this connection the writer might mention that he has a specimen of diorite from the twelfth level of the Copper Cliff mine showing a good deposit of leaf-copper, which must have been formed by the reduction of the chalcopyrite by reducing solutions leaching through the rock. Several experiments were tried by the writer to determine the form in which the nickel is present in the pyrrhotite when small percentages only are present. Samples from different localities in the district were analysed, but in every case enough chalcopyrite was present to spoil the determination; even after grinding in an agate mortar and separating by a magnet, considerable percentages of copper were found. This, the writer believes, will be a great obstacle in the way of manufacturing nickel steel direct from pyrrhotite, for however free the deposit may seem to be from chalcopyrite, the two sulphides will probably be found to be intermingled in microscopic specks, and the smallest percentages of copper in steel exerts a detrimental effect on it.

GENESIS OF THE ORE DEPOSITS.

This theme has given rise to much speculation, but there now seems to be two recognized theories for their formation, to which the writer wishes to add a third, which might be said to be a combination of the first two, for he believes that in this, as in the disputes over many natural phenomena, both sides are right to a certain degree, just as were the Plutonists and the Neptunists of the time of Werner, and later the ascension and descension schools in connection with vein formations. In both these cases the theory which took into consideration the contentions of both sides was proven to be correct.

The first two theories are:

First. That the sulphides were concentrated along the contacts by sorets principal and the principal of convection currents.

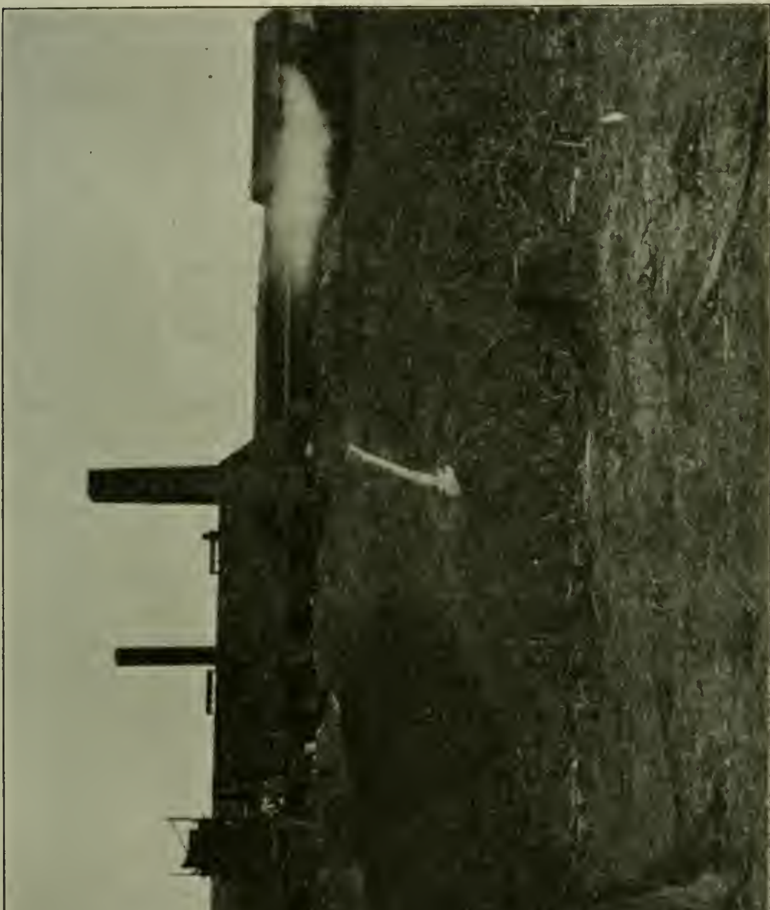


Matte Yard at West Smelter, Canadian Copper Co., 1,000 tons of matte ready for shipment. No. II Mine rock-house in background.

Second. That the ore bodies were formed in the usual way by metasomatic replacement or segregation. To which the writer has added:

Third. That the sulphides are a constituent of the original magma, through which they were first finely disseminated, and were subsequently dissolved out and redeposited along the contact formed by the granite and gneiss by metasomodosis or segregation, these contacts being the points of least resistance for such solutions; or in some cases they may have been deposited in true fissures caused by the shrinkage of the granite dykes when cooling. (In many of the deposits there has been a secondary concentration along faults and fissures, probably caused by such shrinkage.)

In considering any theory for the formation of the ore bodies one is led into a discussion on the relation cf the ore to the greenstone gangue with which even a superficial examination shows them to be related, the ore bodies being always fonnd either in the greenstones, near, or at the contact, of the greenstone and the granite or gneiss. A closer inspection shows the sulphides to be disseminated throughout the greenstone to quite a considerable distance from the main deposits, and to fade away by a fairly gradual gradation. That the sulphides primarily came from the molten magma which composes the greenstone can be inferred from a megascopic examination of these rocks, and proven by a microscopic examination. A thin section of the specimen of this rock, as stated in a previous part of the paper, shows it to be impregnated with the sulphides, while in two sections which were examined by the writer, fairly fresh pyroxene and orthoclase crystals were found to contain inclusions of the sulphide, showing these minerals to have been formed previous to and out of the same magma as the components of the greenstone. Vogt, in describing similar nickel deposits in Norway, speaks af the sulphide as rock-forming mineral, and believes them to have assumed their present form at the time of solidification of the rocks containing them. He calls such rocks, rich in pyrrhotite, pyrrhotite-norites, and regards the ores to be the most basic rock constituent. He considers that the relation of the pyrrhotite-norite to the greenstone is similar to that which the basic borders



West Smelter of the Canadian Copper Co., showing Slag Heaps in the foreground.

on granite-stock hold to the granite ; both, he believes, were formed by the differentiation of a once homogeneous magma. Sandberger separated the dark silicates of a great many rocks, and, by operating on quantities of 30 grams, proved them to contain Cu, Ni, Co, Pb, Sn, Sb, As, Bi, and Ag, and considered them also to act as bases. Whether Vogt's opinion, that the pyrrhotite-norite of Norway is related to the greenstone in the same way as the basic borders on granite stock is to the granite, and that the Norway deposits took their present form on solidification, applies equally well to Canadian deposits, is doubtful, though what he says of the origin of the Norwegian deposits might be applied to the Canadian deposits in every other respect. Those holding to the whole of Vogt's opinion explain the concentration of the ore at or near the contacts in the following way :—Soret proved that if a solution of common salt or other substance be unequally heated there will be a concentration of the salt, etc., at the point having lowest temperature. This would follow from the law of Osmoses, (the relative degrees of concentration being to one another inversely as the absolute temperature.) Thus in considering the molten magma as a solution in which the pyrrhotite and chalcopyrite were dissolved there would be a concentration at the coolest points, which of course would be the line of contact. We might also take into account the principle of convection currents which would be naturally set up in the mass by the differentiation in temperature of the different parts of the molten magma. These, as they passed along the colder surfaces of the walls inclosing the mass would coat them with the sulphides, which being the earlier and less mobile crystallizations would be the first to crystallize out of any molten magma.

The foregoing would of course not hold were the granites and gneisses which have been found in nearly all cases to bound the greenstone near the deposits, proven to be of younger age than the greenstone. We should then have to explain the deposits as having taken their present form subsequent to the eruption of the greenstones. That the granites and gneisses are younger in many cases at least, is proven by their cutting into the greenstones in the form of stringers or small dykes near the junctions.

Partial view of East Smelter of the Canadian Copper Company, Copper Cliff, Ont.

Such is found to be the case near the Murray mine and several other localities in the district. The younger age of these granites and gneisses is now admitted by all authorities on the subject, still, some who have admitted it do not seem to have recognized the fact that, this being so, the deposits cannot have been formed along the contacts while the greenstones were still molten, as they intimate. In some cases cracks and cleavage joints in the greenstone are filled with thin seams of mineral matter pointing undoubtedly to aqueous action; while also the granites and gneisses near the contacts are sometimes found to contain specks of the sulphides. These facts, in conjunction with those pointed out in former parts of the paper, have caused the writer to form the opinion on the formation of the veins which he stated in the third theory. In the writer's opinion, such a theory violates no known laws, and harmonizes more with most of the principles which have been discovered in connection with these deposits, as well as conforming to the general principles laid down as the bases of nearly all vein formations.

MINING IN THE SUDBURY DISTRICT.

The mines of this region consist mainly of large open cuts and enormous so-called stopes, which are worked by what might be said to be a crude form of "underhand stoping." The walls of the mines are so solid that almost no timbering is required. The stringy and distributed nature of the deposits necessitates the cutting away of a large amount of rock material, and in one mine the Canadian Copper Co. are virtually slicing the top off of a large hill in the process of removing the ore.

OTHER NICKEL REGIONS.

Nickel has also been found in the United States, Norway, and New Caledonia, but the New Caledonia and Ontario deposits are the only ones now producing any considerable quantities of the metal. The Norway deposits, which are similar in character to those of Ontario, have produced some nickel in the past, but they are now about worked out. New Caledonia deposits consist of a hydrated silicate of nickel and magnesia called garnerite, after their discoverer.

Interior of West Smelter, Copper Cliff, Ontario.

They are bright apple-green in color, and are found at or near the contact of the clay with the inclosing serpentine in a stockwork-like formation, consisting of pockets or small veinlets traversing the mass in all directions. The ore averages about 10 per cent. nickel, after sorting with serpentine as gangue. The deposits are mined in a somewhat primitive fashion, mainly by large quarries, the red clay being first carefully stripped, and then the ore which lies immediately beneath is broken down and sorted by hand into rich and poor qualities. The former contains 8 per cent. or over of nickel, and the latter, which contains 3 to 4 per cent, is thrown aside as worthless.

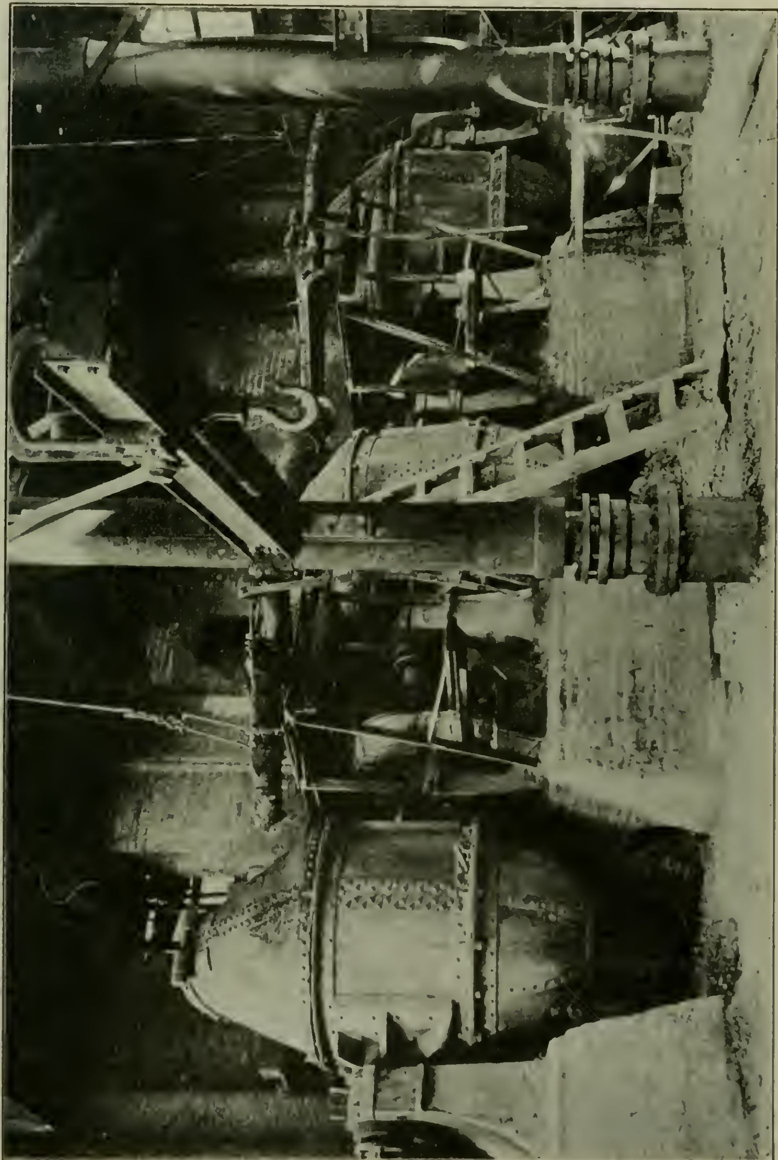
METALLURGY.

The process in vogue at the works of the C. C. Co. is to send the ore as it is brought from the mine to a structure called a rock-house, where it is sledged the proper size for a 15 x 9 in. Blake, set to about 1¾ inches, with a capacity of two hundred tons per hour to which it is fed. It then passes through a series of trommels, the fines passing a ¾ inch ring, mediums a 1¾ inch ring, and coarse a 4 inch ring. The coarse fall on bumping tables from which the ore and gangue is partially separated by hand-picking. The ore may now either be smelted "green," that is, without roasting, or it goes to the roast heaps, where it burns for from two to six months, thus oxidizing the sulphur, which is reduced in this way from about 24 per cent. or thereabouts to 2½ to 8 per cent. An average sample of the roast ore gave:

Copper	3.25	per cent.
Nickel	2.16	"
Sulphur	8.32	"
Iron	25.61	"

And the rest gangue.

Each heap contains from one thousand to four thousand tons of ore, the average being about two thousand tons, and they burn from two to six months, the time depending on their size. The place selected for the piles is first covered with fine ore distributed evenly over the clay soil, the ground around being well drained to prevent as far as possible the leaching out of the nickel and copper sulphates, then a



Converters at East Smelter, Copper Cliff, Ontario.

foundation of cordwood, stamps, etc., through which are arranged canals filled with kindling wood communicating to chimneys for the supply of draught. Then the interstices are filled up with small wood and chips, over which is laid the coarsest class of ore, then the mediums, next a layer of rotten wood or chips, then a layer of regular raggings and over all a layer of fines and flue dust. When sufficient of the sulphur is oxidized they are blasted up and the ore is sent to the smelter.

There are two smelters now at Copper Cliff with thirteen furnaces in all. The furnaces are water-jacketed and belong to the Herreshoff type, each having a capacity of a hundred and twenty-five tons per twenty-four hours. They are each supplied with a circular well, mounted on wheels which rest on a track so that the well may be easily pulled away in case of a freeze up or when the furnace is to be tapped out. The well serves as a settling chamber in which the slag and matte separates, and it also prevents the formation of "salamanders," which Peters says are the terror of copper smelters. The slag runs out from an opening near the top and the matte is drawn off from a lower opening at certain intervals, the duration of which depend on the ore being smelted. Every two furnaces are supplied with a flue dust chamber leading to a tall stack. These chambers are for the purpose of saving the flue dust, which carries about 7 per cent. metal. An analysis of a typical sample gave:

Cu........ 4.25 per cent. Ni ...... 3.37 per cent.

The ore is smelted with seven to eight tons of ore to one ton of coke; it is very seldom that any flux is required as the ore contains all the ingredients of an easily fusible and fluid slag. But when the charge is very high in iron or other bases, a little of the most acid greenstone is used. This is one of the excellent features of the Sudbury ores and one in which they surpass those from New Caledonia, as there is very seldom any room taken up in the furnace, or any heat lost in the smelting of extraneous fluxes, while no expense is incurred in the handling of such materials. The slag is a mono-silicate of iron and contains about 40 per cent. iron and 0.25 to 0.2 per cent. of nickel

Construction of Canadian Copper Company's branch line to Creighton Mine.

and copper being present in the form of specks of matte and not in the form of oxides as was formerly supposed. The slag either runs into troughs and is carried away on the dump by the waste water of the furnace jackets or is caught in pots and dumped into a ravine in the process of making a foundation for the extension of the smelter.

Low-grade matte, or that produced by the smelting of "green ore," is run into pots and spilled on a dump while still molten. When cool it is broken up and sent to the roast heaps, and after oxidation is re-smelted and issues from the furnace as "standard matte." The former carries from 8 to 15 per cent. metal while the latter carries from 25 to 42 per cent. An analysis of a typical sample of the former gave—

Cu........ 7.45 per cent. Ni........ 6.01 per cent.

and a sample of the latter gave—

Cu........ 20.35 per cent. Ni........ 16.48 per cent.

The standard matte is caught in pots which are dumped when cool, the matte being then broken up and sent to the smelting works of the Orford Co., situated about 500 yards south of the Copper Cliff mine. Here the matte is first pulverized in a Krupp ball mill of two hundred tons capacity per 24 hours, and is then fed to three straight line roasters whose dimensions are about 4 ft. high by about 150 ft. long by 25 ft. wide. These furnaces are continuous, the material inside being pushed along by a series of rakes fastened to an endless chain. The roasted material contains from 2½ to 3 per cent. sulphur, and is hoisted up by a bucket elevator to the charging floor of two brick cupola furnaces whose dimensions are 8½ ft. to charging floor and 12 by 7 ft. on a horizontal section, each being supplied with three charging doors.

The matte which issues from these furnaces contains from 65 to 80 per cent. metal. An analysis of a typical sample gave:

Cu........ 39.75 per cent. Ni........ 31.26 per cent.

The slag contains from 2.5 per cent. to 3.5 per cent. of metal and is resmelted. The matte is shipped to the Orford Copper Co. at Constable's Hook, New Jersey, where it is refined by the alkaline sulphide process, which depends on the fact that if a fairly rich nickel-copper matte be smelted with sulphate of soda and coal the sulphides of copper and iron unite with the sulphide of soda produced in the process, to form a very fusible mass, while the nickel sulphide known as "bottoms," which is of greater specific gravity, sinks to the bottom fairly free from the other two metals. Upon cooling, there is a distinct line of separation visible, and the nickel sulphide in a yellowish white mass is readily removed from the dark irridescent iron-copper matte.

The Canadian Copper Co. also have three converters which they sometimes use in the producing of 80 per cent matte, an analysis of which is given in a former part of the paper. During last summer they shipped two hundred tons of this matte to Cleveland. Ohio, to be refined at their experimental plant there. The converters are of the Manhes type and are supplied with hydraulic power. Their dimensions are: length, 7 ft. 3 in., diameter 5 ft. 8 in., number of tuyeres 12, diameter of tuyeres ¾ in. They have a capacity when newly lined of 1½ tons, with old lining 3 tons. The blowing engine which supplies them with draught is of the double cylinder simple slide valve type and maintains a pressure of six pounds of air per square inch when blowing one converter. The lining of the converter is the principal point on which the economic success of the process depends. It not only protects the furnace but it supplies silica for the formation of a silicate of iron slag. This has been found to be the only successful way of supplying silica to the charge. If supplied with the charge it simply floats on top, and if let in at the bottom it rises to the top without performing its function. The lining is composed of clay and silica, the clay giving to it plasticity, and protection to the furnace. An analysis of a sample of converter slag gave:

FeO	67.6 per cent.	Cu	1.2 per cent.
SiO_2	27.5 "	Ni	1.4 "
S	0.5 per cent.		

The converters are first heated by burning wood in them, and then the charge which has been melted in a small melting furnace on the upper floor, is run in by troughs, the converters are swung into place and the blast started with low pressure at first, then full pressure for about forty to fifty minutes. The end of the reaction is told by the temperature of the flame and by the flakes of slag blown out of the converter, which as the end is approached become large and frothy. The blast is then turned off and the metal is allowed to settle for a few minutes, then the converter is revolved, and after the slag is spilled off the matte is turned into molds.

NICKEL IN THE ARTS.

Nickel has a specific gravity of 8.3 to 8.9 per cent., an atomic weight of 58.6 and an atomic volume of 6.6. Its melting point is about the same as that of steel, depending on the amount of carbon present. Specific heat is about 0.108 to 0.110. Nickel is slightly stronger than pure iron, is harder and withstands oxidation by moisture and steam much better. When heated to redness no perceptible oxidation is noticeable: it is slowly soluble in hydrochloric and sulphuric acids, and is readily soluble in dilute but remains passive in concentrated nitric acid. Nickel is used in plating and as an alloy in the manufacture of German silver. When alloyed with iron and steel it forms a remarkable series of metals. It has the greatest range of adaptability of any alloy and so has met with a very great amount of popular approval, and its use is rapidly becoming as much recognized as that of carbon or manganese steel. On the addition of nickel to iron or steel its greatest influence is shown in the limit of proportionality while the ultimate strength and to a high degree the elastic limit is increased. An alloy of 8 per cent. of nickel with pure iron has 3.8 times the elastic strength of pure iron. Nickel is now being used for a great many purposes, among which might be mentioned rails for railroads, armour for armour-clads, rifles and small arms, a specification for which from the United States government stated that 4.5 per cent. of nickel must be present in the steel. Nickel steel is also used in the manufacture of rivets, tubing, and bicycle parts, also in tool steels and a number of machine parts for which its peculiar strength, ductility and incorrodibility gives to it especial fitness.

All nickel steel alloys are remarkably homogeneous, easily workable and susceptible to high polish. Some nickel alloys have been used recently for electrical purposes on account of their peculiar property of losing magnetism when heated and regaining it when cooled, and there now promises to be a great demand for nickel in the future, for the new Edison storage battery alone, while all of the above uses point to a demand which will tax to the utmost the vast resources of the mines of Ontario. This is well shown by the price of nickel now being from 50 to 60 cts. a pound on an open market, while a few years ago it was less than half of this on a restricted market.

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The writer wishes to acknowledge his sincere gratitude to Prof. W. G. Miller for many kind suggestions and much patient instruction.

MEETINGS.

ANNUAL GENERAL MEETINGS.

MONTREAL,

4TH, 5TH, AND 6TH MARCH, 1901.

The annual general meetings of the members were held in the Winds r Hotel, Montreal, on Tuesday, Wednesday, and Thursday, 4th, 5th, and 6th March. There was, as usual, a large attendance of members, including many ot the students attending the mining classes at McGill and the School of Mining, Kingston.

The following, among others, were present:—C. Shields, General Manager Dominion Coal Co., Sydney, C.B.; P. L. Naismith, General Manager Alberta Railway and Coal Co., Lethbridge, Alta.; W. H. Aldridge, Canadian Smelting Works, Trail, B.C.; Hon. J. H. Ross, Commissioner of the Yukon Territory, Dawson, Y.T.; T. W. Gibson, Director of the Bureau of Mines, Toronto; J. Obalski, M.E., Inspector of Mines, Quebec; Dr. Eugene Haanel, Superintendent of Mines, Ottawa; Dr. Robert Bell, Acting Director, Geological Survey, Ottawa; J. C. Drewry, Canadian Gold Fields Syndicate, Rossland; James McEvoy, Crow's Nest Pass Coal Co., Fernie, B.C.; Dr. J. B. Porter, M.E., Prof. of Mining Engineering, Montreal; Dr. W. Goodwin, Director School of Mining, Kingston; P. Kirkgaard, M.E., Canadian Gold Fields, Deloro, Ont.; E. D. Ingall, M.E., Chief Div. of Mineral Statistics, Ottawa; Prof. W. G. Miller, School of Mining, Kingston; Prof. T. L. Walker, Prof. of Mineralogy, Toronto University, Toronto; Alex. B. Allan, (Allan, Whyte & Co.) Glasgow, Scotland; J. A. Hanway, Colonial Copper Co., New York; J. T. McCall, Canada Iron Furnace Co., Montreal; Dr. Frank D. Adams, McGill University, Montreal; H. M. Wylde, Sec. Mining Society of Nova Scotia, Halifax; Wm. Blakemore, Mining Engineer, Montreal; John E. Hardman, S.B., Mining Engineer, Montreal; Milton L. Hersey, M.A.Sc., Montreal; George R. Smith, M.L.A., Bell's Asbestos Co., Thetford Mines, Que.; R. T. Hopper, Standard Asbestos Co., Montreal; E. W. Gilman, Canadian Rand Drill Co., Sherbrooke, Que.; Eugene Coste, Mining Engineer, Toronto; Dr. A. E. Barlow, Geological Survey, Ottawa; Dr. R. A. Daly, Geological Survey, Ottawa; Dr. R. W. Ells, Geological Survey, Ottawa; Dr. H. M. Ami, Geological Survey, Ottawa; R. W. Brock, Geological Survey, Ottawa; Jules Coté, Secretary Department of Mines, Quebec; E. R. Faribault, Geological Survey, Ottawa; A. A. Bowman, Canadian Rand Drill Co., Toronto; D. D. Mann, MacKenzie & Mann, Toronto; S. J. Simpson, James Cooper Manufacturing Co., Montreal; J. E. Boss, Spokane, Wash.; Chas. D. Maze, Civil Engineer, Montreal; Prof. G. R. Mickle, School of Practical Science, Toronto; D. W. Robb, Robb Engineering Co., Amherst, N.S.; E. P. Mathewson, Metallurgist, Montreal; Andrew MacKenzie, Dominion Coal Co., Montreal; Daniel Smith, Ontario Powder Works, Kingston; W. T. Rodden, Hamilton Powder Co., Montreal; Robert Chalmers, Geological Survey, Ottawa; Hugh Fletcher, Geological Survey, Ottawa; J. A. Dresser, M.A., Richmond, Que.; J. M. Clark, K.C,, Toronto; Frederick Hobart, Mining Engineer, New York; J. E. Rothwell, Mining Engineer, Tweed, Ont.; Chas. F. C. Hansen, Jas. Cooper Mnfg. Co., Montreal; W. W. Leach, Geological Survey, Ottawa; H. W. De-Courtenay, (Firth & Sons) Montreal; Captain Robert C. Adams, Montreal; Joseph James, Actinolite, Ont.; W. H. Smith, M.E., Canada Iron Furnace Co., Montreal; O. N. Scott, Listowel, Ont.; C. M. Doolittle, Hamilton, Ont.; J. B. Tyrrell, Mining Engineer, Dawson, Y.T.; C. O. Senecal, Geological Survey, Ottawa; C. P. Hill, Kitchener, B.C.; C. F. Ludwig, Mine Superintendent Dominion Coal Co., Sydney, C.B.; B. T. A. Bell, Editor CANADIAN MINING REVIEW, Ottawa.

TUESDAY MORNING SESSION.

The opening session was held on Tuesday morning, 4th March, in the Library of the Institute, Mr. J. E. Hardman, in the absence of the President through illness, presiding.

The Minutes of the last Annual Meeting having been published in Vol. IV of the Journal of the Institute were held as read. The following new members were elected at this and the later sessions of the Institute:—

A. A. Bowman, Canadian Rand Drill Co., Toronto, Ont.
Professor T. L. Walker, University of Toronto, Toronto, Ont.
John E. Rothwell, Mining Engineer, Tweed, Ont.
W. H. Smith, Canada Iron Furnace Co., Montreal, Que.
Frederick Hobart, Mining Engineer, New York, N.Y.
B. J. Forrest, Mining Engineer, Thornhill, Ont.
Alfred C. Garde, Mining Engineer, Payne Cons. Mining Co., Sandon, B.C.
Phelps Johnson, General Manager, Dominion Bridge Co., Montreal, Que.
C. P. Hill, Kitchener, B.C.
Hon. J. H. Ross, Commissioner Yukon Territory, Dawson City, Y.T.
C. F. Ludwig, Mines Superintendent, Dominion Coal Co., Glace Bay, C.B.
Dr. R. A. Daly, Geological Survey, Ottawa, Ont.
B. A. C. Craig, General Manager, Canada Corundum Co., Toronto.
Spencer L. Dale Harris, Ottawa.
Erne Dill Harris, Kingston, Ont.
H. W. McInnes, Mining Engineer, Halifax, N.S.
Lt. E. Dale Harris, C.E., Wei Hai Wei, China.
J. C. Drewry, Canadian Gold Fields Syndicate, Rossland, B.C.
Hamilton Lindsay, C.E., Toronto, Ont.
Allan Dale Harris, Montreal, Que.

SECRETARY'S REPORT.

Mr. B. T. A. BELL—While the past year's operations in mining and metallurgical enterprise have been greater than at any period in the history of the Dominion, and there has been a very remarkable expansion in the production of coal and coke, iron and steel, nickel, copper and asbestos, the mining industry in certain districts of the West suffered from a depressed market for silver and lead, strikes, and, perhaps, more than to any other, from the natural and inevitable reaction following upon a period of unwholesome speculation in mines and mining shares. Later on in this report, I hope, as I did last year, to submit a few notes and statistics reviewing the more prominent features of mining activity in the various provinces and I only refer to this depression now as it has to some extent reflected upon the affairs of the Institute and may account for the fact that our membership does not show as large an increase as it did this time last year.

MEMBERSHIP.

At 31st December last our membership had increased to 331 as compared with 323 in 1900, 277 in 1899, and 192 when the Institute was reorganized under its present Charter in 1898.

It is also pleasing to note that while as usual at our Annual Meeting we lose a number of members our strength will be maintained, if not increased, by the acquisition of those who have been elected since the printed list was distributed, and by others, whose names will be submitted for your approval at this meeting.

Our Student Membership will, it is gratifying to report, be considerably reinforced by the affiliation en bloc of the members of the Mining Society of McGill, under a special clause in the By-Laws, recommended for your adoption by the Council.

The thoroughly representative character of our membership, embracing as it does the best elements in the profession and industry of mining in Canada, and its distribution by provinces and countries, will be seen by a reference to the printed list sent to members in January.

MEMBERS REMOVED BY DEATH.

It is my painful duty again to record the loss of three members by death since our last meeting together.

Mr. Lionel Shirley, Civil and Mining Engineer of Montreal, a gentleman who took a deep interest in the affairs of the Institute, died early in the year in the Western States whither he had gone on account of poor health. Latterly Mr. Shirley had been engaged in railway engineering but he will be remembered as one of the pioneers in the palmy days of phosphate mining on the Lievre and as the engineer who opened up that remarkable deposit of muscovite mica known as the Villeneuve Mine.

Mr. James F. Lewis, President of the Canadian Rand Drill Company of Sherbrooke, Que., who died after a long and painful illness, at Boston on July 23rd. A member of the Council, he was a never failing attendant at all its meetings, often at great inconvenience to himself and his business, while he was ever ready to give his time and his energy to promote the best interests of our organization. In the death of genial, big-hearted "Jim" Lewis the Institute has indeed sustained a severe and irreparable loss.

Mr. J. Roderick Robertson, General Manager of the London & B. C. Gold Fields, Limited, of Nelson, B.C., killed by an explosion of dynamite, in the Murray Hill Hotel, New York on 27th January. Mr. Robertson was one of the most widely known and respected mining men in British Columbia. A shrewd, far-seeing, highly capable man of business, genial, kindly and generous in disposition, "Rod." Robertson was greatly liked by every one and the conspicuous success of the large mining corporation of which he was the active head, was very largely due to his enterprise and ability.

MEMBERS SERVING IN SOUTH AFRICA.

In my last report attention was called to the fact that four members of the Institute were with different regiments in South Africa. Captain J. Edwards Leckie, D.S.O., M.E., of Greenwood, B.C., who served with distinction as an officer in Strathcona's Horse, accompanied by his brother Captain R. G. Leckie, M.E., of Vancouver, B.C., and Captain Bruce Carruthers of Kingston, all members of the Institute, have again volunteered their services on behalf of the Empire and are now serving in South Africa with the 2nd Canadian Mounted Rifles. Major Hamilton Merritt who has gone out as second in command of this fine regiment is also a well known Canadian Mining Engineer and at one time was a member of the Council of the Institute.

MEETINGS AND PUBLICATIONS.

The Annual Meetings of the Institute were held at Montreal on 6th, 7th and 8th March and were, as usual, exceedingly well attended. Twenty-three papers were presented and these, together with the transactions of the Institute during the year, constitute the fourth volume of our Journal published and distributed to members in June. This volume was widely distributed among the principal British, American, European, and Colonial mining societies and it was favorably noticed by the leading mining journals, a number of them reprinting some of the papers.

The other publications were: 500 copies of the Secretary's Annual Report; 300 copies of Dr. Adam's paper on the "Iron Ores of Bilboa;" 50 copies of Professor Miller's paper on the "Iron Ore Fields of Ontario;" and 500 copies of the List of Members.

STUDENT'S COMPETITION.

Three very creditable papers were presented to our transactions in competition for the President's prize, the Council ultimately awarding the medal to Mr. C. V. Corless, of McGill, for his description of the "Coal Creek Colliery" of the Crow's Nest Pass Coal Co.

SUMMER EXCURSION.

Very complete arrangements were made for an excursion during the first week of September to the nickel, copper and iron mines of Sudbury and Sault Ste. Marie returning by way of the Hastings County gold mines, but as it was found impossible at the time to get such an attendance of members as this important field warranted the event was postponed.

LEGISLATION.

In accordance with a resolution adopted at the Annual Meeting a deputation from the Institute had an interview at Ottawa with the Premier, the Right Hon. Sir Wilfrid Laurier, and other Ministers, and asked for the disallowance of the "Act to Amend the Mines Act" adopted by the Ontario Government in 1900, imposing prohibitory taxation on copper and nickel ores. It is satisfactory to know that while the Dominion Government did not disallow the Act its constitutionality will be made the subject of a special test case between the two Governments at no very distant date.

LIBRARY AND READING ROOM.

Our collection of books, periodicals, maps, photographs, etc., has been considerably extended during the year, the following, among other works on mining and metallurgical practice being added: Schnabel's "Metallurgy", two vols.; Locke's "Gold Milling;" James on "The Cyanide Process," and Vol. IX of the "Mineral Industry." A large number of exchanges and periodicals were also bound and the photographs suitably framed. This collection, now a very valuable one, has attained such dimensions that the present quarters in the Windsor Hotel are becoming too small for its proper accommodation and it will be necessary very soon to seek additional premises either in the hotel or elsewhere.

The Report was adopted.

RESOLUTIONS OF SYMPATHY.

Mr. WM. BLAKEMORE having referred in feeling terms to the loss sustained by the death of Mr. J. Roderick Robertson moved the following resolution:—

"That the Canadian Mining Institute in Annual Meeting assembled desires to place on record its sense of the serious loss sustained by this Institute and by the mining community of British Columbia in particular through the lamented death of the late MR. RODERICK ROBERTSON and wishes to extend to his family its sincere sympathy in their bereavement."

The CHAIRMAN referring to their late co-worker Mr. James F. Lewis, intimated that he hoped to contribute to their Transactions an obituary note referring to his services to the mining industry and to the Institute.

TREASURER'S REPORT.

Mr. J. STEVENSON BROWN presented his statement of accounts duly audited covering the year ended 31st. January showing : Receipts $4590.61; Disbursements $3,633.21; Cash balance on hand $957.40.

The report was adopted.

AMENDMENTS TO BY-LAWS.

The SECRETARY submitted copy of the By-Laws containing certain amendments recommended by the Council.

These were on motion adopted.

CANADIAN SOCIETY OF CIVIL ENGINEERS' BILL.

The CHAIRMAN—The Canadian Society of Civil Engineers is again seeking legislation in the Ontario and Manitoba Legislatures with the object of making it a close corporation in these Provinces. The bill was considered at a meeting of the Council last evening and it was decided to refer further action upon it to this meeting.

Mr. COSTE—The Bill is not so bad as it used to be. The exemption of the members of our Institute and those engaged in mining seems to cover the ground very well.

Mr. BELL—Let the other engineers—those who are not members of the Society—fight it if they want to.

The CHAIRMAN—When we look at this thing as members of the Instiiute we have no kick coming.

Dr. ADAMS—As an Institute we can guard ourselves as individuals.

Mr. BLAKEMORE—In the practice of my profession I may be called upon to survey or build a railroad. Would I not be required, under this Bill, to belong to the Canadian Society of Civil Engineers ?

Dr. W. L. GOODWIN—I think the Institute has one or two courses open to it with regard to this Bill. In Section 2 " No person shall be entitled within the Province of Ontario......to act or practice as a civil engineer" ; the term Civil Engineer is not defined here or elsewhere in the Bill. In Sec. 4 we find " All By-Laws of the Society shall be valid and shall be deemed to apply"—if enacted would this not give the Canadian Society of Civil Engineers what would amount to legislative powers? With regard to definitions, examination of the Quebec Act shows that the Society defines a C. E. to cover every kind of engineer whatsoever and there is nothing in this Bill to prevent them, if the Bill becomes law, from defining it in the same way in Ontario. In Section 2, Clause D "unless he is entitled to do so as the holder of a diploma or of a degree conferred by some institution of learning in the Dominion of Canada so to do." In this clause, the words "unless he is entitled to do so" are indefinite and Section 4 would give the Society power to make all By-Laws, define the kind of diploma or degree which would entitle the engineer to practice as a C. E. (also defined by the By-Laws of the Society). Section 2, Clause E together with Section 4 would give the power to apply any test whatever to engineers coming into Canada from Great Britain or the United States and while I do not wish to impute any unfairness or motive it would manifestly be unwise to give such powers to a Society which represents only a section of the engineering profession. Section 8 is as broad and fair as a qualification could possibly be made. It reads "This Act shall not be deemed to apply to members of the Canadian Mining Institute in so far as concerns their operations as mining or metallurgical engineers or in any way whatever in the management or operation of mines or metallurgical works." This power can be worked so as to inflict hardship on mining engineers and metallurgical engineers and on their employers. Had this Act been in operation during the past two years it might have been used to prevent, or to interfere with the designing and construction of the extensive projects and shipping facilities of the Helen iron mine under the provision of "Any other than a member of the Canadian Society of Civil Engineers." The whole objection to the Bill can be summed up as follows:—It must be first shown that legislation is necessary and that the engineering profession is suffering from the lack of it, and when this is established it must then be shown that it would be wise to confer such powers to a body duly representing a section of the engineering profession of Canada. I contend that such action would neither be wise nor just. If restrictive powers are to be given at all they should be given to some Society or Association which represents the whole engineering profession. Therefore, Gentlemen, I think the duty of the Institute is plain, not to touch the Bill at all in any way but let it meet its fate in the Ontario Legislature. (Applause.)

Mr. J. STEVENSON BROWN—The whole mining interests of Ontario might prejudiced by the passing of this Act and it is our duty to oppose it.

Mr. B. T. A. BELL—The Bill hasn't got a thousand to one chance of passing anyway.

THE CHAIRMAN—After hearing Dr. Goodwin's very lucid statement of objection to the present Bill it seems to me to be the duty of the Institute to enter the fight again.

Dr. ADAMS—While fully approving of what Dr. Goodwin has said it seems to me we are expressly exempted as mining engineers from the operations of this Act. The supposition of Mr. Blakemore that he would be denied the right to design or construct a railway or dam seems to be very fully provided for by the exemption in favor of members of our Institute.

DR. GOODWIN—The clause under C.E. in this Act is to be interpreted by the By-Laws of the Canadian Society of Civil Engineers. My objection is that the Act relegates to this Society, a body only representing a section of the engineering profession, powers which can by these By-Laws be made to apply to the whole profession.

After some further discussion the Secretary, on motion, was instructed to wire the Chairman of the Private Bills Committe in Ontario and Manitoba Legislatures protesting against the passage of any such legislation in favor of the Canadian Society of Civil Engineers.

SCRUTINEERS APPOINTED.

On motion, Messrs. H. W. DeCourtney and W. Blakemoie were appointed Scrutineers for the election of officers.

APPOINTMENT OF AUDITORS.

On motion, Messrs. George Macdougall and H. W. DeCourtney were re-elected auditors for the ensuing years.

SUMMER EXCURSION.

The SECRETARY suggested that the excursion postponed last year, visiting the Sudbury, Sault St. Marie and Hastings County mining districts be, if possible, carried out this year. He also suggested that as these districts would be of particular interest to them, the members of the Lake Superior Mining Institute might be invited to participate in these excursions as the guests of the Institute.

Mr. COSTE—It would be to our advantage to have them with us.

The suggestion meeting with hearty approval of the members it was agreed to leave the details in the hands of the Secretary.

The meeting adjourned at one o'clock.

TUESDAY AFTERNOON.

The members assembled in the Club Room at three o'clock, Mr. J. E. Hardman in the Chair.

The CHAIRMAN, having called the meeting to order, expressed the regret of himself and the members at the unavoidable absence through illness of their President Mr. Chas. Fergie.

The following papers were read by title:—

1. Notes on Gold Dredging.
   By F. Satchell Clarke, Vancouver, B.C.
2. On a Method of Mining Low Grade Ore in the Boundary District, B.C.
   By Frederic Keffer, M. E., Anaconda, B. C.
3. On The Copper Bearing Rocks of the Eastern Townships.
   By John A. Dresser, M. A., Richmond, Que.
4. On the Analysis of Insolubles.
   By Douglas Lay, A.R.S.M. Nelson, B.C.
5. Notes on Wire Ropes.
   By W. D. L. Hardie, M. E., Lethbridge, N.W.T.
6. Notes to Accompany Plan and Drawings of the Athabasca Mine, Toad Mountain, B.C.
   By E. Nelson Fell, A.R.S.M., London, England.

ORES OF THE BOUNDARY DISTRICT.

Mr. R. W. BROCK of the Geological Survey gave an interesting address on the geological features and character of the ores of the Boundary Creek District of British Columbia.

A paper by Dr. Ledoux of New York on Copper Production in the same district was taken as read, Dr. Ledoux being unable to reach Montreal in time for the meeting in consequence of the floods.

DAWSON AND SELWYN PORTRAITS.

The CHAIRMAN—Before going on with the papers I would like to call your attention to the fact that we have with us the Acting Director of the Geological Survey, Dr. Robert Bell, and in the absence of the President, it becomes my duty to present to him for the Survey the portraits of two of its former Directors. These portraits were purchased by funds entirely separate from the Institute. We all recognize the great services rendered by them to make known the mineral wealth of this country. I have much pleasure in presenting them to the Survey on behalf of the Institute.

Dr. ROBERT BELL—I have to thank you all for your liberality in subscribing to the funds for these two splendid portraits of my predecessors—Dr. Selwyn and Dr. Dawson. The former was Director for twenty-five years and before that held positions in Australia and Great Britain. Dr. Dawson was on the Survey since 1875 and was Director for the last six years. The portraits will be very welcome to us. We have the portrait of Sir William Logan and now with these will make the three Directors. I have only again to thank you for the kindly thought which prompted the presentation of these portraits.

PRESENTATION OF THE STUDENT'S MEDAL.

The CHAIRMAN then called for Mr. C. V. Corless, an undergraduate of McGill, and on behalf of Mr. Fergie presented him with the President's gold medal awarded by the Council for the best paper contributed during the year to the Transactions of the Institute.

Mr. CORLESS briefly and suitably replied.

MINING PROGRESS IN CANADA DURING 1901.

Mr. B. T. A. BELL—Last year in my Annual Report to the members I incorporated a review of the principal features of our mining progress during the previous year. That statement was found to be of some service to the members and is my excuse for again presenting to you such authentic figures as I have been able to gather together respecting the mineral development of the Dominion during 1901. From figures furnished direct to me by the courtesy of the mine managers, and the returns given by the various Provincial Bureaus of Mines, a conservative estimate would place the total value of the mineral production of the Dominion in 1900 at a little over seventy millions of dollars, distributed as follows :—

YUKON.	
Gold, Silver, Coal	$18,500,000
BRITISH COLUMBIA.	
Gold, Silver, Copper, Lead, Coal, Coke, etc....	20,713,501
ALBERTA, ASSINIBOIA, MANITOBA.	
Coal, Gold, Gypsum, Platinum, Building Material	1,700,000
ONTARIO.	
Copper, Nickel, Iron, Steel, Gold, Silver, Zinc, Arsenic, Corundum, Natural Gas, Petroleum, Salt, and other products....................................	11,712,188
QUEBEC.	
Asbestos, Iron and Steel, Chromite, Graphite, Mica, Ochres, Barytes, etc.....	3,500,000
NEW BRUNSWICK.	
Copper, Manganese, Coal, Gypsum, Building Material etc	1,000,000
NOVA SCOTIA.	
Coal, Coke, Iron, Steel, Gold, Gypsum, Grindstones, Building Material..............................	13,000,000
Estimated Total Mineral Production of the Dominion of Canada in 1901................................	$70,125,689

COAL.

In its relative value to the trade and commerce of the country the greatest of our mineral industries is unquestionably the production of coal which shows a considerable increase in tonnage and values over any previous year in the history of coal mining in Canada, From figures furnished direct to me from the collieries a close estimate would place the total quantity of coal mined in Canada in 1901 at 5,748,845 tons of an estimated value at the pithead of not less than $18,000,000. The distribution of this output was as follows:—

From Nova Scotia	3,834,360	tons.	
" British Columbia....................	1,529,210	"	
" Alberta, Assiniboia and Manitoba....	370,275	"	
" New Brunswick.......	10,000	"	
Yukon............................ ..	5,000	"	
Total Coal Raised in 1901..............	5,748,845	tons.	5,748,845 tons.
Bituminous Coal imported during the year	3,135,158	"	
Total Bituminous Coal.....	8,884,003		8,884,003 tons.

And Exported

To Great Britain..................	29,909 tons.	
" United States..................	1,395,142 "	
" Newfoundland..................	83,153 "	
" Other Countries..................	65,457 "	1,573,661 tons.
		7,310,342 "
We also imported Anthracite Coal.......		2,024,383 "
Making the total consumption of coal in the Dominion during the past calendar year..................		9,334,725 tons.

COKE.

The product of our coke ovens will also show a considerable increase. Returns show the output from Nova Scotia to have been 241,936 tons and from British Columbia 134,760 tons, or a total coke output of 376,696 tons. During the year we exported 57,505 tons and imported 652,710 tons.

IRON AND STEEL.

As Mr. Drummond will, doubtless, deal very fully with these industries in his paper, I will only briefly summarize the returns forwarded to me, showing as they do a very marked and extremely gratifying expansion over previous years.

ORE PRODUCTION.

Province of Nova Scotia:—		
Mined by Nova Scotia Steel Co............		18,619 tons.
Province of Quebec:—		
Mined by Canada Iron Furnace Co..........	11,808 tons.	
Shipped by Ottawa & Gatineau Valley Railway	750 "	
Other estimated..........................	1,000 "	13,558 "
Province of Ontario:—		
Mined by Lake Superior Power Co..........	261,203	
Shipped from Madoc via G.T.R............	305 "	
" " Trenton via G.T.R.........	2,134 "	
Add difference to balance figures reported by Bureau of Mines......................	8,896 "	272,538 "
Total Iron Ore mined in Canada in 1901....		304,715 "

IRON ORE IMPORTED.

By Dominion Iron and Steel Co:—		
From Spain..........................	23,411 tons.	
" United States..........................	16,428 "	
" Cuba..........................	11,191 "	
" Newfoundland..........................	385,329 "	
		436,359 tons.

By Nova Scotia Steel and Coal Co :—

From Newfoundland	32,801 tons.	
" Cuba	117 "	
		32,918 "

By Canada Iron Furnace Co :—

From United States........................	9,275 tons.	
		9,275 "

By Hamilton Steel and Iron Co :—

From United States........................	56,849 tons.	
		56,849 "

By Deseronto Iron Co :—

From United States........................	17,602 tons.	
		17,602 "

Or total Ore Imports of........................... 553,003 tons.

RECAPITULATION.

From Newfoundland........................	418,130 tons.	
" United States....	100,154 "	
" Cuba........................	11,308 "	
" Spain	23,411 "	
		553,003 tons.

IRON ORE EXPORTED.

During the calendar year we exported as per Trade and Navigation Returns 306,244 tons of iron ore of an estimated value of $774,673.

PIG IRON MADE.

Province of Nova Scotia :—

Dominion Iron and Steel Co.................	111,014 tons.	
Nova Scotia Steel and Coal Co...	26,793 "	
		137,707 tons.

Province of Quebec :—

Canada Iron Furnace Co....	5,400 tons.	
Macdougall & Co..........................	656 "	
Electrical Reduction Co.......	300 "	
		6,356 "

Province of Ontario :—

Canada Iron Furnace Co	33,648 tons.	
Deseronto Iron Co..........................	9,975 "	
Hamilton Steel and Iron Co.................	67,512 "	
		111,135 "

Total Pig Iron made in Canada................. .... 255,198 tons.

PIG IRON EXPORTED.

Trade and Navigation Returns show that 57,600 tons of a value of $593,739 were exported during the calendar year.

STEEL MADE.

Province of Nava Scotia :—

Nova Scotia Steel and Coal Co., Ingots........	25,678 tons.

Province of Ontario :—

Reported by Bureau of Mines........... 14,471 tons of a value of $347,280

Total Steel made.............. 40,159 tons

IRON AND STEEL BOUNTIES PAID.

The following bounties were paid by the Dominion Government during the fiscal year ended 30th June last :—

ON PIG IRON.

Canada Iron Furnace Co :—	
Radnor Forges—	
Production to June 30th, 1901—	
5,463,945 tons from Canada ore at $3..........	$16,391 83
111,565 tons from foreign ore at $2.........................	223 13
Midland, Ont :—	
Production 7 m. to June 30th, 1901—	
18,948,10 tons from Canada ore at $3..................	56,844 30
1,162,525 tons foreign ore at $2.........................	2,325 05
Deseronto Iron Co :—	
Production 14 m. to June 30th, 1901—	
54 tons from Canada ore at $3.....	162 00
13,653 tons from foreign ore at $2.........................	27,306 00
Dominion Iron and Steel Co :—	
Production 5 m. to June 30th, 1901—	
27,643,695 tons from foreign ore at $2...	55,287 39
Electric Reduction Co., Buckingham :—	
Production January, 1900 to April, 1901—	
391 tons from Canada ore at $3.........................	1,173 00
Hamilton Steel and Iron Co :—	
Production 13 m. to June 30th, 1901—	
15,033,16 tons from Canada ore at $3.............	45,099 48
38,678,07 tons from foreign ore at $2......................	77,356 14
John McDougall & Co :—	
Production January 1st to May 14th, 1901—	
79,315 tons from Canada ore at $3.........................	2,379 46
Nova Scotia Steel and Iron Co :—	
Production 13 m. to June 30th, 1901—	
9,897,295 tons from Canada ore at $3......................	29,691 88
18,509,705 tons from foreign ore at $2.	37,019 41
	$351,259 07

BOUNTY ON PUDDLED BARS.

Hamilton Steel and Iron Co :—

Production 13 m. to June 30th, 1901—

5,567,695 tons at $3	$16,703 09

BOUNTY ON STEEL INGOTS.

Hamilton Steel and Iron Co :—

Production 13 m. to June 30th, 1901—

9,436,985 tons at $3	28,310 96

Nova Scotia Steel Co :—

Production 13 m. to June 30th, 1901—

23,915,595 tons at $3	71,746 78
	$100,057 74

IRON AND STEEL EXPORTS.

(As per Trade and Navigation Returns.)

Stoves	$ 7,438
Castings	67,140
Machinery	470,136
Sewing Machines	18,279
Scrap	168,438
Hardware	95,213
Steel	416,796
Bicycles	381,569
Parts Bicycles	78,547
Total exports	$1,703,556

OUTPUT OF GOLD.

From Yukon	$18,000,000
" British Columbia	5,596,700
" North West Territories	40,000
" Nova Scotia	620,000
" Quebec	1,440
" Ontario	244,443
Total gold production	$24,502,583

OUTPUT OF COPPER.

From British Columbia	$4,951,698
" Ontario	627,080
" New Brunswick	100,000
Total copper production	$5,678,778

IMPORTS OF COPPER.

Scrap	$ 6,133
Ingots	121,562
Bars	593,344
Sheets	270,591
Tubing	42,729
Rollers	10,111
Rivets	6,828
Wire	99,540
Cloth	604
Other	49,405
	$1,200,847

OUTPUT OF LEAD.

British Columbia	50,529,260 lbs. of a value of	$1,970,641
Quebec shipped	554,000 " " "	11,350
	51,083,260 lbs.	$1,981,991

LEAD IMPORTS.

Pig	$137,561
Bar	69,178
Pipe	11,293
Shot	1,932
Other	53,105
Nitrate	12,533
Tea	50,145
	$335,747

NICKEL MATTE.

Ontario, as reported by Bureau of Mines	$627,080

SILVER.

From British Columbia, 4,685,718 ozs. of a value of	$2,624,002
" Yukon	125,000
" Ontario, 151,400 ozs. of a value of	84,830
" Quebec (in concentrates) estimated	5,000
Total silver production	$2,838,832

The quantity exported as shown by Trade and Navigation Returns was 3,513,500 ounces of a value of $2,016,727, and bullion exported during the first six months of the year of a value of $8,865 or a total of $2,025,592.

ASBESTOS PRODUCTION.

The production of this valuable mineral is entirely confined to the Province of Quebec and during 1901 was the largest in quantity and value since this industry was established in the early eighties. Returns of shipments show :—

Via Quebec Central Railway :—		
From Coleraine	64,000 lbs.	
" Black Lake	9,520,551 "	
" Thetford Mines	48,431,750 "	
	58,016,301 lbs. or	29,008 tons.
Via Grand Trunk Railway :—		
From Danville		5,468 "
Via Ottawa Northern and Western :—		
From Low	40,880 lbs. or	20 "
Total Asbestos shipped		34,496 tons.

ASBESTIC.

Via Quebec Central Railway :—		
From Black Lake	2,301,040 lbs. or	1,150 tons.
Via Grand Trunk Railway :—		
From Danville		4,758 "
Total Asbestic shipped		5,908 tons.

Of these shipments, Mr. Obalski, the Government Inspector of Mines has sent me the following distribution by grades :—

No. I	2,083	tons of a value of	$348,579
No. II	2,660	" "	263,855
Fibre	14,659	" "	450,193
Paper stock	14,054	" "	211,688
Asbestic	6,831	" "	10,114
Total	40,287	" "	$1,284,429

These shipments were to Great Britain, United States, Germany, France and other countries.

COPPER PYRITES.

The production of this mineral which for many years has been confined to the Eustis and Nichols mines in the Eastern Townships of the Province of Quebec was augmented in 1901 by two new sources of supply in the same district and by the output from a promising mine in the Township of Massey, Ontario. A portion of this was utilized for the manufacture of sulphuric acid and other chemicals in Canada. The value of the year's production would probably approximate about $160,000 of which Mr. Obalski estimates that $126,000 came from the Province of Quebec.

CHROMITE.

The Eastern Townships of Quebec, as in former years, furnish the output of this mineral, which may be placed at $50,000. Mr. Obalski estimates that the shipments of No. I grade amounted to 528 tons of a value of $9,424 and 610 tons of No. II valued at $7,320 with a balance on hand at the end of the year of 350 tons of No. I and 3,200 tons of No. II. It is worthy of note that several hundred tons have been used at Buckingham by the Electrical Reduction Company in the manufacture of ferro-chrome. One of the many remarkable things brought out by an examination of the Trade and Navigation Returns is that these quote the shipment of 759 tons at a valuation in excess of $30.00 per ton, a figure entirely out of proportion to the market prices for this mineral.

MICA.

The production of Mica was, as in previous years, confined to the Provinces of Ontario and Quebec and in 1901 would approximate $200,000. A feature of the year was the largely increased home consumption of mica for electrical insulation, its use in the manufacture for boiler coverings, and the steadily growing demand for it in Great Britain and on the Continent. The exports during the calendar year were:—

To	Cut.		Trimmed.	
	Lbs.	Value.	Lbs.	Value.
Great Britain......	54,199	$17,024	47,750	26,394
United States.	203,537	49,846	11,329	1,547
Other Countries....	4,440	1,690	3,230	427
	262,176	68,560	62,309	28,368

To	Untrimmed and Ground.		Total.
	Lbs.	Value.	Value.
Great Britain.... .	20,160	5,070	48,488
United States......	269,856	49,834	101,227
Other Countries....	4,285	721	2,838
	294,301	55,625	152,553

GRAPHITE.

This industry, although still not a very large one, gives evidence of growth and promises to assume larger dimensions in the near future. The bulk of the production in 1901 came from Ontario but the acquisition of the strong company recently organized in the United States to work the Walker Mine at Buckingham, Que., should give an impetus to the production of this valuable mineral during the present year. The exports during the calendar year are reported to have been 21,653 cwt. of a value of $35,102. During the same period we imported plumbago, crucibles and other manufactures of graphite of a value of $55,564.

PHOSPHATE.

The production of this, at one time, one of the prominent mineral industries of the Dominion, was, as last year, confined to the quantity raised as a by-product of mica mining in the Provinces of Quebec and Ontario and probably did not exceed a value of $10,000 of which Mr. Obalski estimates that $6,280 was furnished by Quebec. It is, however, significant that the Trade and Navigation Returns show an import of this mineral from the United States of a value of $8,219 presumably for the Electrical Reduction Co. at Bnckingham, Que., once the great centre of phosphate production in Canada.

OTHER MINERALS.

Trade and Navigation Returns for the year show the other exports to have been:—Felspar 4,369 tons of a value of $10,973 ; Antimony (from Quebec) 10 tons of a value of $1,643; Manganese 440 tons of a value of $4,820; Slate 16,750 tons of a value of $10,000; Salt 39,224 bushels of a value of $6,510; Ochres 801,553 lbs. of a value of $7,233; Gypsum crude 235,995 of a value of $231,385; manufactured ditto of a value of $15,333; Oil crude and manufactured, $36,425; Granite, Limestone, Bricks and other building materials $158,066; Grindstone crude and dressed, $8,688.

BRITISH COLUMBIA.

This Province occupied the leading position among the mineral producing territories of the Dominion, the value of her mineral production in 1901 having increased from $16,344,751 in the previous year to $20,713,501. Mr. W. F. Robertson, the Provincial Mineralogist, in a bulletin issued last month, estimated the quantity and value of the various products as follows :—

	1900.		1901 (Estimated).	
	Quantity.	Value.	Quantity.	Value.
Gold, placer.......ozs.	63,936	$1,278,724	43,204	$892,500
" lode .... "	167,153	3,453,381	227,696	4,704,200
Silver . ... "	3,958,175	2,309,200	4,685,718	2,624,002
Copper..... .....lbs.	9,997,080	1,615,289	30,736,798	4,951,698
Lead............. "	63,358,621	2,691,887	50,529,260	1,970,641
Coal.........long tons	1,439,595	4,318,785	1,529,210	4,587,630
Coke........ "	85,149	425,745	134,760	673,800
Other materials	....	251,740	....	309,030
Totals..........	....	$16,344,751	....	$20,713,501

Writing to me under date of 1st February, Mr. Robertson briefly reviews the features of the year's progress, as follows :—

"This estimate, I am satisfied, will be found 'within the mark' when the final statistics are completed. It will be seen that the total gross value of the output, including coal, etc., has this past year increased some 25 per cent., while the product of the lode mines has increased from $10,069,757 to $14,250,541, or about 40 per cent. The tonnage of the lode mines for 1901 is estimated at 909,223 tons as against 554,796 in 1900, an increased output of about 64 per cent.

The value of the coal and coke industry is estimated as $5,261,430, as against $4,744,530 for 1900, an increase of over 10 per cent., and this is limited only by the limited market and defective transportation facilities, matters soon to be remedied.

These figures speak rather eloquently of the progress of the Province as a mineral producer. To review the Province by districts:—

As yet the *Northern districts* are entirely placer gold producers, and this year there is a decrease of some 35 per cent. in placer gold output. This is to be accounted for as follows :—

In *Atlin district* the camps are about changing from sluicing to hydrulic methods, and the couple of hydraulic plants expected to have made an out-put were tied up by legal squabbles between themselves and also with the owners of individual claims.

The *Chilkat section* has done nothing, partly owing to excessive rainfall, causing floods which three times washed away all works.

In the *Cariboo district* the hydraulic mines, notably the Consolidated Cariboo Hydraulic Company, found themselves short of water supply during the last part of the season, owing to the sudden warm weather in spring carrying off the snow very rapidly and so leaving no supply for the later months.

In *East Kootenay* lode mining is largely confined to low grade silver-lead ores, and the market price for such ores has been so exceedingly low as to leave little, if any, profit to the mines.

This is one of the most serious problems in the Province to be faced and cannot be here discussed. Relief from these conditions is hoped for by the establishment of a lead refinery now under construction. This section would have shown a considerable decrease but for the increased output of coal and coke.

IN WEST KOOTENAY.

Slocan has about held its own both in tonnage and values, the higher silver contents of the Slocan ores enabling shipments to be made despite the low market for lead-bearing ores.

Nelson is expected to make a very considerable increase owing to the increased out-put of gold ores and to the resumption of shipping of ore from the Silver King mine (Hall Mines Ltd).

Trail Creek has always been a "storm centre" and had its share of labor troubles, but, somehow or other, the yearly out-put has increased despite certain stoppages.

In *Yale district* productive mining is practically confined to the *Boundary* section, where the enormously increased output of very low grade copper-gold-silver ores has been brought about by the establishment of transportation and smelter facilities.

The *Coast district* has about held its own both in coal and lode mining, a number of copper properties have come forward and promise much for the future.

The increase in production during the past year has been a very agreeable surprise to most people, so persistent have been the attempts on the part of certain unsuccessful operators to circulate reports to the contrary effect.

The so-called "labour question" has caused much uneasiness, but I think such is unwarranted. There is no doubt but that the mine labour obtainable in the Province is, on the average, very poor, chiefly through inexperience. Under normal conditions this would soon remedy itself, but when the tonnage out-put increases at the rate of 64% per annum it is quite impossible to expect that miners can be trained at that rate.

The rates of wages for this class of labor are very high as compared with the other provinces of the Dominion, but the demand for such labour is so great that it is no wonder that the men demand, and get, high wages.

It is recognized that many of the low grade properties cannot go on paying such wages; this means a delay until conditions are readjusted by time and an increased population. The only important strike that occurred during the year was in the Rossland camp, and this, I am glad to say, has been adjusted."

YUKON TERRITORY.

While there has been a shrinkage in the value of the gold production, the progress of mining in the Yukon has been entirely satisfactory, the total output during the past year being estimated at about eighteen and a half millons of dollars, as follows:

Gold dust and bullion received at Government Assay Office Seattle	$10,915,000
Purchased by United States Mint and Selby Smelting Company, San Francisco	6,680,000
Add dust not reported and dust used in Territoryas a medium exchange say	1,000,000
Or an estimated production of	$18,500,000

The production during the preceding years was:—1897, $2,500,000; 1898, $10,000,000; 1899, $17,500,000, and in 1900, $28,000,000. A district which has produced over $73,000,000 in five years must take rank not only as Canada's greatest gold-field but as one occupying a leading position among the gold-fields of the world.

Mining in the Yukon territory has been assuming a condition of much greater stability than prevailed during the previous years, and among the men who are acquainted with or are interested in the Klondyke gold fields there is a greater feeling of confidence and assurance that the richness and extent of the gold-bearing area is only just beginning to be truly appreciated. It is quite true that some of the richest spots on Eldorado and Bonanza Creeks have been almost worked out, often quite regardless of the cost at which the work was being prosecuted, for, let the working costs be ever so high, these costs still, in the cases of some of the richest claims, amounted to but a small percentage of the gross output of the mines. Although these claims are now seriously depleted, and although there may be no other part of the Territory where three miles and a half of a creek valley will yield twenty-five or thirty million dollars' worth of gold, as Eldorado Creek has done, still there are extensive tracts, in the bottoms of valleys, and on terraces along their sides underlain by gravel rich in gold, from which the precions metal will be washed out in large quantities for many years to come. The existence of the very rich pockets, such as those on Eldorado Creek, encouraged extravagance of every kind, but with the depletion of these profits, and the realization of the idea that the wealth of the country lies chiefly in its lower grade gravels, better machinery and organization and more economical methods have been introduced, and the district is entering a state of solid and quiet prosperity, founded on moderate profits, and moderately remunerative work for a large number of people, rather than on excessive profits and very high wages for a few.

In 1898 the method of mining all the deeper gravels, which are frozen from the surface down to bed rock, and far into bed-rock, was, in winter, to pick down through the frozen wall or "muck," then build fires in the bottom of the shaft so begun, and shovel out the gravel so thawed until bed-rock was reached. At the bottom of the shaft so sunk fires were laid against the sides of the gravel, and drifts were carried from thirty to forty feet away rom the shaft, the ground thawed and mined being hoisted by handwindlasses and piled in dumps to be washed when the streams began to flow in the spring. In most cases the wood used was hauled to where it was needed by dogs. As the ordinary rate of wages for labor of all kinds was $1 an hour, this style of mining was very expensive, and none but the richest ground would pay a profit over working expenses. The next year thawing by steam was introduced, small boilers were taken to the mines, and used, not only to thaw the ground, but also to operate hoisting engines to raise the pay-dirt mined in the drifts to the surface. Then larger boilers were imported, pumps were set up to pump water, when water by gravity was difficult to obtain, and, finally, pulsometers were installed underground to pump hot water against the face of the gravel, and thus thaw the pay-dirt with hot water instead of with steam. While at first this underground mining was all done in winter, now, with the use of steam or hot water it can be done either in winter or in summer, and, if in the latter season, the pay-dirt can be mined, hoisted, dumped from self-dumping buckets into sluice boxes, and the gold washed from it in one continuous operation. During the past summer, most of the men who went to the Yukon were laborers who went with the intention of working for wages and making the best living possible. Many of the old-timers brought in their wives and families, and a spirit of general contentment has taken the place of the grumbling, unrest, and discontent of previous years.

In his report to the Hon. the Minister of the Interior the Hon. James H. Ross, Commissioner of the Territory, points out that the great requirement of the Territory is cheaper transportation. Every reduction in freight rates, every reduction in the cost of living in the Yukon makes possible the introduction and operation of a higher class of machinery and cheaper production of gold. At the present time, ground that could not be worked at a profit a year or two ago can now be successfully mined. It is confidently anticipated that large areas which have already been mined to the full extent that they probably could be at the time they were mined under the then existing conditions can soon be wholly re-worked at handsome profits. Transportation has been the serious obstacle to cheap mining. The expense, not only of getting things into the country, but of moving them from one place in the country to another, has been enormous. Many instances can be furnished where thrice, four, five, and ten times the cost paid for an article at Vancouver or Victoria for getting that article into position on some mining claim twenty or thirty miles from Dawson. He has endeavoured to aid in the cheapening of transportation within the Territory by providing for the expenditure of every available dollar upon the construction of a circle of roads connecting all the important mining creeks with Dawson, which is the centre of supply for the Territory. The road construction has been mapped out on a large scale, with the view of having each year's operations tend towards completion of a general system calculated to meet to the fullest extent the fullest possible needs of the people.

Last year, in this report, I referred to the development of the deposits of lignite on Rock Creek and Cliff Creek. The output of this coal during the year is estimated to have been about 5,000 tons, of a value at the pit of about $50,000. Silver to the estimated value of $125,000 was also won.

The total royalty collected up to 1st July last year, after deducting the exemption allowed by the regulations was $2,192,645.41 ; of which $596,368.03 was collected during the year ended 30th June last.

Up to July 1st, 1901 there were recorded 24,524 placer claims, 2,793 quartz claims, 16,573 renewals and relocations, and 25,020 assignments of claims. To the same period 59,449 free miners' certificates were issued, producing a revenue of $596,168.62 and during the last fiscal year 12,511 miners' certificates were issued yielding a revenue of $125,861.

Leases now in force to dredge for minerals in the submerged beds of rivers in the Yukon cover 270 miles. The total revenue received for leaseholds up to July 1st, 1901 was $139,655.50 and for the last fiscal year $2,650.

It is further worthy of remark that the general revenue from the Yukon during the year ended 30th June last, viz.: 2,011,311.07 is the largest on record, being an increase of $207,787.01 over 1899-1900. The Government Assay office, established at Vancouver, treated up to 1st January last 465 deposits, representing 57,221 ounces gold of a value of $939,654.41.

As an encouragement to miners to have their gold assayed at this office, the government has passed a regulation by which miners who personally deliver their gold at the office are refunded one per cent. on the net value of the gold upon which they have paid royalty, so that in the case of the rich miners the royalty is reduced to only four per cent.

GOLD DREDGING IN THE YUKON AND ON THE SASKATCHEWAN.

Leases now in force to dredge for minerals in the submerged beds of rivers in the Yukon cover 270 miles and in the North West Territories 911.75 miles. The total revenue received by the Dominion Government for dredging leases in the Yukon up to 1st July, 1901 was $139,655.50 and for the fiscal year $2,650. The total revenue received for the rent of the leaseholds in the North West Territories up to July 1st, 1901 was $20,262.71 and for the past fiscal year $3,000.

On the Saskatchewan gold dredging is emerging from the experimental stage and gives promise of becoming a successful industry. Hitherto, the chief difficulty has been the saving of the fine gold but it is claimed that Mr. Hobson, the manager of the Saskatchewan Gold Proprietary, Ltd., who had two dredges, the Minto and Otter, at work intermittently on the river last season, has overcome this. Mr. McDonald, Chairman of the Universal Corporation and a New Zealand dredging expert of some standing, who has been supervising the operations of the Proprietary company claims that process of mining has centered down to one and one only successful method, that is the ladder and endless chain system.

Dipper dredges have been tried and found too slow ; suction dredges have had their pipes cut out and the principle has been abandoned. The ladder and endless chain system has been the only one to prove successful. The Otter, Minto, and Alberta, the three dredges which were worked this summer, were fitted with this style of machinery, but none of them proved entirely satisfactory. The reason of this partial failure was not in the weakness of the principle but in the weakness of the machinery. The machinery had been designed in England by supposed to be competent mining engineers, but was found altogether too weak in parts to do the work which it was called on to do in dredging into solid gravel banks. Thus numerous breakdowns occurred and it was always some weak link in the machinery which was found to have given away. The Minto was launched on 4th of May, but it was not until July that the dredge could be got to work. She was run for only short intervals during the summer, the breakdowns being of frequent occurrence, and at last was condemned with her machinery and laid up for complete overhauling next season. The Otter made by far the best run of the three, though even she did not run like anything of her theoretical capacity. Probably at no time during the season did she run at more than ten cubic yards per hour, bar measurement. Her results would have necessarily have been much larger had she not been forced, through having no coal tender, to work on bars in the vicinity of the town which had been worked over by grizzley miners for the past thirty years.

The Minto worked about 2,000 cubic yards, her machinery being very unsatisfactory, and though much of the gold was lost, through these defects, she is reported to have saved at the rate of 28 cents per cubic yard. With all the dredges the amount of gold washed was not so great as it might be, but the amount of gold saved for each yard of gravel washed was quite satisfactory.

ALBERTA.

The output from the collieries at Anthracite and Canmore were 14,742 and 88,499 tons respectively, a total of 103,241 tons compared with 98,000 tons produced in the previous year. Lethbridge collieries of the Alberta Railway and Coal Co. also show an increase in production amounting to 35,233 tons, the output for the year being 217,034 tons as compared with 181,801 tons in 1900. The selling price of these coals f.o.b. at Winnipeg was $9.00 for Anthracite and $7.50 for bituminous coal.

Although the discovery of a first class coking coal along the line of the Crow's Nest Railway is not new, still nothing had been done towards its development till last summer, when the possibilities of profitable investment appears to have drawn the attention of capitalists to this field. The value of this coal, particularly to Eastern British Columbia where it can be utilized in the reduction of ores can hardly be estimated, while the coal measures are of such great extent that the working can hardly fail in time to be profitable. Mr. H. L. Frank and associates are expending a large amount of money in opening up their property at Blairmore.

ASSINIBOIA.

The production of lignite at Roche Percee will show an increase over previous years it being estimated that quite 43,000 tons were consumed in Manitoba and the Territories as far west as Regina. The selling price of this coal f.o.b. Winnipeg was $3.75 ; at Melita $2.60 ; at Brandon $3.20 ; and at Regina $3.30.

MANITOBA.

Of the large number of quartz claims taken up in 1898, 1899 and 1900 not more than fifty are to-day in existence and little or no development has taken place on any of them. Reference was made last year to the establishment of works by the Manitoba Union Mining Company for the treatment of Gypsum deposits located in the vicinity of the north eastern arm of Lake Manitoba and of the large deposit of natural cement in the Pembina Valley. Returns from the company show that the output of cement was about 5,000 barrels and the output of Gypsum 600 tons, and the management state that this output will be very largely increased during the present year. The price realized for the company's cement f.o.b. cars at Arnold, on the Morris Brandon branch of the C. P. R. is $2 per ton ; $13 per ton was realized at Winnipeg for the output of Gypsum. A mill has been erected at a cost of $15,000 and a steamer transports the plaster to Westbournes Delta, the terminus of the Canadian Northern Company's branch line at the southern end of Lake Manitoba.

At Lac du Bonnett, an elaborate brick plant has been established by the Lac du Bonnett Mining Developing and Manufacturing Company to exploit an extensive deposit of excellent clay. It is said that although the present daily output is only 30,000, the machinery has a capacity of 75,000 brick per diem. This deposit has been proved to be of value for the manufacture of brick, vitrified brick and drain tiles.

ONTARIO.

The mineral industry in Ontario made satisfactory, and in some branches, rapid progress during 1901. The chief metals characteristic of the Province are iron, nickel and copper, in all three of which large advances were made in quantity and value of output. The production of iron ore last year amounted to 272,533 tons as against 90,302 tons raised in 1900. The greater portion of the ore was from the Helen mine at Michipicoton owned by the Clergue interests. Search for other ore bodies has been very active. A large extent of "iron ranges" has been located, and energetic prospecting by diamond drills and otherwise is now going on. Sanguine men look for a duplication of the Mesabi and Vermillion ranges in Western Ontario. Three blast furnaces running steadily throughout the year made 116,370 tons of pig iron valued at $1,701,703 as compared with 62,386 tons worth $936,066 in 1900. Steel was produced by the open-heart process to the amount of 14,471 tons valued at 347,280 as against 2,819 tons worth $46,380 the previous year.

The nickel mines of the Sudbury region increased the quantity of their output by 25 per cent. and the value by 130 per cent. The brisk demand and good prices which have prevailed during the year have led to more extensive operations, the matte which is now being produced being of much higher grade than formerly. The latter circumstance accounts for a considerable part of the increased value. During the year the Mond Nickel Company at Victoria Mines put their smelters in blast, and are now turning out an 80 per cent. matte by the bessemer process. The bulk of the production, however, remains at the credit of the Canadian Copper Company, whose low grade mattes are ground, calcined and re-smelted at the Ontario Smelting Works erected by Col. Thompson of the Orford Copper Company, which came into operation during the year. A noticeable feature of the year was the opening of the Creighton mine in the southwest corner of Snider township from which 500 or 600 tons of ore are being shipped daily to the smelters at Copper Cliff. This mine has every indication of proving to be an enormous deposit. The Manitoulin &

North Shore Railway extending westward from Sudbury serves this mine as well as several other nickel properties, two of which, the Gertrude and the Elsie, are owned by the Lake Superior Power Company. A considerable tonnage of ore has been raised from these mines, and roast heaps have been inaugurated at the Gertrude of ore from both mines. Smelters are also to be erected there.

The yield of precious metals was somewhat smaller than in 1900, 14,293 ounces of gold worth $244,443 being produced as against 18,767 ounces worth $297,861 the previous year. The Mikado, Sakoose and Sultana mines in northwestern Ontario have remained steadily at work, and about the beginning of 1902 were joined by the Black Eagle, formerly the Regina, where a new thirty-stamp battery has been installed. In eastern Ontario the Deloro and Belmont mines have been doing good work. The production of arsenic at the former has also been greatly increased.

The yield of silver was 151,400 ounces worth $84,830 as against 160,612 ounces valued at $96,367 in 1900. Consolidation has recently taken place by which the West End, Porcupine, Badger, East End and Keystone mines have passed under the control of a new company. It is expected to undertake large operations and increase the present output.

The out-put of non-metallic minerals shows a small increase in value over 1900, the total being $6,785,791 as against $6,733,338. There was a decided increase in building materials, and a falling off in petroleum. The other principal items remain at pretty nearly the same level The decrease in petroleum is partly due to the natural diminution in the output, which is about five per cent. less than in 1900, and in part to the fact that a larger proportion of crude than formerly is now used for fuel and in the making of gas. Natural gas also fell from $392,823 to $336,183. The decrease was partly due to the stoppage by the Ontario Government of the export from the Essex field to Detroit, which took place near the close of the year.

The making of cement is now assuming considerable proportions in the Province the out-put being 489,288 barrels as against 432,154 barrels in 1900. Some complaint is made of American competition and the out-put, though larger, was a little smaller in value, being estimated at 670,880 as against $698,015.

Carbide of calcium was produced to the value of $168,792 as compared with $60,300 in 1900. Corundum worth $53,115 and arsenic worth $41,677 were also notable products.

The results of the year have been to demonstrate the importance and value of the mining industry iu the Province, and were such as to lead to sanguine expectations for the future.

I am indebted to the courtesy of Mr. Gibson, the Dtrector of Mines, for the following table showing the

MINERAL PRODUCTION OF ONTARIO FOR 1901.

PRODUCT.	1900.		1901.	
	Quantity.	Value. $.	Quantity.	Value. $
Metallic:				
Copper.... .. .. lb.	6,728,000	319,681	9,074,000	627,080
Gold .... oz.	18,767	297,861	14,293	244,443
Iron Ore ....tons.	90,302	111,805	272,538	174,428
Nickel . ... lb.	7,080,000	756,626	8,882,000	1,731,650
Pig Iron ....tons.	62,386	936,066	116,370	1.701,703
Silver .... oz.	160,612	96:367	151,400	84,830
Steel ....tons.	2,819	46,380	14,471	347,280
Zinc ore ....tons.	500	500	1,500	15,000
Total Metallic		$2,565,286		$4,926,379
Non-Metallic:				
Arsenic...............lbs.	600,000	22,725	1,389,056	41,677
Building Materials—				
(Brick,stone,lime,etc.) tons.		2,688,351		3,034,854
Carbide of Calcium .....tons	1,005	60,300	2,771	168,792
Cement .... bbls.	432,154	698,015	489,288	670,880
Corundum . . .. lb.	120,000	6,000	1,068,000	53,115
Petroleum........Imp. gals.	23,381,783	1,869,045	21,433,500	1,467,940
Natural Gas		392,823		336,183
Salt ....tons.	66,588	324,477	60,327	323,058
Other Products		671,602		689,292
Total Non-Metallic.....		6,733,338		6,785,791
Add Metallic		2,565,286		4,926,397
Total Production		$9.298,624		11 712,188

QUEBEC.

The production of asbestos was the outstanding feature of the year in Quebec, the total value of the output being estimated to have been not much short of a million and a half dollars, the largest in the history of the industry. Three modern and splendidly equipped milling plants were installed at Thetford Mines, three at Black Lake, and one at Broughton. Seven companies operated all the year round and three others intermittently, occupying a force of about 1500 men. It is expected that with no change in the market twelve companies will be in operation in 1902 requiring a force of at least 2000 men. The other mineral products of the Province were iron ore, chromite, mica, felspar, copper pyrites, galena, burnt ochre, barytes, phosphate, and building material.

NEW BRUNSWICK.

Mining in New Brunswick was mainly confined to the production of copper, manganese, gypsum and building materials. A small quantity of coal was also won. At Dorchester the Intercolonial Copper Company mined 40,000 tons and have installed a first-class mining and treatment plant.

NOVA SCOTIA.

Mining progress in Nova Scotia was again chiefly remarkable for the continued and very gratifying expansion in the production of coal, coke, iron and steel. As already stated the total output of coal for the twelve months was in excess of 3,800,000 tons an increase of quite 500,000 tons over the production in 1900 and a result very largely, if not entirely, brought about by the operations of the Dominion Coal Company which raised 2,561,783 tons as compared with 1,999,737 tons in 1900. This company delivered 863,633 tons to St. Lawrence ports; it exported about 600,000 tons to the United States, principally for gas and coke-making; and the balance of its production practically went to the Sydney steel works.

The Dominion Iron and Steel Company has now its furnaces and convertors running and this enterprise will very shortly be operating on a large scale, which means, unless some untoward change takes place in the trade that we are assured of a very material increase in our coal consumption during the present year. The output of the Province for the year was reduced by something like 70,000 tons of American coal purchased for the Intercolonial Railway.

The Nova Scotia Steel and Coal Co., have continued their regular operations at the Sydney Mines Pit, and have completed the construction of an up-to-date coking plant. They are engaged now in building a new shipping pier, and in opening the Lloyd's Cove seam.

In Inverness County considerable progress has been made in development. The Port Hood Colliery has been placed on a good footing for shipping coal. At Broad Cove, the development of that field has been steadily advanced in a substantial manner by the Inverness and Richmond Collieries and Railway Company.

American capital has taken hold of the Mabou district, and is preparing to win the submarine areas.

In Pictou County the only development of note has been the opening of one of the Marsh seams by the Nova Scotia Steel & Coal Co. It is stated that the coal from this opening is specially adapted for use in the convertors of the Company, and that the entire output of the mine will be absorbed for this purpose.

In Cumberlaed County the development of the Springhill reserves of coal has been continued in a satisfactory manner, and the collieries have been overhauled and refitted in every respect. Much interest has been taken during the year in explorations in the other districts of the Province yielding indications of the presence of coal. The Provincial Government acquired some time ago five drills, two of these were of the "Calyx" pattern, and have proved very successful. The other drills are the Bullock pattern, two being hand-drills, and the other a steam drill. These drills have been licensed to parties in various parts of the Province for prospecting for various minerals, and have proved highly successful. The results of explorations in the new coal fields appear, as far as carried out, to give proof of the presence of a number of seams of coal of good quality, and as a rule of about the thickness of the smaller seams worked in Cumberland County.

The following returns of the output of the var'ous collieries during the twelve months have been compiled from figures furnished to me by the managers:—

COLLIERY RETURNS 1901.

Dominion Coal Co	$2,561,783
Cumberland Railway and Coal Co	411,000
Acadia Coal Co	270,253
Nova Scotia Steel and Coal Co	237,184
Intercolonial Coal Co	204,402
Canada Coals and Railway Co	68,055
Gowrie and Blockhouse	20,700
Port Hood Coal Co	20,000
Cape Breton Coal Co	13,534
Inverness and Richmond	13,500
Sydney Coal Co	8,949
Other, estimated	5,000
	$3,834,360

COKE MADE.

Dominion Iron and Steel Co	192,873	tons.
Acadia Coal Co	11,738	"
Intercolonial Coal	5,305½	"
People's Light and Heat Co	8,480	"
Nova Scotia Steel and Coal Co	23,540	"
Total	241,936	tons.

PIG IRON AND STEEL MADE.

Dominion Iron and Steel	pig iron	111,014	tons.
Nova Scotia Steel and Coal Co	"	26,793	"
do do	steel ingots	25,678	"

Gold Mining in Nova Scotia has practically remained stationary, the output being about 31,000 ozs.

The Richardson, Blue Nose, Brookfield, and most of the other regular producers report satisfactory yields. A number of new mines have been opened; but in a number of cases further work has shown that they cannot be depended on for permanent outputs.

The most encouraging feature of gold mining in the Province is the preparation being made to open the Dolliver Mountain district by a strong American syndicate. This lies on the same belt as the Richardson, and is believed to present even larger beds of medium grade ore. An up to date mining and milling plant is being installed by this company.

The gold and silver contents of the ores of the Cheticamp River in Inverness county have contined to attract the attention of the Cheticamp Mining Company, and it is reported that they are now able to effect a classification of the lead and zinc ores of that district, so as to put them in a marketable concentrated shape. The result of these operations will be watched with much attention for there are numerou, indications in that district of the presence of mineral deposits of auriferous copper and lead ores.

The production of pig iron as stated was 137,807 tons. The only company carrying on iron ore mining operations was the Nova Scotia Steel and Coal Companys which mined about 18,000 tons at Bridgeville, Pictou County.

A little over 418,000 tons of Bell Island ore were imported for the furnaces at Sydney and at Ferrona. Ore was also imported from the United States, Spain and Cuba.

The explorations for iron ore were not marked with much spirit. A little work was done on the Whycocomagh deposits which resulted in tracing beds of ore still further north. The explorations completed at Nictaux in Annapolis County have shown clearly the enormous extent and great value of the iron ores of that district.

The remainder of the mineral production of Nova Scotia continued much as in previous years. The export of Gypsum was about 136,000 tons in addition to small quantities used lccally for fertilising and architectural purposes.

The production of limestone was about 100,000 tons largely used for the furnaces at Sydney and Ferrona.

A few hundred tons each of Barytes and Infusorial earth were reported from various points.

The exploitation of the copper ores of Cumberland and Colchester Counties is being continued. At present a smelter is being erected near Wentworth with a capacity of 25 tons a day. At Cape D'Or, in Cumberland County, the Colonial Copper Company has done a lot of preliminary work on beds in the trap carrying metallic copper. It is stated that the indications are promising for a rich and extensive deposit.

The CHAIRMAN—I would call the attention of the members to the enormous amount of work entailed in getting these figures together by our Secretary (applause).

After some discussion by Messrs. Ingall, the Secretary, Chairman, and others, on the various methods adopted in Canada of computing values, and the necessity of adopting a greater uniformity in the dates of publication of statistics by the Provincial and Dominion Governments, the meeting adjourned at 5.30.

TUESDAY EVENING SESSION.

The members assembled at eight o'clock, Mr. Cornelius Shields, General Manager of the Dominion Coal Co., occupying the chair.

GOVERNMENT AID TO MINING.

Mr. C. SHIELDS, in taking the chair, expressed his pleasure at meeting the members of the Institute. It was a great honor to preside over such a distinguished gathering, particularly on the occasion of the discussion of such a question of so much moment as Government aid to Mining. The proposal to establish a Dominion Department of Mines, was a move in the right direction, one which had already been too long deferred.

Mr. J. E. HARDMAN then introduced the question in an excellent address, reproduced elsewhere in full in this issue. He dwelt upon the national importance of mining and of the urgent necessity of the establishment at Ottawa of a Department which would give special attention, not only to economic geology, but to the various phases of mining and metallurgical development which had of late years assumed a leading position in the industrial progress of the Dominion.

Dr. F. D. ADAMS—The question, "How may the government of a country promote the interests of mining and the development of its mineral resources?" is one which may find various answers according to the character of the country and the financial position of the government.

In every civilized country of the world at the present time there is a national geological survey, and the principal and avowed aim of these surveys is the development of the mineral resources of their respective countries. That is to say it is the universal opinion among the civilized peoples of the world that geological surveys are of practical benefit to them.

The law establishing the United States Survey provides that the Director shall have charge of the Mineral resources and products of the national domain." Now we in Canada are blessed with a very extensive national domain and comparatively limited financial resources, and the question which faces us is how can we best with the means at our disposal set about developing our mineral wealth.

I believe the most effectual way in which the government can do its share towards this development consists in increasing the efficiency of, and, if necessary, entirely remodelling an institution which we already have and which in times past has done good work for the Dominion. I refer to our Geological Survey, and would like to point out certain ways in which the efficiency of this valuable institution could be increased and the services which it renders to the country be made of more direct practical value.

The first and chief aim of all national geological surveys is the preparation of a good geological map of the country. On this is shown the distribution of the various rocks which form the earth's crust in these countries, and the position and distribution of all known mineral deposits. These maps also show the connection of the mineral deposits in question with certain geological formations, and hence, the distribution of the formations in question being shown, the areas in which additional occurrences are to be sought. This areal mapping has been carried on for years by the Geological Survey of Canada and a considerable part of the more settled portion of the Dominion has been mapped. The value of many of these maps has been very widely recognized. I might cite as samples : Lawson's Geological Maps of the Lake of the Woods and the Rainy River District, which were of immense value in the development of that region; the maps by Dr. Geo. M. Dawson, of various portions of British Columbia, and Mr. Fletcher's maps in Nova Scotia.

This work should be continued until we have a good geological map of all those portions of the Dominion which are worth surveying geologically.

I believe, however, that this work, which occupies the greater portion of the staff of the Geological Survey of Canada, might be carried out in a much more efficient manner than it is at present. We have to remember in the first place that in Canada there are no topographical maps. The township maps, issued by the Crown Lands Departments of the various Provinces, consist of a series of lot and range lines with a few lakes and streams indicated where they cross, or sometimes where they do not cross, the lines in question. They are innocent of all delineation of roads, hills, etc., not to mention contour lines. Some of these maps are tolerably accurate so far as they go, while others are intolerably inaccurate. When an attempt is made to put a series of these township maps together they cannot be made to fit. Like the Gentiles, each is a law unto himself. Further trials also await the man who, having compressed a series of these maps into compact form, endeavors to hang them unto the proper projection. He will find that this is, in almost every case, impossible. In the case of a map which Dr. Barlow and I recently made for the Geological Survey of Canada, of a large district in Central Ontario, it was found impossible to ascertain within four miles the position of one of the principal villages in the area, and special lines of transit survey had to be made from the Georgian Bay to Kingston to determine the precise location of this and other points upon the projection.

Now, in order to show the geological structure of any district, a good topographical map is absolutely necessary, and the geologist, with us, has to make it for himself. When, therefore, he undertakes the geological survey of any district he is obliged to spend, let me say three-quarters of his time in doing topographical work and one-quarter of his time in geological investigation. This is manifestly a great waste of time and money, for the geologist, who commands a higher salary than the topographer, spends most of his time doing topographical work which generally he cannot do as well as a specially trained topographer, while in some cases a man who is really a topographer is selected to make the survey and his geological work is accordingly of very indifferent quality. The general rule that a man cannot do two things well at the same time governs here, although for years the Canadian

Survey have been endeavoring to show that it does not hold. In their case we may safely say that the exception proves the rule.

When we turn to the geological surveys of other countries we find that they employ a separate and distinct class of skilled topographers, who go into the area first and make a topographical map which is then handed to the geologist who uses it as the basis for his work. In order to make the Canadian Survey more efficient this plan should be adopted. The regular field staff should consist of two sections: —(1) topographers, and (2) geologists. The former class should be the more numerous and would not command such high salaries as the geologists. Each class would thus be enabled to do its work thoroughly and well and I venture to say that under this arrangement the geologists would accomplish much more work than they can do at present, and the geological maps *could be prepared and published more rapidly*, thus avoiding the delay in issuing maps of important areas, which is in many cases at present unavoidable. Under this plan of working moreover we would have in the case of every area surveyed, not only a good geological map but a good topographical map, which would have a value of its own for many diverse purposes.

The "folio" exhibited shows how the work of the United States Geological Survey is carried on in this direction. The country is divided up into quadrangles, which vary somewhat in size according to the circumstances of the case; and the survey of these quadrangles is taken up in the order of their relative economic importance. When the survey is completed the information which has been collected is presented in four maps, as follows:—

1. The topographical map of the area, which is uncoloured.

2. The geological map.

3. A second geological map, giving special prominence to all occurrences of deposits of special economic value.

4. A map with geological sections crossing it in certain lines which bring out clearly the geological structure of the area in question.

These maps are accompanied by a short explanatory text. These "folios" form part of the great geological and topographical map of the United States now in course of construction. Some fifty of them have been already published and they now appear at the rate of about ten per annum. I was informed recently by the Director of the United States Geological Survey that there was not a single important mining area in the United States from which he had not had applications asking that the necessary surveys be made and one or more of these folios issued for the districts in question.

Now, while in Canada we cannot undertake to do work so rapidly as this and while this precise form of publication is probably not the most suitable for us, we can certainly obtain many hints from these folios of the United States Geological Survey which will enable us to improve our Canadian maps.

There is another class of work which should be undertaken by the Canadian Geological Survey, and which would be of the greatest practical value to the country. This is "Mining Geology," and consists in the preparation of detailed reports or monographs on certain limited areas where mineral deposits of great economic value are known to exist. These reports should be accompanied by geological maps on a large scale, and should embody the results of as complete a study of the area as is possible, in which all resources of modern knowledge are brought to bear upon the problems presented, and comparisions drawn with foreign areas of similar character, from the development and working of which much valuable information bearing on the areas surveyed could often be obtained. The reports should be clearly written, in language "understanded of the people," so that they would be of direct practical value to all interested, either in the area in question, or in mineral deposits having the character of those described. Prompt publication of such economic work is specially imperative, for its value as an aid to development decreases with every day and almost every moment of delay. As districts worthy of such study one might mention, among many others, the Copper-Nickel district of Sudbury, the Chromic Iron Ore district of the Eastern Townships, and the Iron Ore regions of certain portions of Ontario. How many camps in British Columbia would, during the past two or three years, have profited by such special study, and how many would even now profit by it ?

For this work I believe geologists of special fitness and training should be selected, who might or might not be permanently connected with the Staff of the Survey. With proper assistance from the Topographical Staff and the Chemical Department, the work should go rapidly forward. It might frequently be found advantageous to secure the services of outside geologists or mining engineers, especially competent to report upon certain classes of mineral deposits, *e.g.*, coal, manganese, graphite. For special pieces of work the men on the Survey staff engaged in this work should form a distinct class of Mining Geologists and especial prominence should be given to their work.

The addition of these Mining Geologists to the staff and the vigorous prosecution of this class of work by the survey is the chief innovation needed to make the work of this Department tell, as it should, in the development of our mineral resources. In connection with this class of work, the Survey could with great advantage arrange to co-operate with the Universities and so make use of the unusual facilities offered in the ore dressing and metallurgical laboratories of the Canadian Mining schools for the purpose of making concentration and other tests such as are now being regularly carried out in these laboratories, on ores, etc., from various portions of the Dominion.

Concerning the duties of the Survey in preparing annual mineral statistics, I shall say nothing, not because this matter is unimportant, but because it has already been so well emphasized by Mr. Hardman. The Statistical Department should, however, extend its work and make itself of still further value to the country by publishing, at frequent intervals, bulletins on the Mineral Resources of Canada—as, for instance, one on the Iron Ores of Canada ; others on Canadian Coal Fields ; Canadian Asbestos Deposits ; Canadian Clays, Building Stones, etc.—in which the information scattered through the various reports and thus not available as a whole to inquirers, would be gathered together, brought up to date, and published in convenient form. This Department should in fact undertake all the functions of a Bureau of Mines and Mineral Resources. For the satisfactory and economic working of the Survey, furthermore, the Chemical Department should be entirely reorganized.

The staff of the Survey would thus consist of the following classes of officers : (1) Mining Geologists ; (2) Field Geologists ; (3) Topographers ; (4) Chemists and Assayers ; (5) The offices of the Bureau of Mines and Mineral Resources. There would also be the Petrographer, the Palæontologists, the Accountants, the Museum staff, etc.

I believe, then, that the Government has in the Geological Survey the nucleus of a department which might render the most important and valuable assistance to the mineral history of the whole Dominion. The Survey however, needs to be *reorganized and extended*, and converted into a "Department of Mines and Geological Survey." (Applause.)

In my humble opinion, moreover, the establishment of a Department of Mines separate from the Geological Survey would be unwise. The aims, and to a great extent, the work of both departments would be identical. The work above outlined could be carried on by a single bureau far more satisfactorily, for no line of division between the two could be drawn. Neither a Geological Survey nor a Department of Mines could by itself attain its full measure of usefulness, and if two separate Departments were created there would be a continual overlapping of work, which would lead not only to confusion but to waste of time and effort, and loss of efficiency. Lack of proper co-ordination in the various classes of work, which is one of the weak points of the Geological Survey at present, could be entirely prevented by making one strong, well-organized department, which would undertake all the various sorts of work that the Government should be called upon to do in the interests of our mining industries. (Applause.)

Mr. W. BLAKEMORE—It is not my intention to take up much of your time, but I desire to follow up what has been so ably said by the previous speakers with a resolution to the following effect : "That the Canadian Mining Institute, in annual session assembled, desires to direct the attention of the Federal Government to the magnitude and importance of our mining industry, which during recent years has developed so rapidly, and respectfully urges the increase of Government aid wherever possible, and the establishment of a strong and practical Department of Mines, believing that nothing will do more to develop the natural resources and promote the general prosperity of Canada." I question that any gentleman who does not attend our meetings knows the magnitude of our mining industry—We have heard from the report of the Secretary, that the mineral production in 1901 reached seventy millions of dollars. Now just for a moment let me call your attention to this fact, that only 20 years ago the total mineral production was not a great deal more than the single item of copper or nickel produced last year, and that will show you with what leaps and bounds it has gone forward. Let me make this suggestion, there is no impropriety in our endeavouring to impress the Government with the magnitude of the industry we represent and asking them to do more than they have ever done before on that account, especially when it is borne in mind that no increase has been made to the Government grant to the Geological Department for 20 years. It stands now as it stood then, at $100,000. (Applause).

Mr. B. T. A. BELL—Before the motion is put to the meeting perhaps I may be permitted, as one who has been actively associated with the mining industries of this country for a period of some seventeen years, to emphasise the necessity of the establishment of a Department of Mines entirely separate and distinct, if need be, from the present Geological Survey, a Department whose chief aim shall be to give to the public more complete and more frequently published statistics of our mineral production, accurate and up-to-date monographs of mining districts and mining industries and information of a more commercial character than we have hitherto been able to obtain either from the Federal or Provincial Governments. The remarkable expansion of mining as an industry in Canada and its immense importance to the trade and commerce of the Dominion are not fully realized by the people of this country. It is significent that out of our mineral production last year, amounting to over seventy millions of dollars, the great bulk of our output was exported. My own idea is that greater prominence must be given to the commercial and business aspect of our mining industries, that one of the chief aims of a well equipped and capably administered Department of Mines would be to collect and furnish, not merely periodically in its reports, but on demand, the latest available data concerning the development and progress of our mining industries. Business men, capitalists enquiring into industries for the purpose of investment, require official data of a business character and the Government should be able to supply them with it. More attention should be given to such questions as the capital invested in our mines, the dividends paid, cost of extraction and treatment, labor, machinery equipment, mining and metallurgical practice, markets, freights, and the numerous other questions of a commercial nature which people desirous of placing money in an industry naturally desire to ob- from an official source. By combining the technical with the industrial and commercial, by employing a competent staff of economic geologists and topographers, together with a corps of first-class mining engineers a Department of Mines will do much to advance the development of the great mineral resources of the country. (Applause.)

Dr. ROBERT BELL—I would like to say a few words not only upon the Geological Survey but upon the remarks of the gentlemen who have preceded me. There seems to be an impression that we are not practical. The Geological Survey was instituted to do practical work and it has done so since the moment I have been connected with it. I began a little more than a boy and I have travelled and worked from Nova Scotia to the McKenzie River, from the Rockies of British Columbia to Baffin's Bay, until I have come to be regarded as a sort of living index to the younger fellows of the work of the Survey. Sir William Logan was a practical man and did practical work and we have endeavored to do that ever since. I am glad that some suggestions have been made wherein the work of the Survey might be improved. I have always said that more should be done in the direction of economic geology and we have tried to do so far as we could. Dr. Adams has pointed out the importance of topographical work preceding the Geological Survey ; that is all very well if the Government would undertake it. We are obliged to do topographical work simultaneously with the geological work. Dr. Bell then referred to the work done by McConnell in the Yukon, by Gwillim in Atlin, by Brock in the Boundary, by McEvoy, in the Crow's Nest Pass, by Low, and other members of the staff. I don't want anything more practical than the work of these men. We want science first and business after. I had almost forgotten about the chemical branch ; we have good chemists and they are very hard working men. Dr. Hoffman goes back to his laboratory every night and his heart is in his work. I think our chemical work is done well. Altogether we are doing, I think, excellent work on behalf of the country.

Mr. B. T. A. BELL—Just a remark—The object of this discussion is not to criticize the Geological Survey, for we all recognize the value and importance of that excellent institution. We do, however, urge upon the Government the necessity of a Department of Mines which will give to the public more information of practical utility to business and mining men than hitherto has been available from any Government source.

Mr. BLAKEMORE—When I made use of the words practical man I did not as Dr. Bell has done refer to him as a California saloon keeper. I think that in any mining department whether attached to the Geological Survey or not there should be attached permanently or in an advisory capacity a first-class mining engineer with a practical experience in mining.

Mr. EUGENE COSTE—I think it was in 1884, if I remember correctly, that a Parliamentary Committee investigated this question and made a report to the Government the outcome being the establishment of the present Mines Branch of the Geological Survey. It has been said here to-night that it has not been the fault of the Geological Survey if foolish investments in mines have been made. I differ somewhat from this view. Of course there will always be foolish speculations in mines, as in other matters, but if at that time the Director of the Geological Survey had done what the Parliamentary Committee of the House of Commons had recommended him to do, and had thoroughly organized and equipped the work of that Mines Branch I am not so sure but that many of the foolish investments might have been prevented. Although appointed mining engineer in charge of the Branch I was not only not assisted, but even hampered, by the Director of the Survey, and finding it impossible to carry out the work as I conceived it ought to have been done, I sent in my resignation. There is no question that a properly equipped mining Department should be organized with a compe'ent staff of mining engineers, economic geologists, topographers and assayers, and also with the temporary outside help from time to time, of mining men and engineers who are experts in special subjects or industries, and whose experience and knowledge would be most valuable. So far the Federal Government has not appreciated the magnitude and importance of the mining industries of the Dominion. They have, until recently, taken no steps to inform themselves upon their necessities and requirements. Had there been a properly constituted Mining Department at Ottawa I venture to say there would have been no such bungling in the mining regulations adopted for the Yukon. When that great goldfield was discovered they were taken by surprise, they had no one to advise them, regulations were made and changed every week, and for that matter are being changed yet, too often, creating no end of dissatisfaction in that country. Now if the Government had had in its service first-class mining engineers to advise them, questions of this character would be greatly simplified. There is no doubt the Government should pay more attention to the mining industries and organize a proper Mining Department, either in connection with the Geological Survey or outside of it, but it must be organized and established on a thorough business basis. (Applause.)

Dr. EUGENE HAANEL—I came here rather to listen than to speak, nevertheless, I have been very deeply interested in the papers that have been presented,—ably and well done. The one point that has presented itself to me from the discussion is that a Department of Mines is an absolute necessity for the mineral development of Canada and I am exceedingly sorry that Mr. Sifton could not be with us to hear what you have said, but he was ordered to go South. I think my report to him will encourage him on this subject and greatly strengthen his hands.

Mr. J. C. DREWRY—I am not a member of the Geological Survey nor a Mining Engineer, nor a practical man from California, but as one trying to make an honest dollar in mining out there in British Columbia. I am very glad to be here. We all acknowledge that the work of the Geological Survey is good but it could be made better and more practical—that is the word to use—and I hope that Mr. Sifton will go on and establish a Department of Mines—swallow up the Geological Survey if necessary—but at all events go ahead and give us an institution that will be practical and useful.

Mr. B. T. A. BELL—Would it not be well to adjourn this discussion until tomorrow afternoon?

Mr. EUGENE COSTE—Can't we get through to-night?

Mr. HARDMAN—As the seconder of the resolution I would say that we expect other members from a distance to-morrow and it might be well to give them an opportunity of discussing the resolution.

Dr. J. B. PORTER—A few minutes ago Dr. Adams recommended the reorganization of the Geological Survey, with a Mines department as its most important branch. Now Mr. Drewry advises the creation of a great Department of Mines, to which the Geological Survey should be made subordinate.

These recommendations apparently conflict, but in reality they differ in no essential respect. It is of little moment whether we have in the future a Department of Mines with a Geological branch, or a Geological Survey with a Mining branch, provided that the whole thing is under one competent executive, and be given thorough-going support. Let us have no doubling of Bureaus to waste our effort, but rather one strong department—whatever its name—and at the head of this department a competent executive. This man may be a geologist, or a mining engineer, or neither ; the essential thing is that he be capable of taking a broad view of the whole matter, and of choosing wisely his geologists and mining engineers. With such a man the department will do what the country needs, and we need not trouble ourselves about the name by which it is called.

Mr. B. T. A. BELL—I would suggest that the resolution be remitted to a Committe consisting of Messrs. Shields, Hardman, Coste, Dr. Bell, Dr. Goodwin, Blakemore, Dr. Adams and Professor Miller, and that their report be presented at tomorrow afternoon session.

Mr. JAMES McEVOY—While the Geological Survey is doing good work still there is room for improvement and we might suggest improvement along the lines of the United States Geological Survey.

Mr. C. SHIELDS—It seems to me that the action of the Meeting should be clearly set forth in one resolution and it is possible that the one we have before us might be improved—might be made much stronger.

Mr. B. T. A. BELL then moved the appointment of the Committee. Carried.

The meeting adjourned at 10.30 p.m.

WEDNESDAY AFTERNOON.

The members reassembled at three o'clock, Mr. John E. Hardman, S.B., M.A.E., presiding.

CIVIL ENGINEERS' BILLS.

The CHAIRMAN—The Committee appointed to examine and report upon the Canadian Society of Civil Engineers Bills present the following resolution:—

> *Resolved* that the Canadian Mining Institute having examined and considered the Civil Engineers Bill now before the Ontario and Manitoba Legislatures is of the opinion that this Act should not be passed since it gives powers to the Canadian Society of Civil Engineers which should not be

given to any one branch or section in the present condition of the engineering profession. Such powers should be retained by the Government itself or reserved for a society or association representative of the whole profession.

The Committee also suggests that action relative to the proposed Bill in B.C. be placed in the hands of the Secretary with power to act in the premises.

(Signed) JOHN E. HARDMAN.
DR. W. L. GOODWIN.
WM. BLAKEMORE.
E. COSTE.

The resolution was then put to the Meeting and adopted.

NATIONAL IMPORTANCE OF MINING.

The CHAIRMAN—On behalf of the Committee to which last evening you remitted Mr. Blakemore's resolution, I have to report that we have been in session all morning but have been divided upon two resolutions, the one by Mr. Blakemore and an amendment to it proposed by Mr. Coste adding the words "and which shall include the present Geological Survey and all necessary branches".

Mr. COSTE, seconded by Dr. ADAMS, moved the adoption of the amendment.

Mr. BLAKEMORE, seconded by Mr. J. C. DREWRY, moved for the adoption of the original motion.

Mr. JAS. McEVOY—We should have more in these resolutions. The Geological Survey should be reorganized and it would be advisable, it seems to me, to clearly specify to the Government the lines upon which this reorganization could be made effective.

Mr. EUGENE COSTE—In support of my amendment I would only say that we must recognize existing conditions and I feel that we should not be too radical in our recommendations. The Geological Survey exists and any new Department of Mines should, in my opinion, include the Survey.

Mr. INGALL—As a Government officer do you understand either resolution to mean the abolition of the Survey?

The CHAIRMAN—The resolution as I understand it does not interfere with the Geological Survey at all. The motion brought up last night is one for a recommendation to the Government for an entirely different department devoted to mining alone. Therefore, answering Mr. Ingall's question, I can't see for my own part why the Survey has anything to say or is in any way connected with this resolution asking for a Mines Department.

Mr. BLAKEMORE—Replying to Mr. McEvoy I do not think it would be wise at this stage to introduce any details into the resolution.

Dr. W. L. GOODWIN—The difficulty I find with Mr. Blakemore's resolution is that it recommends the establishment of a Department—a new Department of Government.

Mr. B. T. A. BELL—That is just what it means and that is just what we want.

Dr. GOODWIN—Just so; but the Government may not regard so large a scheme as practicable from their point of view. On the other hand Mr. Coste's resolution leaves to the Government the establishment of a Bureau devoted to mining and the other branches that would be necessary, in a way that would conveniently fit in with existing conditions. I think the Survey should be mentioned in our resolution because it would be unwise to disconnect the work that the Geological Survey is doing, which is the scientific basis of mining. I would suggest a Department of Mines and Geology, which should include all branches necessary to cover the work of geological and topographical surveying, mining statistics, hydrography, and, perhaps, forestry.

Mr. GEORGE CAMPBELL—I, for one, do not believe in half measures. We have Departments of Marine and Fisheries, of Agriculture and of Labor, why not have a Department of Mines?

Dr. ADAMS—The basis of a Department of Mines should be the Geological Survey. If Mr. Blakemore's resolution goes before the Government they will say the Mining Institute does not consider the Geological Survey to be of any value to the country and to the Department of Mines. Now we do consider the Survey to be of value to the country and to the Department of Mines. A former speaker has compared the Department of Mines with that of Agriculture or Fisheries, but the cases are not quite parallel. Mineral lands are owned by the Provinces—the Federal Government has no control of mines in the Dominion.

Mr. B. T. A. BELL—Yes they have—What about the Yukon and the Territories?

Dr. ADAMS—When these Territories become Provinces, as they ultimately will, the mining lands will pass from the Dominion into their control, as is now the case in the older provinces.

Mr. B. T. A. BELL—I see we have with us to-day our old friend Captain Adams, one of the pioneers who, eleven years ago, promoted the organization of the Quebec Mining Association out of which our present Institute has evolved. I am sure I voice the sentiment of everyone present when we welcome Captain Adams back again to our meetings. Perhaps he has something to communicate to the discussion.

Captain R. C. ADAMS—I am very much surprised at the kind illusion made to me in asking me to address the meeting. I regret to say that I am not in very good health and am not prepared to make a speech. I am, however, heartily in favor of a Government Department or Bureau which will classify and concentrate the information concerning mines collected by the Provinces.

The CHAIRMAN having called upon Mr. T. W. Gibson, Director of Mines for Ontario.

Mr. T. W. GIBSON—Not having been present last evening I am not aware of t e trend which the discussion on this matter then took, but from what I have gathered from the remarks of the speakers this afternoon, the differences of opinion seem to be as to details and not as to the principle. Whether it would be better to establish a Department of Mines under the Dominion Government, with a responsible minister, who would have a seat in the Cabinet, at its head, or a sub-department, which should include everything connected with the mining industry, including the Geological Survey, I am not prepared to offer an opinion. I would like, however. to remind the meeting that this work has already been taken up, to some extent, at any rate, by the Provincial Governments. The mining lands in all the older Provinces are the property of the Provinces, and the laws relating to mining are made by the Provincial Legislatures. There is, therefore, a possibility of clashing of authority and overlapping of work, which in any scheme of the kind projected should be avoided. While not at all desirous of opposing anything which the Institute may decide to recommend, I would suggest that this point should be carefully considered. Members of the Institute will be glad to know that in Ontario the mining industry is making rapid strides. The output from our mines last year was about twelve millions of dollars in value, as compared with a little over nine millions in 1900.

Mr. JAMES McEVOY—I think we might overcome the difficulty by using the words "*A* Geological" instead of "*The* Geological Survey". (Laughter).

Captain ADAMS—I would ask Mr. Bell what a Department of Mines will do more than the Geological Survey does now?

Mr. B. T. A. BELL—I am afraid, Captain, it would take three or four full sessions of the Institute to do that satisfactorily. (Laughter).

Prof. T. L. WALKER—I think I am right in maintaining that geology is a wider subject than mining. If the Geological Survey is to fall from its present position to that of a subordinate branch of a Department of Mines that would be a step backward.

Dr. ROBERT BELL—There is a great deal of force in what Professor Walker has said, and all I can say is, if you can't do us any good don't do us auy harm.

Mr. B. T. A. BELL—I would call the attention of the Chair to the irrelevancy of this discussion. We are discussing the question of a Department of Mines with which, at this stage, in my humble judgment, the Geological Survey as an institution has nothing whatever to do.

The CHAIRMAN—I am anxious to confine the discussion to the question. We are not dsscussing the Geological Survey we are simply asking for greater recognition of the mining industry. The relation of the Geological Survey to a Department of Mines is a matter of expediency which may very well be left in the hands of the Minister of Interior and the Government. We say to them—these are our views give the mining industry a show.

Mr. EUGENE COSTE—We have discussed this matter for sometime now and I am emphatically in favor of embodying in the resolution the reference to the Geological Survey. In doing so we do not say that we want the Survey to occupy an inferior position. The words have been put there to suggest to the Government that it is necessary to have not only a Geological Survey but a topographical survey and all the other branches in order to make a Department of Mines complete and efficient. Why not say it in plain words? I think it will help matters to say frankly in our recommendations to the Government that we of course need a competent Geological Survey as a part of a fully equipped and efficient Department of Mines.

Dr. ROBERT BELL—This is a very important matter. I agree with what Mr. Coste has said. He has been a member of the Geological Survey staff and appreciates us but I think in the way he puts it he does not appreciate us. In the United States the Geological Survey is supreme and most comprehensive and includes a Division of Mines and Mineral Statistics.

Mr. BLAKEMORE having withdrawn his resolution, the CHAIRMAN put the amendment, moved by Mr. COSTE, seconded by Mr. BLAKEMORE, as follows:

> *Resolved* that the Canadian Mining Institue in Annual Session assembled desires to direct the attention of the Federal Government to the magnitude and importance of our mining industry which during recent years has developed so rapidly and respectfully urges an increase of Government aid wherever possible and the establishment of a strong and practical department of mines or of a department which shall be devoted to the interests of the mining and metallurgical industries and which shall include the geological Survey and all other necessary branches.

The motion was carried by a large majority.

WEDNESDAY EVENING.

The members reassembled at 8 o'clock in the Ladies Ordinary, there being a very large attendance. Mr. Hardman again occupied the chair.

Prof. W. G. MILLER opened the session with a paper describing the "Varied Mineral Resources of Eastern Ontario".

ILLUSTRATED ADDRESS ON THE YUKON.

Mr. FRANK C. WADE, Dawson, Y.T., after a brief introduction by the Chairman, was very cordially received as he stepped forward to begin his address to the members on mining and business progress in the Yukon. In his address he adopted the method of contrasts, showing both verbally in his address, and by a large number of fine lantern slides, the different state of affairs in the North four years ago and to-day. The Chilkoot Pass in the first rush and the passenger train on the Yukon and White Pass Railroad—the roughly built barge of the prospector and the Yukon River steamer—the Dawson of tents and the brick-built city of to-day—with numerous similar contrasts of to-day, all effectively brought out by the photographs.

Mr. Wade said: I suppose you are all familiar with most of the facts with regard to the Yukon and its situation, because of the interest that was awakened in that far-off country in 1897 and 1898; but perhaps it would be well to point out one or two features with regard to its area and extent. To begin with, the Yukon is situated on our west coast, locking arms with Alaska—in fact, there is a little too much locking arms on the part of Alaska at the present time. That long arm that goes down on the western coast seems to get longer all the time, so that it is difficult to tell which is our own country and which is the Alaskan arm with which we are encircled from time to time.

In the fact that Alaska at the north was purchased by the United States Government from the Russians, we have the first error or misfortune made with regard to the Yukon, and one of the most unfortunate things that ever occurred so far as the development of the north-western part of Canada is concerned. It was bad enough to have an immense hostile country below the 49th parallel, and all along our south. It was worse to allow that country to become possessed on the north of a large district which must ever remain hostile to us. We see the difficulties of it every day—customs difficulties, the trouble in delimiting our boundary, the tearing down of the British flag at Skagway, and other matters which might at any time lead to international complications.

The Klondyke, which is a portion of the Yukon, is situated in about sixty-four degrees north latitude; in fact, Circle City, a little below the Yukon, was so called because it was supposed to be within the Arctte Circle; it was afterwards found out not to be within the Arctic Circle, but it was sufficiently far north to justify the name. The Yukon country itself is 198,000 square miles in extent, which is considerably more than the area of Quebec, and very considerably more than the area of Ontario—twice the area of Ontario as it used to be given in the geographies.

The Klondyke mining camp, of the trade of which I have to speak, is a circumscribed area, bounded on the south by the Indian river, on the north by the Klondyke river, on the west by the Rocky mountains, and on the east by the Yukon. It is some 800 square miles in extent.

The mileage of creeks actually operated in the Yukon does not go over fifty miles. Professor McConnell, Mr. Meyers, and others who have visited the conntry agree that there is no reason for imagining that the gold area will not extend to almost all the creeks in the Yukon, and when I tell you that only fifty miles have been worked, and that there are seven thousand miles of creeks in the Yukon, almost all of which are unprospected, you can have some idea of the future which lies before that country. (Hear, hear). As to the little area of the Klondyke, with which we have to deal, I would like to make it clear to you that it has only been actively developed during the last four or five years.

The first stake was driven by George Cormack on Discovery Claim at Bonanza, on August 16th, 1896. The stampede into the country commenced in 1897, and continued in 1898. The first large gold production was made in 1898, when

$10,000,000 were taken from the pay gravels of the country. That is according to the Governmental returns, but a government return is like an income tax return—I do not care what the Government is, or what the municipal body that is at the head of affairs, such a return must always be misleading. You remember that old story which is told in Fawcett's "Political Economy," about a street in London where the income tax was levied, and nobody on the street had an an income at all, although it was one of the richest streets in London; but afterwards when the street was closed and every resident had to be paid damages according to his income, the amount swelled to enormous proportions.

It must not be expected that a royalty official return will be any more accurate than an income tax return, especially when the miners are not the old miners of the old '49 days, the old miner or old prospector who spends all his life in the mountains, whether it be on the American or the Canadian side, and whose single boast is his honor, and especially when they are dealing with a substance in which so much value is incorporated in so small a space or bulk as it is in the case of gold.

However, taking the returns as they are, ten millions of dollars were taken out of the soil in 1898, sixteen millions in 1899, twenty-two millions of dollars in 1900, and twenty-four millions in 1901. And yet people ask us every day on the street, in the face of these figures, if the gold production of the Klondyke is falling off. It has almost trebled in four years.

When we first arrived in the Yukon in 1897, and, travelling over the ice during that winter, came to Dawson, the sensation that I, in common with all others, no doubt, experienced, was a very composite one. It did seem strange, after passing over hundreds or even thousands of miles of forest, stream, and wilderness, to suddenly descend into a little basin formed by the junction of the Yukon and Klondyke rivers in among the hills, under the shadow of Moosemin mountain, and find a little city all by itself, a sort of microcosm, a coming metropolis.

Even then, in the dead of winter, Dawson City was composed of tents and huts made up of rough frames covered with tarred paper, with some whipped lumber made in the locality, but largely made up of packing boxes, and anything else that could be obtained. Windows there were none. What might be called the windows of the cabins were made up largely, at the mines and in the city, of bottles set side by side. Strange to say—and this is a matter to be considered in connection with the referendum—no matter how remote the country, and no matter how impossible it is to get window glass, if you penetrate into the regions adjoining the North Pole you find bottles, bottles everywhere. There they were turned to a useful purpose, because they were set side by side, and chinked in with moss, and they made a very good window indeed.

However, such was Dawson in 1897-8, a collection of tents adjoining the old fishery hut of George Cormack, a collection of tar paper and canvas houses scattered around without any regard to sanitary arrangements, and with no street. Nothing better could have been expected.

We were in our infancy, and just then Miss Flora Shaw, of the London *Times* descended upon the camp and found we had not good roads, and that the billiard tables were not strictly up to date, and the London *Times* has been talking about it ever since.

However, the spirit of enterprise soon became very evident in the camp, with the result that after the lapse of four years we have to present to you the city of Dawson. In 1898 a cluster of huts, today a city with an assessment of $12,000,000 real estate and personalty. (Applause). In 1898 there was not a steamer on the Upper Yukon river ; the first small steamer—a very small one indeed—arrived in June, 1898, and the succession of steamers arriving has been so tremendous that now we can show you on the Upper Yukon a fleet of twenty-seven steamers valued at $878,000, and just bonded on the British market for nearly $1,000,000.

On the Lower Yukon river were formerly the "Arctic" and the "Weir" and a few of the old tubs of the Alaska Commercial Company that were being operated. We now have two fleets. The fleet of the Northern Navigation Company, of twenty-eight steamers, valued to the assessor at $1,125,000, and the fleet of the North America Transportation Company, of seven ships, worth about half a million of dollars.

So that on the two ends of the river we have about two and a half million dollars' worth of steamers.

In the city of Dawson we have about $12,000,000 worth of real estate and personalty. In the two years we have produced about $46,000,000 of gold. In houses and land alone the assessment amounts to some $5,000,000.

So that in four years that little country has piled up a total—I am not taking into account all the public buildings built by the Government, or the 218 miles of roads built by the Government with all these public improvements—of over $100,000,000, and that not at some railroad centre in Eastern Canada, and not at some great lake terminus in the Province of Ontario, but at sixty-four and one-half degrees north latitude, under the very shadow of the North Pole.

It seems to me that is very excellent evidence of what enterprise in a country can accomplish.

The White Pass railway was also built, and last year that White Pass railway netted some one million and a quarter of dollars in profits, and paid a dividend of twenty-five per cent. to its shareholders.

On all sides, then, you have evidences of enterprise, trade, and progress.

During last year there were carried into the country by the White Pass railway and the steamers in connection with it, no less than 36,000 tons of freight, as against 32,000 tons in the year previous. And last year there were taken in from Vancouver alone 9,600 cattle, horses, and sheep, as against some 2,000 in the latter part of 1898. So much for our trade in the Yukon.

But what can be said with regard to our trade interests in the Yukon ? What trade interests have the Canadians as a people managed to secure in the Yukon, and to what extent have they shared in the marvellous prosperity of that camp?

It is indeed regrettable that a camp of such value, so far as gold mining is concerned, has to be opened up to the entire world. It does seem regrettable that foreigners and aliens from everywhere should be allowed to swoop down on that camp, and without "by your leave" or "if you please," or without even an epithet to command your admiration and attention, simply take possession of our mines on Eldorado and Bonanza—on Eldorado, where the gold mines run $2,000 to the lineal foot; on Bonanza, where they run $1,000 to the lineal foot. It seems hard that these men should be able to take possession of the mines and to send and carry the gold away to Seattle and other places, and build public buildings in a magnanimous way in the different cities of the United States, build great stone blocks in Seattle, Portland, and San Francisco, and that we in Canada should have nothing whatever left in return for all that is taken away. I say that it seems unfortunate that this should be so. It is difficult to distinguish between this state of things and simply allowing our friends on the other side of the line to enter the treasury at Ottawa with wheelbarrows or whatever other utensils they may prefer, and to carry away the gold that belongs to the country.

However, it cannot be helped. An alien law in a mining camp could never possibly succeed in Canada. The alien law was tried in Atlin, with the result that the Atlin camp was killed the moment the law was passed; and if the alien law had been applied in the Yukon, the Yukon would have been strangled at its very birth.

The United States nation has, with its Swedes and Germans, hardy men of great industry, furnished the grandest class of miners that the world can produce. We have found them in the Yukon leading the way. In the early days of Cassiar it was impossible at times to get enough British subjects to fill a jury. In the Yukon, in my own department, I have had to use the same jurors over and over again, owing to the difficulty in getting sufficient British subjects. While the English and Canadian show no aptitude for mining (whether it is abhorrence to working underground or not, I do not know), the French Canadian in the Yukon has shown himself an excellent miner, and today very closely contests the belt with the Swede, the Norwegian, the Scandinavian, and the hardy Norseman that we have in that country.

The great business in the furnishing trade of the Yuken is, of course, the outfitting of the prospector. In the early days that was the greatest business. The prospectors who came to the country claimed that they could not be properly outfitted on the Canadian coast. The Canadians did not understand the needs of the prospector as the Americans did in those cities of the United States, where they had had much more experience in mining matters than had been gained in Canada.

To put it in a rather simple way, the prospector, you remember, goes far away from the centres of population, and travels one hundred and fifty or two hundred miles into the wilderness, and he must not only have the staples of existence, flou. to make his slap-jacks, the bacon that he requires from time to time, and the tea, but he must have his small and inexpensive luxuries. All the pleasures that enter into the hard existence in those remote points in the wilderness (if he has any pleasures), are very gross and material indeed, and are not to be mentioned in such a select assemblage ; but if the miner does enjoy anything it is some luxury, some little jelly or preserves put among his outfit. The out-fitters of the American coast cities, with due regard to his tastes and pleasures, were able to make a more attractive outfit than were the outfitters of the cities on our side of the line.

There are a great many lines of goods which should be furnished to the Yukon trade. Why is it that we do not furnish butter to the Yukon trade ? Surely our butter is better than any that could be furnished from any other part of the world. But our butter is packed in such tins, and in such a way, that the rust and air affect it. My experience is that Canadian butter cannot be bought, because it always spoils. That is the regular experienee in camp. When we arrived at Skagway in 1897, four tons of Canadian butter had to be thrown over the edge of the dock into the Lynn canal, which was certainly a fine advertisement at the outset for Canadian butter.

Then take Canadian bacon. Why do we not use Canadiau bacon in the Yukon country ? We want to use it. I say for the credit of the trading institutions up there, whether large or small, they feel that they are to make their money there, and they want to use all the Canadian staples they can ; but they claim they cannot use Canadian bacon because it is not cured to last a sufficiently long time. Everything has to be carried in during the summer, to last not four or five months merely, but an entire season and half a season afterwards—a year or eighteen months. So much for our butter and bacon. These are technical matters in which I may be astray, but I tell you simply what all the business men in the country tell me.

Why do we not monopolize the Yukon market in canned goods ? Our goods are probably better and sweeter, and there is probably more food in them than in similar goods from anywhere else. They object to the labels ; they object to the tins as being too heavy.

Why do we not have our rubber goods in that country ? For the simple reason that if we bought the Canadian rubber miners' boots which are furnished at the Coast, it would take almost a team of horses to carry those boots up to the mine. The prospector or miner can go and get a pair of Gold Seal rubber boots from the other side of the line, which are light and easily worn.

Our shovels are too long in the handle ; our picks are too heavy. Of the steel candlesticks to be driven into the frozen gravel we have not shipped any into the country.

Why does not Canadian cheese take possession of the market of the country, and Canadian condensed milk ? In some cases it may be from lack in the supply of the articles themselves, and in other cases through fault in the method of packing and labelling, or in the tins or articles in which the goods are placed. But above and beyond all other reasons, because the manufacturers of our country have taken no interest in the country, and the newspapers have taken no interest in the country, and Parliament has taken little interest in the country beyond the debates which have taken place during the last few sessions.

It seemed to me it might be well to bring these matters before this Institute, and it might be well worth while to point out, too, that there is no difficulty whatever in entering that country at the present time.

I am often asked—everybody who comes from that country is often asked—"Isn't it very difficult to get into the country? Isn't it frightfully cold when you get there?"

Here we object to our British friends always alluding to Canada as the Lady of the Snows; but every Canadian seems to hurl the same insult at our Yukon country. It is true we have cold there in the winter-time; but you have it cold down here and in every part of Canada in the winter-time. And surely every grown-up Canadian has stamina sufficient to know what a small argument that is.

We have the most beautiful summers it is possible to imagine; a more glorious summer climate could not well be conceived. In the winter the cold is dry. We have, however, an open summer up to the end of September and well on into October; then by the middle of May the ice is gone out of the Yukon river, and from then on to the end of September or October we have as delightful a summer as you have. And we have what you have not in the summer. During the summer time we have daylight all night, which makes it possible to carry on all the works of the country at a double shift, and in that way to accomplish a great deal more than can be accomplished anywhere else.

We have the country, we have the climate, and we have the products (Applause).

On the conclusion of Mr. Wade's address a very hearty vote of thanks was tendered to him, and the meeting adjourned at eleven o'clock.

THURSDAY MORNING SESSION.

The session opened at eleven o'clock in the Library, Mr. Hardman in the Chair.

OFFICERS AND COUNCIL FOR 1902.

The Scrutineers, who had previously examined the ballots, reported the election of the following Officers and Council for the ensuing year:—

PRESIDENT.

Mr. Charles Fergie, Intercolonial Coal Co., Westville, N.S.

VICE-PRESIDENTS.

Dr. Frank D. Adams, McGill University, Montreal.
Mr. Robert R. Hedley, Hall Mining and Smelting Co. Nelson.
Mr. Eugene Coste, M.E., Prov. Nat. Gas and Fuel Co., Toronto, Ont.
Mr. Graham Fraser, Nova Scotia Steel and Coal Co., New Glasgow, N.S.

COUNCIL.

Mr. John B. Hobson, M.E., Con. Cariboo Hydraulic M. Co., Bullion, B.C.
Mr. Frank Robbins, M.E., North Star Mining Co., Nelson, B.C.
Mr. W. F. Little, H. W. McNeill Co. Ltd., Anthracite.
Mr. Frederick Keffer, M.E., B.C. Copper Co., Anaconda.
Mr. Cornelius Shields, Dominion Coal Co. Sydney, B.C.
Mr. R. E. Chambers, M.E., Bell Island, Newfoundland.
Mr. W. L. Libbey, N. Brookfield, N.S.
Mr. D. W. Robb, Robb Engineering Co., Amherst, N.S.
Mr. A. P. Turner, Canadian Copper Co., Sudbury, Ont.
Mr. P. Kirkegaard, Canadian Gold Fields Ltd., Deloro.
Mr. E. A. Sjostedt, Lake Superior Power Co., Sault Ste. Marie, Ont.
Professor Courtenay DeKalb, Boston, Mass.
Mr. J. T. McCall, Canada Iron Furnace Co., Montreal.
Mr. B. Bennett, King Bros., Thetford Mines, Que.
Dr. J. Bonsall Porter, McGill University, Montreal.
Mr. George R. Smith, M.L.A., Bell's Asbestos Co., Thetford Mines, Que.

TREASURER.

Mr. J. Stevenson Brown, Montreal.

SECRETARY.

Mr. B. T. A. Bell, Editor *Canadian Mining Review*, Ottawa.

LOCAL BRANCHES OF THE INSTITUTE.

Mr. B. T. A. BELL suggested a resolution in favor of organizing local sections of the Institute in the various mining centres of the Dominion. He explained that if his plan was adopted the sections would be organized under the charter and by-laws of the Institute; their members would be members of the Iustitute; and papers presented at the meetings would be regarded as Institute papers and find full record in the volumes of the proceedings. He further explained that the object of this plan was to interest many who were unable to attend the Annual Meetings owing to the long distances to be travelled. Moreover, the local sections would be able to hold more frequent meetings, at such intervals as they might decide for themselves and thus create and maintain an interest which would be of value to the Institute generally and also to local mining.

The recommendation was generally approved and the following resolution, presented by Dr. W. L. GOODWIN, was unanimously adopted :—

"That in view of the great extent of the Dominion and the long distances to be travelled by many members in order to attend the meetings of the Institute, it is expedient to organize local sections in mining towns and camps and other centers, and the Council is hereby empowered to take such action as is necessary to carry out this recommendation".

THURSDAY AFTERNOON.

The Meeting was called to order at 3.30 p.m. Papers illustrated by lantern projections were presented as follows :—

On the Iron Ores of Hudson Bay.

By Prof. G. R. Mickle, Toronto.

On the Iron Ores of Kitchener, B.C.

By Wm. Blakemore, Fernie, B.C.

On Gold Dredging.

By Dr. J. Bonsall Porter, Montreal.

On the Electro-Metallurgy of Copper Nickel Ores.

By Wm. Koehler, Cleveland, Ohio.

These papers and the discussion upon them occupied the whole of the afternoon.

ANNUAL DINNER.

At eight o'clock eighty members and their guests sat down to an excellent menu provided by the Windsor Hotel. A capital instrumental and vocal programme was presented, the intervals being interspersed with very brief speeches in response to a limited number of toasts. A thoroughly enjoyable gathering broke up about twelve o'clock.

FRIDAY MORNING.

A brief business session was held in the Library of the Institute on Friday morning. On motion it was decided to award a gold medal to be known as the Institute's Gold Medal for the best paper contributed to the proceedings of the Institute during the year. A deputation comprising Messrs. Hardman, Brown, Bell, Adams, Coste, Kirkgaard, Dr. Goodwin, and others was appointed to present to the Government the resolution respecting the organization of a Department of Mines.

The proceedings terminated with votes of thanks to the Chairman and to the Treasurer and Secretary.

EASTERN ONTARIO SECTION.

KINGSTON, 2ND JUNE, 1902.

A meeting of members and persons engaged in mining in Eastern Ontario was held under the auspices of the Institute in the British American Hotel, Kingston, on the evening of 2nd June, 1902, Dr. W. L. Goodwin, Director of the School of Mining, presiding. Mr. Joseph Bawden, secretary *pro tem*, opened the proceedings by reading the minutes of a meeting held during the week previous at which it had been decided to organise a local branch. A motion to the effect that "The Eastern Ontario Section of the Institute be now formed" was then put to the meeting and adopted.

The following gentlemen handed in their names for nomination to membership subject to the approval of the Council: Dr. W. F. Coy, H. W. Richardson, Geo. Smith, John Donnolly, M.E., G. O. Grover, J. A. Madill, A. M. Chisholm, Fred. A. Folger, jr., Joseph Francklyn, R. E. Kent, all of Kingston; David Williams, C.E., Port Arthur; A. H. Brown, Metallurgist, Canadian Gold Fields Ltd, Deloro; Fred. Foxton, Sydenham; Thos. Caldwell, Lanark.

The following committee of management was then elected:—

Dr. W. L. Goodwin, Kingston, Chairman.
P. Kirkegaard, M.E., Deloro.
Prof. Carr-Harris, C.E., Kingston.
Prof. S. F. Fitzpatrick, Kingston.
John Donnolly, M.E., Kingston, Secretary.

Dr. Goodwin then read a paper on the subject of "The Occurrence of Mica in Eastern Ontario" which, after some interesting discussion, it was decided to take up again at the next meeting of the Section.

The question of the establishment of the proposed new Department of Mines was also discussed and the local secretary was authorised to wire to Hon. the Minister of the Interior endorsing the proposal to establish such a Department and urging its organisation at the earliest possible opportunity.

At the meeting there were exhibited a very handsome series of phlogopite crystals from the Stoness-Kent mine, and some very fine samples of molybdenite from the Chisholm mine near Kingston.

The Section adjourned to meet again at the call of the chairman.

EASTERN TOWNSHIPS SECTION.

SHERBROOKE, 10TH JUNE, 1902.

A meeting of the Institute for the purpose of organising a local Section to the Eastern Townships was held in the Council Chambers, Sherbrooke, Que., on Tuesday evening, 10th June. Mr. George R. Smith, M.L.A., General Manager of the Bell's Asbestos Company, was called to the chair.

The CHAIRMAN in opening the meeting referred to the influence and importance of the Institute which had done much to promote the interests of the profession and industry of mining in Canada. The mining industries of the Eastern Townships were not heard of very much in the papers, for they had no stock to sell, or schemes to unload, but he ventured to say that their asbestos, chrome and copper mines would take rank industrially with any other of the mining industries of Canada. While at the moment they were not threatened by taxation on the products of their mines, there bad been some talk, and there were some people who openly advocated an export duty on asbestos, so that it was well to be prepared to meet any such emergency. Such emergencies could best be met by organization. A local branch of the Institute would give facilities for local mining men to meet together, and would, doubtless, be made an excellent medium for advancing the great mineral wealth that they knew existed in the Eastern Townships.

Mr. B. T. A. BELL, secretary of the Institute, explained that the main idea the Council had in organising these branches was to give greater opportunities for local mining men to meet together than were afforded by the annual meetings of the Institute. By the formation of such a branch in Sherbrooke he thought much could be accomplished on behalf of the mines and mineral wealth of the district.

Mr. S. W. JENCKES, Sherbrooke, moved "That the Eastern Townships Branch of the Canadian Mining Institute be now formed" Mr Jas. R. Pearson, Danville, seconded the motion. The chairman put the motion which was carried unanimously.

The following gentlemen handed in their names for election as members subject to the approval of Council: Jas R. Pearson, Managing Director, Asbestos and Asbestic Co. Ltd., Danville; H. J. Williams, Manager, Beaver Asbestos Co.; J. A. Dresser, M.A., Richmond, Que.; Jas. R. Woodward, Wm Farwell, James MacKinnon, W. S. Dresser, of Sherbrooke, and P. L. G. Mackenzie M.L.A., of Richmond.

The following committee of management was elected:—

George R. Smith, M.L.A., Bell's Asbestos Co., Chairman.
H. J. Williams, Beaver Asbestos Co., Thetford Mines.
S. L. Spafford, Nicholls Chemical Co., Capelton.
John Blue, C. & M.E., Eustis Mining Co., Eustis.
Jas. R. Pearson, Asbestos and Asbestic Co., Danville.
B. Bennett, King Bros., Thetford Mines.
James S. Mitchell, Sherbrooke, Que.
A. S. Johnson, Johnson's Co , Thetford Mines.
R. T. Hopper, Standard Asbestos Co., Montreal.
J. Dresser, M.A., Richmond.

Mr. Jas. R. Woodward, Sherbrooke, was elected secretary *pro tem.*

Mr. C. C. Hansen, Montreal, read a very interesting paper on the subject of "Power Drills," reproduced elsewhere.

COPPER-BEARING ROCKS OF THE EASTERN TOWNSHIPS.

Mr. J. A. DRESSER M.A., Richmond, presented the following abstract of his paper read before the Montreal meetings of the Institute :—

"The copper-bearing rocks of the Eastern Townships of the Province of Quebec have long been known to comprise three principal belts which run approximately parallel to the northeasterly trend of the Green mountains in their extension into Canada. These belts are about twenty-five miles apart where crossed by the St. Francis river, and are themselves some two miles wide in each case along that river although elsewhere they are often considerably wider.

The most westerly of these, which is the first met in approaching the district from the St. Lawrence valley, is an extensive band of limestone which is sometimes associated with glossy black slates or graphitic shales. Small igneous intrusions are known to occur in the vicinity of most of the copper deposits of this belt, and in some cases the igneous rock itself carries copper. The best known deposits in this band are the once famous Acton Mine, the adjacent deposits at Upton, as well as the mines formerly worked at Roxton, Wickham and St. Flavien.

The central, or Sutton, belt contains amongst others the Harvey Hill mine at Leeds, the Halifax in the township of that name, the Viger in Chester, the St. Francis in Cleveland, the Belrath in Melbourne, and Sweet's mine in Sutton. The country rock of this belt has been generally described as chloritic, micaceous, talcose or nacreous slate and has been regarded as sedimentary in origin and the correlation of various deposits has been made on that assumption. Within the last two years, however, it has been found by the writer that these rocks in most cases at least are disguised volcanics of early geological age and much altered in character. Copper is found, not in true veins, as far as observed, but in lenticular masses conforming to the well-developed cleavage of the rock. The gangue is commonly calcite and quartz, and the character of the deposits such as to indicate their deposition contemporaneously with the gangue. The secondary derivation of the ore from the country rock is further evidenced by the fact that the latter commonly yields a small percentage of copper on assay.

Still more recently a similar discovery regarding the nature of the rock in the Ascot belt, the most easterly of the three bands, has been made by Mr, G. H. Pierce, C.E. This area includes, amongst many others, the widely known Albert and Eustis mines at Capelton, the Howard and others at Suffield, the Ascot and the Sherbrooke, nearer the City of Sherbrooke, the Moulton Hill, a few miles east of the St. Francis river, and the Garthby deposits, forty miles farther eastward. The country rock has not been usually described as differing essentially from that of the Sutton belt in general character, unless it be that the micaceous and nacreous slates have been to found predominate in the former while the chloritic prevail in the latter.

During the course of a recent visit to the Suffield mines, Mr. Pierce observed a massive appearance in the hanging wall of the Silver Star mine which suggested to his practised eye the probability of its igneous origin, although the sedimentary character of the rock, a supposed sandstone, had not been hitherto questioned, as far as can be learned, by the many previous observers of it during the past fifty years. A specimen which was handed the writer by Mr. Pierce proved, on microscopic examination, to be a quartz porphyry, the rapidly cooled equivalent of a granite.

As the rock was known to be one of considerable extent, specimens were subsequently taken by the writer at various points across the belt between Sherbrooke and Lennoxville and from several of the nearest mineral deposits. From these it is apparent that the Ascot belt, like that of Sutton, is a complex mass consisting chiefly of old and highly altered volcanic rocks.

The whole igneo metamorphic complex is occasionally cut by dykes which from their undisturbed position and fresh state of preservation are evidently of a very much later age than the main rock masses. The dykes were the latest rocks to form in the region, while the country rocks were the earliest, thus showing this belt to have been the scene of volcanic eruptions at very widely different times, at one or more of which the lavas ejected carried copper, silver and gold. From the fact that the ore bodies in many instances follow the cleavage of the rock, the form thus given the deposits causes them to easily simulate bedded veins, which they have commonly been thought to be, owing to the cleavage having been generally mistaken for stratification. In view, however, of the igneous character of the country rock, the correlation of various deposits on assumed stratigraphical grounds becomes useless both in the case of the Ascot and of the Sutton belts, and opinions regarding the mode of occurrence of the ores also call for revision.

Concerning the deposits of the Ascot belt, Dr. Ells wrote in the Report of the Geological Survey, 1888-1889, (p. 56 K), "it may be very safely predicted that the real value of many of the mines which were opened twenty-five years ago and speedily closed, has never been ascertained, and that other masses of ore of equal importance to those so long worked, will, at some not distant date by careful prospecting be found. Much of the failure of twenty-five years ago was, doubtless, due to the speculative character of the work done. Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness; often on samples which were obtained from an entirely different location from that represented. The growing importance of these ores as a source of supply for sulphuric acid is being fully realized by the men interested in this industry in the United States and their superiority over most of the ore there found, for this purpose, being acknowledged. They are yet in this eastern belt many places thickly covered by forest growth, the prospecting of which is a difficult matter, but of the many mines already opened and abandoned it is highly probable, as in the case of those now worked, that deeper and more scientific testing would change the aspect of things greatly for the better."

Dr. FRANK D. ADAMS (Montreal) paid a tribute to the thoroughness with which Mr. Dresser had carried out his studies of these rocks. He thought his investigations had a most important bearing upon the future success of copper mining in the Townships.

Mr. B. T. A. BELL said it was a pity the Quebec Government made no appropriation to encourage original investigation of this character.

The CHAIRMAN said he believed something might be done towards extending the usefulness of the present Mining Bureau, if proper representations were made to the Government. He could promise them that he will cordially support anything calculated to promote the mining industries of the Province.

Mr. J. R. WOODWARD stated that the copper deposits of the townships had been receiving his attention, and he was firmly convinced that many of the old mines, which had been abandoned years ago, could be re-opened and worked at a profit. There was enough ore in sight to warrant the installation of a custom smelter having a capacity of at least 100 tons daily. He pointed out that not only Sherbrooke county, but Stanstead, Richmond and Wolfe, and Bagor counties were permeated with promising undeveloped copper properties. Work on these and other mines would be stimulated by the establishment of a smelter at Sherbrooke.

Mr. Wm. FARWELL concurred with the other speakers in the great resources of the Province in copper ores. The Federal Government had granted bonuses to the iron and steel, and the silver and lead industries, and he thought some encouragement might also be fairly asked for the production of copper.

Mr. OBALSKI, inspector of mines, said but few people really realized the great wealth of the Province in its resources of copper ore, and he would cheerfully render whatever assistance was in his power towards bringing the claims of this industry to the attention of the Provincial Government. He had just returned from Matane, where a very remarkable discovery had been made.

After some further discussion, the following committee was appointed to take action with respect to the copper question : Wm. Farwell, J. S. Mitchell, S. W. Jenckes, J. A Dresser, Hon. C. C. Colby, and A. N. Thompson (of Stanstead), John Blue, S. L. Spafford, A. N. Thompson, J. R. Woodward, and the Chairman, and report at a later meeting of the section.

The meeting adjourned at 11.30.

APPENDIX.

An Act to Incorporate the Canadian Mining Institute.

[*Adopted by Parliament of Canada in 1898.*]

WHEREAS the persons hereinafter named have, by their petition, represented that an association known as the Canadian Mining Institute has been founded by the said persons, and others, for the following purposes, namely:—

First, to promote the arts and sciences connected with the economical production of valuable minerals and metals, by means of meetings for the reading and discussion of technical papers, and the subsequent distribution of such information as may be gained through the medium of publications. Second, the establishment of a central reference library and a headquarters for the purpose of this organization. Third, to take concerted action upon such matters as affect the mining and metallurgical industries of the Dominion of Canada. Fourth, to encourage and promote these industries by all lawful and honourable means. And whereas the said persons have prayed that it be enacted as hereinafter set forth, and it is expedient to grant the prayer of the said petition: Therefore Her Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1. John E. Hardman, George M. Dawson, William A. Carlyle, Charles Fergie, John Blue, B. T. A. Bell, A. W. Stevenson, James McArthur, Archibald Blue, William Hamilton Merritt, F. T. Snyder, Henry S. Poole, Wilbur L. Libbey, Robert G. Leckie, Clarence A. Dimock, Geo. E. Drummond, Geo. R. Smith, J. Obalski, John J. Penhale, R. G. McConnell, Frank C. Loring, John B. Hobson and William Blakemore, together with such persons as hereafter become members of the Institute, are hereby incorporated under the name of "The Canadian Mining Institute," hereinafter called "the Institute," for the purposes set forth in the preamble.

2. The Institute may acquire and hold such lands and property as are necessary to carry out the objects and purposes for which incorporation is sought: provided the annual value of the real estate held at any one time for the actual use of the Institute shall not exceed five thousand dollars.

3. The Institute may make such by-laws, not contrary to law, as it deems expedient for the administration and government of the Institute.

4. The affairs and business of the Institute shall be managed by such officers and committees, and under such restrictions touching the duties and powers of such officers and committees as may be prescribed by by-law.

5. The head office 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.

BY-LAWS

OF THE

CANADIAN MINING INSTITUTE

(As adopted at the Annual General Meetings held in March, 1902.)

SEC. I.—MEMBERSHIP.

Par. I.—Members shall be persons engaged in the direction and operation of mines and metallurgical works, mining-engineers, geologists, metallurgists or chemists, and such other persons as the Council may see fit to elect.

Par. II.—Student Members shall include persons who are qualifying themselves for the profession of mining or metallurgical engineering, students in pure and applied science in any technical school in the Dominion, and such other persons, up to the age of 25 years, who shall be engaged as apprentices or assistants in mining, metallurgical or geological work, or who may desire to participate in the benefits of the meetings, library, and publications of the Institute. Student members shall be eligible for election as members after the age of 25 years.

Par. III.—Honorary Members shall be persons who have distinguished themselves by their literary or scientific attainments, and persons eminent in science, or in the development, or history of the mining industries.

SEC. II.—ELECTION OF MEMBERS.

Par. IV.—Applicants for membership shall fill in Form A in the Appendix. It shall then be laid before the Council, who shall have power to elect or reject by a two-thirds vote of the members thereof. When the proposed candidate is elected the Secretary shall give him notice thereof according to Form B (see Appendix), but his name shall not be added to the list of members of the Institute until he has signed the Form C in the Appendix.

Par. V.—Student Members shall be proposed in writing by three members, and if approved by Council, shall become Student Members upon payment of the dues specified in Par. IX, Section III.

Par. VI.—Each person proposed as an Honorary Member shall be recommended by the Council and elected by a majority of the votes cast at a regular meeting.

Par. VII.—Any member may be removed from the list on recommendation by the Council.

Sec. III.—PRIVILEGES AND SUBSCRIPTIONS.

Par. VIII.—The annual subscription from Members shall be ten dollars ($10.00) payable on the first Wednesday of March in each year.

Par. IX.—Student Members shall pay $2.00 per annum.

Par. X.—Any properly constituted Society of Mining, Science, or Engineering Students connected with a Canadian University, Mining School, or Technical College may become affiliated with the Institute and have all the privileges of Student Membership on payment by such Society annually of an amount equivalent to one dollar per head of its membership.

Sec. IV.—OFFICERS.

Par. XI.—The affairs and business of the Institute shall be managed and controlled by a Board comprising *(a)* a President, *(b)* four Vice-Presidents, *(c)* a Secretary, *(d)* a Treasurer, and *(e)* a Council of sixteen members.

Par. XII.—The Board shall hold office as described below, and shall be eligible for re-election; provided that, as to the President, no person shall be eligible for immediate re-election to this office who has served for the two preceding consecutive years.

Par. XIII.—As to the Vice-Presidents, they shall hold office for two years, but two of them shall retire annually. As to the Council, they shall hold office for two years, but eight of them shall retire annually.

Par. XIV.—At each annual meeting there shall be elected a President, two Vice-Presidents, eight Councillors, a Secretary and a Treasurer,

Par. XV.—The term of office shall continue until the adjournment of the meeting at which their successors are elected.

Par. XVI.—The Past President shall hold office on the Board *ex officio.*

Par. XVII.—The Council of the Board shall be elected as far as possible with due regard to representation of the four most important mining Provinces of the Dominion, four members each from British Columbia, Nova Scotia, Quebec and Ontario.

Par. XVIII.—The duties of the Officers shall be such as usually pertain to their offices or as may be delegated to them by the Council or the Institute; in its discretion the Council may require a bond from the Treasurer, and make such remuneration as it sees fit to the Secretary and Treasurer for services rendered.

Par. XIX.—In the absence of the President it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any member of Council, or in the case of their absence, any member present, to take the chair at the meeting.

Par. XX.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the members.

Par. XXI.—The Council may appoint committees for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institute. Such committees shall make a report to the Council, who shall act thereon and make use thereof as they shall see occasion.

Par. XXII.—The Council shall make a report, with a financial statement, at each annual meeting.

Sec. V.—ELECTIONS.

Par. XXIII.—There shall be a nominating committee of five appointed by the Council, at least three of whom shall be from the membership at large, who shall submit a list of nominations to the Secretary not less than sixty days prior to the annual meeting. Nominations for officers to be elected at the annual meeting may be sent to the Secretary at any time not less than thirty days prior to the annual meeting, and the Secretary shall, not less than three weeks before the said annual meeting, mail to every member a list of such nominations. Voting shall be by ballot, and shall be confined to the names thus nominated. A majority of votes shall suffice to elect.

Sec. VI.—MEETINGS.

Par. XXIV.—The annual meeting of the Institute shall be held on the first Wednesday of March in each year, at such place as the Council may determine.

Par. XXV.—Ordinary meetings may be held in each year, at such time and place as the Council shall select. Special meetings may be called by a quorum of the Council at its pleasure or upon the written requisition of ten or more members ; notice of such special meeting shall state the business to be transacted, and no other business shall be entertained.

Par. XXVI.—All questions which shall come before any meeting of this Institute shall be decided by a majority vote of the members present, unless elsewhere specified to the contrary.

Par. XXVII.—Notice of all meetings, whether regular or special, shall be sent by mail at least two weeks in advance.

Sec. VII.—PUBLICATIONS.

Par. XXVIII.—The Council shall have power to edit, or decline to publish, any paper which may be communicated to the Institute at its meetings.

Par. XXIX.—The copyright of all papers, plans, maps and drawings accepted by the Institute shall be vested in it if so agreed between the Council and the author. The author of each paper accepted and printed shall be entitled to twelve copies for his own use.

Par. XXX.—Premiums and prizes not exceediug in value $50.00 may be given anuually for papers read by students during the year. Any such award shall be made by the Council.

Par. XXXI.—Each Member and Student Member shall be entitled to a copy of the Journal of the Institute for the year for which he has paid his subscription.

Par. XXXII.—The Institute as a body shall not be responsible for the statements or opinions advanced in the papers which may be read in the discussions which may take place at its meetings.

SEC. VIII.—AMENDMENTS TO BY-LAWS.

Par. XXXIII.—These By-Laws may be amended at any annual meeting by a two-thirds vote of the members present; provided that written notice of the proposed amendment shall have been sent to each member at least one month prior to the date of the meeting.

SEC. IX.—DISSOLUTION.

Par. XXXIV.—The Institute shall not be broken up unless by the vote of two-thirds of the members present at any general meeting convened for the purpose of considering the dissolution and after confirmation by a similar vote at a subsequent meeting to be held not less than three, nor more than six, months after the first, and notice of this last meeting shall be duly advertised as the Council or a general meeting may advise.

APPENDIX.

FORM A.

APPLICATION FOR MEMBERSHIP.

I, ... of ....

....

approve of the Constitution and By-Laws of the CANADIAN MINING INSTITUTE, and hereby request enrollment as a Member.

Name ....

Profession ....

Postal Address ....

Province or State ....

Date ....

FORM B.

NOTICE OF ELECTION.

....

SIR:—

I beg to inform you that on the ....you were elected a..... ....of the CANADIAN MINING INSTITUTE, but in conformity with the Constitution your election cannot be confirmed until the accompanying form be returned with your signature.

Please remit the amount of your dues for the year, $........, to the Treasurer, Mr........................, at your early convenience.

Certificate of Membership and publications will follow in due course.

I have the honor to be,

Your obedient servant,

B. T. A. BELL,

Secretary.

FORM C.

ACCEPTANCE OF ELECTION.

I, the undersigned, being elected a.......................of the CANADIAN MINING INSTITUTE, do hereby agree that I will be governed by the regulations of the said Institute, as they are now formed or as they may hereafter be altered; that I will advance the interests of the Institute as far as may be in my power; provided that, whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom I shall (after the payment of any arrears which may be due by me at that period) be free from this obligation.

Signed ....

....

Date.... ....

FINANCIAL STATEMENTS.

CANADIAN MINING INSTITUTE.

TREASURER'S STATEMENT, YEAR ENDING FEBRUARY 1ST, 1902.

RECEIPTS.

Balance from last year		$630.61
Subscriptions—265 at $10.00	$2,650.00	
do 38 at 7.50	285.00	
do 9 at 2.00	18.00	
		2,953.00
Sale of Journals		7.00
Dominion Government Grant		1,000.00
		$4,590.61
LESS		
Disbursements per statement		3,633.21
Balance on hand		$957.40

J. STEVENSON BROWN,
Treasurer.

MONTREAL, 1st February, 1902.

Audited and found correct.

(Signed) GEO. MCDOUGALL
" H. W. DECOURTENAY } *Auditors.*

SUMMARY STATEMENT.

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

Publications—		
Transactions	$630.10	
Cuts, line drawings, engravings, &c.	239.66	
Stenographing, copying, half-tones and drawings.	228.70	
Postage, express and other charges	131.80	
		$1,230.26
Library—		
Rent	400.00	
Care of library	104.00	
New books	47.85	
Book case	35.40	
Binding	35.30	
Insurance and sundries	38.25	
		660.80
Meetings—		
Reporting Annual Meeting, and Secretary's disbts.	174.05	
Annual dinner (deficit)	99.10	
Council meetings	40.10	
Disbursements per treasurer	22.50	
Typewriting, copying and assistant	55.60	
Postage, telegrams and sundries	24.43	
		415.78
Law and Legislation—		
Legal expenses	10.00	
Mines Act, Deputation to Ottawa	28.25	
		38.25
Secretary's Office—		
Annual grant	700.00	
Typewriting, assistant, and sundries	68.13	
Stationery, postage and telegrams	42.87	
		811.00
Treasurer's Office—		
Annual grant	250.00	
Bank charges on cheques and drafts	48.66	
Postage, Telegrams, &c.	43.21	
		341.87
General Expenses—		
Disbursements per Secretary	40.15	
Audit	10.00	
This year's subscriptions included in last year	15.00	
Sundry accounts (1900)	33.05	
Typewriting, printing, postage, &c.	37.05	
		135 25
		$3,633.21

J. STEVENSON BROWN,
Treasurer.

MONTREAL, 1st Feb., 1902.

SELWYN-DAWSON PORTRAITS.

STATEMENT OF RECEIPTS AND DISBURSEMENTS IN CONNECTION WITH THE SELWYN-DAWSON PORTRAIT FUND.

Receipts.

Contributions per attached list		$487.00

Disbursements.

F. Brownell, R.C.A., painting two portraits	$400.00	
C. Edlington, for framing same	48.00	
Typewriting and postage, per Treasurer	15.60	
Bank charges on cheques and drafts	6.25	
Printing and mailing circulars per Secretary	10.50	
		480.35
Balance in hand		$6.65

J. STEVENSON BROWN,
Treasurer.

MONTREAL, 20th Feb., 1902.

LIST OF SUBSCRIBERS TO THE SELWYN-DAWSON PORTRAIT FUND.

Lord Strathcona	$150.00
W. T. Jennings	10.00
Dr. H. M. Ami	5.00
G. E. Drummond	5.00
J. J. Drummond	5.00
W. A. Preston	5.00
D. D. Mann	25.00
J. Roderick Robertson	10.00
J. B. Tyrrell	25.00
Hon. Sydney Fisher	25.00
London & B. C. Goldfields	25.00
B. T. A. Bell	10.00
Dr. F. D. Adams	5.00
Dr. Jas. Douglas	10.00
J. W. Evans	5.00
Rinaldo McConnell	5.00
W. H. Aldridge	10.00
O. E. Whiteside	5.00
W. F. Little	5.00
Osler & Hammond	20.00
G. J. Ross	3.00
Wallingford Bros.	10.00
Eugene Coste	5.00
R. D. Fetherstonhaugh	5.00
Samuel S. Fowler	5.00
Bernard MacDonald	10.00
Robert R. Hedley	5.00
Carried forward	$408.00

Brought forward	$408.00
J. B. Hobson	20.00
W. F. Ferrier	5.00
	$433.00

Contributed by Members of the Geological Survey.

Prof. Whiteaves	$10.00
J. M. MacCoun	1.00
G. C. Hoffman	5.00
Hugh Fletcher	5.00
H. W. McInnes	5.00
Jas. McEvoy	5.00
C. O. Senecal	1.00
A. P. Low	5.00
Jos. Keele	1.00
R. G. McConnell	5.00
R. W. Brock	1.00
J. C. Gwillim	1.00
H. B. Dowling	1.00
Lawrence Lambe	2.00
Dr. H. M. Ami	5.00
J. M. MacCoun, jr.	1.00
	$54.00
Total	$487.00

OFFICERS AND COUNCIL, 1902.

Past Presidents.

MR JOHN E. HARDMAN, S.B., M.E., Montreal, Que.
MR. SAMUEL S. FOWLER, S B., M.E., Nelson, B.C.

President.

MR. CHARLES FERGIE, M. E., Intercolonial Coal Co., Westville, N.S.

Vice-Presidents.

DR. FRANK D. ADAMS, McGill University, Montreal.
MR. ROBERT R. HEDLEY, Hall Mining and Smelting Co., Nelson.
MR. EUGENE COSTE, M.E., Prov. Nat. Gas and Fuel Co., Toronto, Ont.
MR. GRAHAM FRASER, Nova Scotia Steel & Coal Co., New Glasgow, N.S.

Treasurer.

MR. J. STEVENSON BROWN, Montreal.

Secretary.

MR. B. T. A. BELL, Editor *Canadian Mining Review*, Ottawa.

Council.

MR. JOHN B. HOBSON, M.E., Con. Cariboo Hydraulic M. Co., Bullion, B.C.
MR. FRANK ROBBINS, M.E., Nelson, B.C.
MR. W. F. LITTLE, H. W. McNeill Co., Ltd., Anthracite.
MR. FREDERICK KEFFER, M.E., B.C., Copper Co., Anaconda.
MR. CORNELIUS SHIELDS, Dominion Coal Co., Sydney, C.B.
MR. R. E. CHAMBERS, M.E., Bell Island, Newfoundland.
MR. G. H. DUGGAN, C.E., Dominion Iron and Steel Co., Sydney, C.B.
MR. D. W. ROBB, Robb Engineering Co., Amherst, N.S.
MR. A. P. TURNER, Canadian Copper Company, Sudbury, Ont.
MR. P. KIRKGAARD, Canadian Gold Eields Ltd., Deloro.
MR. E. A. SJOSTEDT, Lake Superior Power Co., Sault Ste. Marie, Ont.
PROFESSOR COURTENAY DEKALB, Boston, Mass.
MR. J. T. McCALL, Canada Iron Furnace Co., Montreal.
MR. B. BENNETT, King Bros., Thetford Mines, Que.
DR. J. BONSALL PORTER, McGill University, Montreal.
MR. GEORGE R. SMITH, M.L.A., Bell's Asbestos Co., Thetford Mines, Que.

DECEASED MEMBERS.

G. R. COATES, - - -	Mine Centre, Ont.
JAMES MACGREGOR, .-	Nanaimo, B.C.
W. J. NELSON, - -	Montreal, Que.
MAURICE A. BUCK, - - -	Kaslo, B.C.
COL. T. J. TUCK, - -	Sherbrooke, Que.
H. A. BUDDEN, - - -	Montreal, Que.
JAMES KING, - - - -	Quebec, Que.
W. BARCLAY STEPHENS, -	Montreal, Que.
JAMES FOLEY, - -	Montreal, Que.
Dr. CARL HOEPFNER, -	Hamilton, Ont.
G. A. BIELENBERG, -	Greenwood, B.C.
Dr. G. M. Dawson, - -	Ottawa, Ont.
LIONEL H. SHIRLEY, -	Montreal, Que.
JAMES F. LEWIS, -	Sherbrooke, Que.
J. RODERICK ROBERTSON, -	Nelson, B.C.

LIST OF MEMBERS, 1901-1902.

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Hon. W. S. Fielding, M.P., Ottawa.

Hon. Clifford Sifton, M.P., Minister of the Interior, Ottawa.

HONORARY MEMBERS.

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John Birkinbine, *Mining Engineer*, Philadelphia, Pa.

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(As at 31st December, 1901.)

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