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The CANADIAN MINING REVIEW

Established 1882

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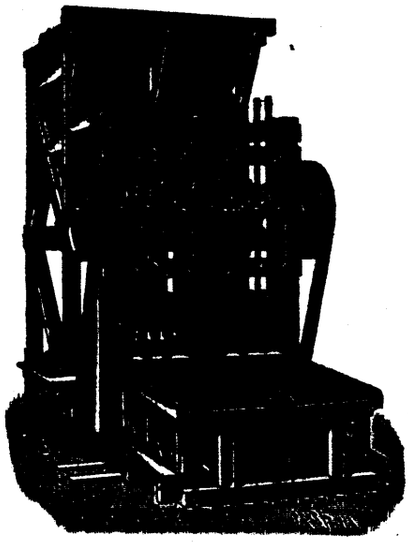

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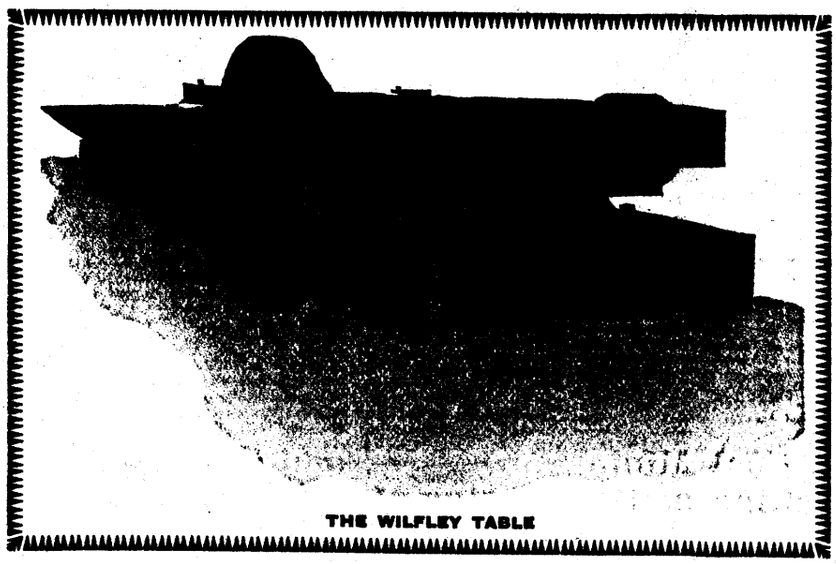

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VOL. XXI., No. 8. AUGUST, 1902. VOL. XXI., No. 8.

Mining Progress in Nova Scotia.

The present summer shows the continued prosperity of Nova Scotia mines. Work has continued steadily, and good prices have been realised for the coal, one of the best customers of the trade being the Dominion Iron and Steel Company, which took last quarter about 150,000 tons. The Dominion Coal Company has successfully sunk its big No. 2 shafts, and the bankhead, one of the largest in the world, is being pushed rapidly. The underground workings are being extended, and an output of 2,000 tons a day is maintained by temporary hoisting engines. The Nova Scotia Steel and Coal Company is completing a new Donkin shipping pier at North Sydney, and is opening a slope on the Lloyds Cove seam, and preparing to develop the Boulardeie section.

The Cape Breton, New Campbelton, and Port Morien mines are working steadily. On the northern side of the island, the Inverness and Richmond Collieries and Railway Co. are continuing their development at Broad Cove, and building a shipping pier at Port Hastings on the Strait of Canso.

The Port Hood Colliery is now in steady working order, and taking its share of the trade. At Mabou a company is preparing to develop the submarine areas, and to build a railroad from the mine to Orangedale on the Intercolonial Railway.

Extensive explorations are being carried on in every part of Cape Breton suspected to contain coal. The Mullin's seam has been traced for a couple of miles from the head of Lingan Bay towards Sydney, and outcrops of new seams are reported from the Cow Bay district.

In the River Inhabitants Basin the outcrops of some coal beds have been traced, but as yet no systematic exploration work is being done.

On the Mainland, work has continued in the coal mines with few changes of interest. The Marsh Colliery, near New Glasgow, of the Nova Scotia Steel and Coal Company, has become a regular producer of coal. The output of this mine is entirely absorbed by the company's steel works. The total production of the quarter ended June 30th is about 60,000 tons greater than that of the corresponding quarter last year when the production amounted to 1,040,000 tons.

The five Government drills have been kept in steady work proving underlying seams at certain collieries, and testing the coal producing limits. Borings made in Hants and Colchester counties, while not penetrating seams large enough to be of economic valne, have served to define more accurately the productive areas.

The interest of geologists, miners, and of the general public has long been turned on the problem of the existence of coal field north of New Glasgow. Here a series of rocks newer than the coal measures occur throughout the northern part of Pictou County, out under the Gulf and Prince Edward Island. If, as there is reason to believe, the coal of New Glasgow, interrupted by a bed of conglomerate, extends under these newer rocks, there are hundreds of square miles of coal fields. The Government of Nova Scotia, acting in conjunction with some energetic parties in Pictou County, has purchased a Calyx drill capable of boring to a depth of 3,000 feet. It is proposed to bore to the north of New Glasgow in the hope that before this depth is reached, the presence of a coal field may be proved. If this experiment proves successful, Pictou may be a great coal producing centre when many more pretentious districts have been abandoned.

The Dominion Iron and Steel Company may now be said to have overcome the difficulties experienced in getting their blast furnaces in good working order. Their coke is now of a grade equal to the burden. Some of the converters are now working, and the remainder will shortly be completed. The frame of the steel rail mill is up, and it should be running at the end of the year. When completed, these works will require over 800,000 tons of coal a year. The Dominion Iron and Steel Company, possibly in anticipation of an export duty on iron ore leaving Newfoundland, are turning some attention to provincial iron ore deposits. Some prospecting has been done at Mira, Whycogomah, and other points. The presence of the cheap and good Newfoundland ore has discouraged search for local ores.

The Nova Scotia Steel and Coal Company are gradually getting their steel plant under way. It is confidently expected hat Mr. Graham Fraser, with his great local experience, will present his shareholders with a plant up-to-date in every respect, and not burdened with the expenses of experiences dearly bought by an amateur. The Torbrook iron ore district in Annapolis County has been fully proved to be of enormous extent, and will play an important part in the next iron ore deal in Nova Scotia.

The gold industry has kept on its usual quiet way, the returns for the past quarter being about 6,500 ounces. The mines working last year have, with few exceptions, continued at a profit. The Dolliver Mountain Company is now getting its preliminary work pushed, and should soon be added to the list of our larger producers. The Richardson, Waverley, Brookfield, Royal Oak and Blue Nose mines may be named among those working steadily. Few new discoveries of value have been reported. The prospector of the early days of gold mining in this province has nearly disappeared, and his loss is being felt, as the number of men who devoted themselves to prospecting is steadily

decreasing. Their skill and patience in detecting and following the traces of veins laid the foundation of all our best mines.

Another cause of the quietness in gold mining may be found in the fact that investors now demand properties prepared for inspection and with considerable development work on them. This necessitates the expenditure of time and money, two requisites not always combined in the Nova Scotia promotor.

The manganese ores of the College Grant, Lunenburg Co., are being systematically examined on behalf of some New York parties, but the production of the other deposits is practically *nil.* The gypsum, quarry, oil shale, infusional earth, and the brick-making interests are kept employed as usual.

A Nova Scotia School of Mines.

The desire of the supporters of Dalhousie College to add a School of Mines to their prosperous University naturally leads to the consideration of the instruction proposed.

At present one branch of mining education has received considerable successful attention from the Government of Nova Scotia. There are seven coal mining districts, and for them about twelve local instructors have been appointed. These men conduct classes, and present to a Provincial Board candidates for certificates as Underground Managers and Overmen. The managers of the coal mines are also required to pass before the Board, but as yet it has been found impossible to provide more than a partial instruction to enable them to qualify themselves

The principle underlying the qualifications of these men is that they be at least twenty-one years of age, be of good character, and have been employed underground for at least four years, and that their practical undergroumd experience should be added to by a knowledge of the principles of ventilation, working, surveying, etc., to meet the general requirements of coal mining. Similar arrangements have been made with respect to enginemen employed in raising and lowering men in coal mines.

The Government recognising that the holders of these certificates had to be drawn from men unable to spare the time to attend Collegiate lectures, sent instructors to them, and has succeeded in passing numerous candidates on a grade at least equal to that demanded by other Governments.

Under this system over five hundred and fifty certificates have been issued, and a number of our mines are being successfully managed by men who began work in them in the most humble capacities.

The Province having made this provision for its coal mine officials might logically be called upon to consider the advisability of instructing the gold and iron and other mine managers and foremen, and further of providing in the general interest of the mineral resources of the Province for the education of trained mining geologists, mineralogists and experts. The scattered positions of these mines rendered the extension of the educational system as applied to the coal mines, of doubtful value, and the undertaking of a fully equipped School of Mines appeared in view of the pressing demands from other important industrial occupations to be a matter requiring careful consideration. It is at this state of the evolution of mining education in Nova Scotia that Dalhousie College proposes to enter the field. If it equips a School of Mines on the lines laid down by McGill and Queen's Universities, it fulfils the last logical step which could be demanded from the Government of Nova Scotia.

It will doubtless from its three or four years course turn out men well equipped in the theory of mining, and instructed in the sciences underlying its application, but devoid of practical experience. On the other hand the Mines Department is giving to men more or less qualified practically some general knowledge of the laws and theory underlying the management of coal mines. In order to avoid waste of money and energy these two schemes should be modified to supply their deficiencies.

It may be conceded that in the comparatively extensive communities engaged in coal mining, the present system of the Government is is the best for underground officials and enginemen, many of whom are obliged to labor for their living, and could not afford to attend regular courses. In the case of other mines it might be possible by a system of district scholarships to enable promising men to receive instruction at some School of Mines. In the case of those desiring certificates as Managers of coal mines, having passed the lower grades, it might be feasible by a similar system of scholarships to assist annually a certain number of those obtaining the highest marks as Underground Managers to qualify themselves in a School of Mines for that final grade.

As practical experience in underground employment is justly considered essential in candidates for the mining certificates of the Department of Mines, the graduates of a School of Mines would be obliged to add a term of underground employment before receiving an equivalent of a certificate of competency.

As the object of the Government of the Province, and of the Governors of Dalhousie is in this connection primarily the development and proper working of our mines, it is to be hoped that upon the establishment of the School of Mines, both parties will agree upon a course of studies and regulation of time which will combine the practical and academic sides of mining education.

Mining Progress in British Columbia.

The annual report of the Minister of Mines for the year 1901 was issued this month, and, as in former years, contains an immense amount of serviceable information concerning the mines and mining districts of British Columbia.

The volume is beautifully printed and handsomely illustrated, and Mr. Robertson, the Provincial Mineralogist, is to be congratulated upon its publication.

In the opening section of the volume, Mr. Robertson reviews the progress of the various mining industries as follows:—The mining industry has, during 1901, still maintained that rapid growth which has characterised it since the inception of lode mining some ten years ago. It is all the more gratifying to be able to make this announcement again this year, inasmuch as reports to the contrary have been so widely circulated that the impression that 1901 has proved a disastrous year has gained much credence, not only abroad, but even within our own borders. Statistics are the best refutation of this impression, and it is with much gratification that attention is drawn to the preceding statistical tables. These show that the value of the mineral production of this Province for the past year is greater than that of the Yukon; that we have in our mineral deposits a "Klondike" of our own, and a permanent and growing one at that. The Yukon is credited with an output of $18,000,000, while British Columbia produced $20,086,780.

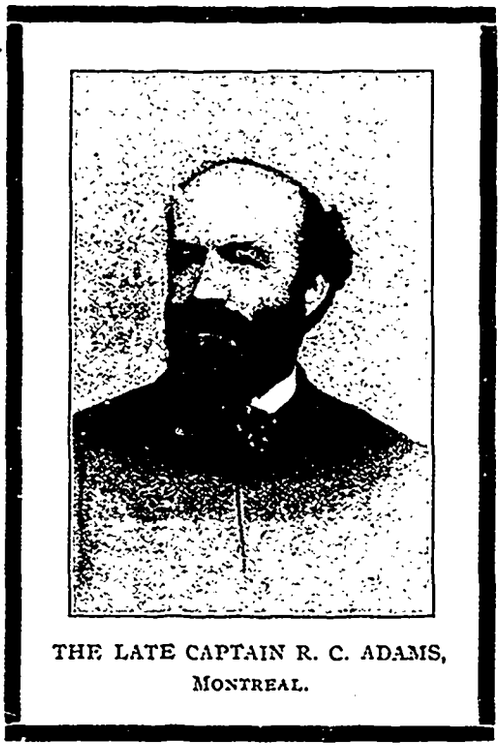
Table 1 gives the total values of the various mineral products of the Province up to and including the year 1901, showing the amount contributed by each mineral to make up the total of $172,241,988, the grand total of the Province's earned increment to the mineral wealth of the world. Gold still retains the first place in this list with a total production of $63,554,543, coal and coke following with a total production of $54,157,315.

OBITUARY.

The Late Captain Robert C. Adams, Montreal, and Howard West, A. R. S. M., New Denver, B.C.

THE REVIEW sorrowfully chronicles this month the loss of two well known members of the profession and industry of mining in Canada in the deaths of Captain Robert C. Adams, of Montreal, and Howard West, A.R.S.M., of New Denver, B.C.

Captain Adams was prominently identified with mining in the Province of Quebec for many years, having been one of the pioneers in the Canadian phosphate industry of the early eighties. He was then managing director of the extensive properties worked by the Anglo-Canadian Phosphate Company, Limited, in the Buckingham and Perth districts. On the collapse of phosphate mining he became became interested in the mica trade and in metalliferous mining in truest, and a contributor who, in its early history, did much to help it forward to its present position. Captain Adams was born in Boston, Mass., in 1839, and at the age of fourteen entered the merchant marine, a profession which he followed successfully for many years. On retiring from the sea, as stated, he became actively interested in mining, taking up his residence in Montreal. He was president of the Canadian Secular Union, and of the Montreal Pioneer Freethought Club, and among his contributions to literature may be mentioned the following:—"On Board the Rocket," "History of England in Rhyme," "History of the United States in Rhyme," "Travels in Faith," "Pioneer Pith," etc.



THE LATE CAPTAIN R. C. ADAMS, MONTREAL.

THE LATE HOWARD WEST, A.R.S.M. NEW DENVER, B C.

British Columbia where he had extensive interests in the Boundary and other sections of that Province. He was one of the founders of the Quebec Mining Associatiou and for several years the active head of that vigorous organisation during the period when the owners of Quebec mining property were combatting the obnoxious mining legislation of the Mercier *regime*. He was also a member of the Canadian Mining Institute, but owing to failing health did not, in recent years, take any active participation in its work. Unassuming, genial and kindly, a thinker of no mean calibre, a man of undoubted ability, both as a platform speaker and as a writer, Captain Adams will be remembered with affection by the older mining fraternity of Quebec. By his death THE REVIEW has lost another friend, one of its oldest and

THE REVIEW extends to Mrs. Adams and to his son, Mr. Walter Adams, M.E., its heartfelt sympathy in their sore bereavement.

THE LATE HOWARD WEST.

We were greatly shocked the other day to read in a western paper of the sad death by drowning of Mr. Howard West, A.R.S.M., of New Denver. Mr. West had gone for a swim in Slocan Lake and it is thought had taken cramp while in the water. The late Mr. West was an Englishman, a graduate of the Royal School of Mines, who came to Canada about ten years ago and began practice as an assayer at New Denver, He was a singularly lovable character, upright and honorable in all his dealings, and was immensely popular in the Slocan.

Table 2 shows the gross value of the mineral output for each year, and is particularly intended to illustrate the growth of the mining industry from year to year. From this it will be seen that in the last ten years the output has increased from $2,978,530 in 1892 to $20,086,780 in 1901, and this increase has been gradual and steady, the result of new properties added to the producing list each year, and the increasing development of the older properties.

The increases for each year from 1896 over that preceding are shown below:—

	Increase over previous year.	Per cent. increase.
1896	$1,864,914	33
1897	2,947,312	39
1898	451,593	4⅓
1899	1,486,270	13⅔
1900	3,951,620	31⅔
1901	3,742,029	23

The per capita mineral production of the Province for 1901 was $134.

Table 3 gives in detail the amount and value of the various mineral products for the past three years. As compared with 1900, the production for 1901 shows, for:—

Placer Gold	a decrease of	27⅓ per cent.
Lode Gold	increase of	26 "
Silver	"	25 "
Copper	"	175 "
Lead	decrease of	25½ "
Coal	increase of	1½ "
Coke	"	49 "
Other Materials	"	22⅓ "

Table 4 shows the gross value of the mineral products for the last three years produced by the various divisions and districts, and illustrates the growth of productive mining in the various parts of the Province.

Table 5 shows the yearly production of placer gold since 1858, showing a grand total to date of $63,554,543. In this is included gold obtained by placer mining, hydraulicing, and dredging.

Table 6 shows the production of the lode mines of the Province since 1887, which is the earliest period in which any lode mining was carried on, although it never amounted to anything appreciable until 1892.

While coal mining and placer mining are undoubtedly just as truly mining as is "lode mining," and the production therefrom is just as truly a part of the mineral output—still, in the popular sense, the term "mining" is confined to lode or metal mining, and for this reason this table is most interesting as indicating the growth of such "mining" in the Province.

That this growth has been phenomenal is shown by the following figures:—

In 1894 the product of the lode mines was valued at $781,342, while in 1901 it has increased to $13,683,044, or nearly 18 times as much in eight years

The product of these mines in 1901 is valued at $13,683,044, an increase over the previous year of $3,613,287, or equal to 36 per cent.

The tonnage of ore mined in 1897 was 169,362 tons; in 1898 it had increased to 215,944 tons, or about 27½ per cent. increase over the previous year. In 1899 it was 287,343 tons, or equal to 33 per cent. increase; in 1900 it was 554,796 tons, or 93 per cent. increase; in 1901 it was 920,416 tons, or about 66 per cent. increase over the previous year.

While this great increase in tonnage is chiefly due to the increased output of the mines previously working, still there have been a number of new shippers added to the list during the past year.

The following table shows the number of mines in each district which shipped during the past year:—

TABLE SHOWING DISTRIBUTION OF MINES SHIPPING IN 1901.

District.	No. of Mines Shipping.	No. of Mines Shipped over 100 tons in 1901.	Men Employed in these Mines.		
			Below.	Above.	Total.
Cassiar—					
Atlin	1	..	1	..	1
East Kootenay—					
Fort Steele	4	4	173	63	236
Other divisions	4	1	19	7	26
West Kootenay—					
Ainsworth	13	7	126	33	159
Nelson	11	8	282	211	493
Slocan	36	21	676	194	870
Trail	13	9	685	267	952
Others	8	2	39	27	66
Lillooet	3	3	29	14	43
Yale—					
Osoyoos, Grand Forks and Kettle River	17	14	301	227	728
Yale, Ashcroft, Kamloops	2	2	21	19	40
Coast	7	7	184	150	334
Total	119	78	2 736	1,212	3,948

Of the non-shipping mines the statistics are very incomplete, as very few of them report to the Department, and most of them are still in the "prospect stage." Returns have been received, however, from 47 mines in the Province which did not ship in 1901, and show that these mines employed 374 men; 227 below ground and 147 above ground.

Table VII shows the product of the metalliferous mines of the Province, giving in detail the tonnage mined in each division, together with the quantities and values of each of the metals so produced.

Table VIII gives the coal and coke production of the Province for each year from 1836 to date, showing a gross product of the value of $54,157,315.

Tables IX and X show, graphically, the mineral production of British Columbia for 1900 and 1901, as compared with the combined product of all the other Provinces for the same minerals during these years.

This shows that, of the total combined output of the various Provinces of the Dominion during 1901 (excluding the Yukon Territory), British Columbia produced—

82 per cent. of the gold, 96 per cent. of the silver
67 " " copper, 96 " " lead
2 " " iron, none " nickel
30 " " coal, 50 " " coke,

and of the total of preceding minerals about 49⅓ per cent.

Surely British Columbia is entitled to be called the "Mineral Province of Canada."

COAL.

The coal mines of the Province, have, during the past year, made an output never before equalled in their history. The gross output of coal was 1,691,557 tons, of which 221,226 tons were used to make coke, so that the net output for the year was 1,460,331 tons of coal and 127,081 tons of coke. This is equivalent to an increased production over 1900 of coal 1½ per cent., and of coke 49 per cent.

The sales of coal were as follows:—

Sold for consumption in Canada	413,705 tons
" export to United States	895,197 "
" " other countries	18,966 "
Total sales	1,327,868 tons (2,240 lb.)

The total sales of coke amounted to 127,533 tons, of which 80 154 tons were sold for consumption in Canada, and 47,379 tons were exported to the United States. This output has been made from the collieries on Vancouver Island and those near the Crow's Nest Pass. The detailed production of each colliery is shown in the reports of the Inspectors of Collieries. The coast collieries produced 1,26:,744 tons of coal and 153,98 tons of coke. The Crow's Nest collieries produced 198,587 tons of coal and 111,683 tons of coke.

The conditions prevailing in these two districts are so different that they require to be noted separately.

In the coast collieries the output is limited by the market for the product, as these older collieries are better prepared to meet an increased demand. Of their product about 75 per cent. was exported, chiefly to California and mostly as coal. With the completion of the two smelters now under construction on the coast, the market for coke should be materially increased next year.

The Crow's Nest collieries are as yet new, and their output is limited, not by the market, which is unlimited, but by the undeveloped condition of the collieries and the limited transportation facilities, difficulties which are being removed with all possible speed, and next year will undoubtedly see an enormous increase in the output of these collieries. Of their product about 60 per cent. of the coal and 70 per cent. of the coke was consumed in Canada, the remainder going to the United States. It has been a constant struggle for these mines to meet the demands made on them for fuel, and every endeavour is being made to increase the output. There have been many complaints that the local demand for fuel was being neglected to supply the export trade. This difficulty will be obviated as the development and equipment of the collieries is increased. The figures show where the output was sold, and it is certain that next year a far larger proportion of the coal produced will be exported, as it is evident from the demand that it is much better than any other that can be obtained in those States immediately to the southward of British Columbia.

It will be noted that while these collieries only turned out 198,587 tons of coal to be used as such, they converted 180,768 tons into 111,683 tons of coke, selling it as such, so that the actual amount of coal mined was 379,355 tons.

GOLD.

These statistics show that the gold production of the Province—including both placer and lode gold—for the past year, was of a value of $5,318703, which is an increase over that of 1900 of $586,598, or equal to about 12 per cent. increase. This is the greatest gold production British Columbia has ever made. In 1900 the increase was 12½ per cent. over the previous year, and the increase this year over 1900 is 11⅛ per cent, showing the growing importance of the gold output of the Province. This production is derived from placer mining, including ordinary placer work, hydraulicing and dredging, and from lode mining.

The placer gold output for the year 1901 was $970,100—a decrease from the previous year of $308,624. This is accounted for by the fact that the Atlin production has again suffered a serious diminution; the ordinary placers are mostly worked out, and the hydraulic companies which should have been at work making an output, have managed to get into litigation among themselves and with individual miners, so that the season was practically lost. It is hoped and expected that by next season the existing plants, and those now under construction, will be able to work, and if so, the output of the camp will certainly be double.

The Cariboo district shows a considerably decreased production, which is due almost entirely to the small output of the largest company in the district, the Cariboo Consolidated, which, through shortage of water, was only able to work a part of the season. This shortage of water was occasioned by the sudden melting of the snow in the spring, leaving insufficient water for the latter part of the season. The snow usually retained on the mountains is, as a rule, a sufficient reserved supply to last through the season, but last year this all melted at once, causing spring freshets and a dry summer season. The smaller companies in the district did well, and with a normal snowfall and spring all should make a very good showing next season.

A small output has been made from the Liard Division, but as last year was the first year of the operations of the hydraulic companies there, most of the work was preparatory and of the nature of development. On the coast certain deposits of black sand have been worked to a profit, but have not made the output expected.

Dredging for gold, although it continues to receive much attention and large amounts have been invested in capital, has not as yet yielded any very material return or output. That the gold exists in the beds of many of the rivers in considerable quantities has been conclusively proved many times, but the difficulty seems to be to save it. It might be pointed out that in every instance, as far as is known, the dredges operating in British Columbia work up stream, and it is very questionable if such a practice is best suited to the conditions here prevailing, or whether they should not, on the contrary, work down stream. In most of our rivers dredging is done under the following conditions, viz.: A swift current, numerous boulders, fine, flaky gold to be recovered and finally a hard, undredgable, and uneven bedrock.

It is submitted that, under these conditions, a dredge working up stream cannot be expected to save or take up all the gold. The agitation of the river bed by the buckets is great, and the gold will and is bound to settle into crevices in the bedrock. A very small crevice may hold the profits of a month, from which in a hard bedrock it is impossible for a dredge to recover it. Any gold once raised and afterwards dropped is swept by the force of the current back of the dredge bucket and is consequently lost. On the other hand in working down stream a "face" is formed which will be more or less inclined; the gold is swept from the bedrock on to this inclined face of removable material, and would be taken up in a subsequent bucketload.

Placer mining is, of necessity, dependent on the weather, and is as variable in this Province as that commodity, but in lode gold mining, as the mines develop, the production becomes as regular as the output of a manufacturing business, and it is to lode mining that the Province is indebted for its ever increasing gold production. In 1901 the lode mines of the Province produced $4,348,603 in value of gold, an increase over the previous year of $895,222, or 26 per cent. When it is remembered that this increase follows an increase in 1899 of about 30 per cent., and in 1900 of 21 per cent., a fair idea may be formed of the development and growth of the industry. This great increase is due first and chiefly to the development of the Boundary District, but the increased tonnage of the Rossland and Nelson districts has also had its effect. Approximately, this gold has been derived from:—

Direct smelting of copper-gold ore, - -	$3,474,738
Combined amalgamation and concentration	873,865
Total - - - - - -	$4,348,603

It may be said that no absolutely "free milling" gold property is working in the Province; they all carry sufficient values in sulphides to necessitate the saving of such.

SILVER.

The total amount of silver produced in 1901 was 5,151,333 ounces, valued at $2,884,745. This is an increase over the previous year of $575,545 in value. The silver production of British Columbia this past year has been affected in two ways and requires some explanation. Silver is derived from silver-lead ores and from copper ores carrying silver, with a small percentage of "dry" silver ores. In 1900, approximately 90 per cent. of the silver produced was derived from silver-lead ores, probably including most of the "dry" ores, as they were chiefly smelted together and are impossible to separate in the statistics. This year there has been a falling off in the production of lead ores, and a consequent diminution of the silver production, which has, however, been more than offset by the greatly increased tonnage of the copper-silver ores.

As near as can be estimated, the copper-silver ores have this year produced 30½ per cent. of the silver output. The production of "dry" ores, although proportionately small, has greatly increased, but it would be difficult, as before stated, to separate, with any degree of accuracy, this source of production from the others.

LEAD.

The production of lead was this past year 51,582,906 lbs., worth $2,002,733. This shows a decrease in value of $689,154, or about 25 per cent. as compared with the production of 1900, but in fairness the comparison must not stop here; it must be remembered that in 1900 there was a phenomenal increase over 1899 of 206 per cent. The figures show, therefore, that the lead production of 1901, although showing a decrease as compared with 1900, shows an increase over 1898 of 86 per cent., and over 1899 of 128 per cent., and is still 25 per cent. higher than the highest production of any year prior to 1900. The cause of the decrease is not attributable to the mines themselves, but to the condition of the market for lead ores—too large a question to go into here—which has temporarily rendered it unprofitable to mine large deposits of galena very low in silver. Reference is here made particularly to the lead ores of East Kootenay. The Slocan district has not been so seriously affected by the low price obtainable for lead ores, as the ores of this section carry much higher silver values, which has enabled them to be mined and marketed at a profit. As a matter of fact, the Slocan has this year just held its own as regards tonnage of ore mined and values produced.

COPPER.

Each year seems to present some particular feature of interest, and this year it is the greatly increased copper production of the Province. The copper production for the year has been 27,603,746 lbs. of "fine copper," valued at $4,446,963, an increase of 17,606,666 lbs, and $2,831, 674 over that of the previous year, or about 175 per cent. increase in value.

It may here be noted that the recent "break" in the copper market did not occur until the last month in the year, and as, in estimating the values as above, the average price for the year is employed, the value of the product has not been seriously affected.

This copper has been derived as follows:—

Boundary district	14,511,787	lbs.
Trail (Rossland) "	8,333,446	"
Coast "	3,115,872	"
Nelson "	1,599,449	"
Other districts	43,192	"
Total	27,603,746	lbs.

The great increase has been due to the working of the exceedingly large and notoriously low grade copper ores of the "Boundary," which has been rendered possible by the material reduction made in the actual costs of smelting, which are authoritatively stated as having been reduced as low as $1.35 to $1 50 per ton of ore. This low possible cost of the first smelting, now proven, has a wide effect on the future of the district and Province, as it brings within the limit of profitable ores many known deposits of great extent which it has been previously regarded as impossible to profitably treat.

IRON ORE.

It has to be recorded that, as yet, very little iron ore as such has been mined in the Province. There have been a few experimental shipments made and a considerable amount of development work carried on, but from the very nature of things iron ore to be handled at all necessitates an iron blast furnace to treat it, which is, as yet, not an accomplished fact in British Columbia, and will not be until a sufficient development has been done to fully establish both the quantity and quality of ore supply to justify its erection.

The statistics show that 5,746 tons of ore were shipped, which, as before stated, were used for experimental purposes, or as a flux in smelting other ores.

OTHER MINERALS.

There has been a small quantity of platinum produced this year, about $457 worth, from the Similkameen District. This small output is occasioned by the fact that comparatively little placer gold mining has been going on in this district of late, and as the platinum is recovered with the placer gold, little has been produced. This metal has been again noted in the neighborhood of Dease Lake and on the Thompson River in the placer workings, but no record has been obtainable of any quantity having been saved.

No reliable returns are available as to the production of the various building materials, including lime, brick, fire clay, building stone, cement and tile pipes, and the amount credited to these materials in the statistics has been estimated—the estimate erring on the conservative side.

Lime and brick are produced locally in almost every district for home consumption, while on the coast an excellent lime, which has considerable sale abroad, is made from a marble. On the coast, too, a cement of very good quality is made, and supplies much of the local market. On Kootenay Lake a coarsely crystalline marble quarry is being worked for building purposes. There are on the coast several first class granite and sandstone quarries open and doing a local trade. These quarries are so admirably situated as regards water transportation that there is a fair prospect of their becoming an important export industry. Fire-brick, drain-pipes and tile are manufactured on Vancouver Island for home consumption."

SILVER MINING IN ONTARIO.

An Important Consolidation of Some of the Mines of Lake Superior.

The production of silver from the Thunder Bay District of Lake Superior, which a few years ago occupied a very prominent position in the mineral production of Ontario again gives evidence of its old time vitality. Last year the total production of this metal in Ontario 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 into the hands of a new company which promises to greatly augment the mining operations hitherto carried on in this section of Lake Superior. This company, known as the Consolidated Mines Company of Lake Superior Limited, was incorporated in Ontario a year ago with an authorized capital of $1,000,000, and is a combination of American and Canadian capitalists. The total area of the silver-bearing properties acquired

comprises something over 1,800 acres, upon which the mines above mentioned are located. In connection with the photos shown in our illustrated supplement this month, the following notes regarding the past history of these mines will be of interest to readers of the REVIEW:

THE PORCUPINE MINE.

This property consists of Mining Location 96 T, containing 160 acres, and was worked in a spasmodic manner and with a very irregular force for about a year previous to 1887.

A good wagon road to connect with the Canadian Pacific Railway at Murillo Station, and communication with Port Arthur, was built, and in addition to the erection of the necessary camp buildings, some drifting and test-pitting work was done on a vein from 2 ft. to 6 ft. in width, from which there was extracted over $15,000 in ore that for the most part consisted of massive argentite and native silver, shipments of which were made to the smelters.

On the strength of these showings the property was sold for $50,000 cash, and the purchasers proceeded to open up the property by systematic development, blocking out the ore by drifts, shafts and winzes, and the property at the time of closing down (on account of litigation), was very fairly well opened up to commence stoping and milling. While this development was going on some 3,000 tons or more were stoped out above the adit level and milled at the "Badger" mill. Although no accurate figures or data were ever kept of this milling, it is believed, from the information gathered, and from statements made by the manager of the "Badger" at that time, that the ore averaged over 20 ozs. of silver per ton.

On the second level some very rich smelting ore was encountered in the vicinity of the main shaft.

The silver-bearing rocks of this district are those of the Lower Cambrian series known as the Animiki slates. They consist of black argillaceous slate, and are comparatively soft and easily drilled, the rate of drilling by hand being about four (4) feet per hour. Above these slates is a capping of hard massive basalt or trap rock, varying in thickness in different localities from 10 feet to 100 feet. The silver enrichment usually occurs below the junction of the trap with the slates, and is rarely found in the trap in any considerable quantities. The Animiki slates lie horizontally, and the veins, which are of the true fissure type, cut through both the slates and trap at a very steep angle or dip, usually 70° to 80°. The fissures are the result of the faulting of the rocks, and there is in nearly all cases a considerable displacement of the hanging and foot walls, the thrust varying from 10 feet to 60 feet. At the "Porcupine" the difference of level between the junction of the trap and slates on the foot wall and its corresponding point on the hanging wall, is 16 feet, and the depth of the trap capping on the higher side, that is, the foot wall, is 35 feet below the surface. The vein filling consists of a gangue of quartz, calcite and baryta, which in many places exist brecciated with portions of the slate country rock. These gangue constituents are mineralized to a greater or less extent in different portions of the same vein by iron pyrites, galena, argentiferous zinc blende, argentite (silver glance) and native silver. The argentite exists in the vein both in the nugget and leaf form, nuggets of solid silver as large as a man's head having been taken out. Native silver in both the wire and leaf varieties is also encountered, but is not so prevalent as the black sulphide of silver (argentite). A pale green and greasy substance locally known as mountain tallow, which is chemically described as a hydrated silicate of magnesia, is found impregnating both the vein itself and along its walls. This mountain tallow has been found to be intimately associated with rich depositions of silver, and is always looked for as a good indication of the approach to a rich chute of ore.

The dark varieties of zinc blende are found to be highly argentiferous, running in some cases as high as 3,000 ozs. in silver to the ton.

Of the Porcupine mine in January, 1899, (after some additional development work had been carried out under my direct supervision while Manager of the "Badger" mine), I then reported as follows:—"You will notice by glancing at the accompanying underground plan of the Porcupine mine, the amount of ore available for stoping, as well as what has already been stoped out. Approximately, there is ore enough at present blocked out to keep a 10-stamp mill running for at least two years, and sinking the present shaft two hundred to three hundred feet deeper, would open up a very large ore body of a quality that will pay a handsome margin, over and above the expenses of milling and mining, and I confidently expect that a large amount of smelting ore will be encountered, such as had already been shipped when the mine was in operation last, with values running from 300 to 3,000 ozs. to the ton."

The above observations refer only to the Porcupine Mine proper. About 300 feet east of the Porcupine, but upon the same location and parallel thereto, lies the Porcupine Junior, an exceedingly large and well defined vein on which development work was done shortly before the mine closed down. A tunnel was run into the side of the mountain for some distance through the drift and alluvial overflow, striking solid rock formation and what was supposed to be the vein, the outcropping of which shows on top of the hill. This tunnel was driven for a total distance of 695 feet, 539 feet of which was on the vein and where it showed an average width of two feet, and was in places very rich in silver.

Some stoping was also done above this level, and it is estimated approximately that about $20,000 in silver was taken from these workings. Subsequently, it was determined, apparently, that this work was altogether on a "feeder" to the vein, which was intersected at about 40 ft. in, where it showed from 3½ to 4 ft. of solid and well mineralized vein carrying considerable native silver. No further work was done on this vein, but its characteristics are such as to warrant the belief that a very large body of rich ore will be found at or near the junction of the "feeder" with the main vein. This vein is a mine itself, the possibilities of which are as great as that of the Porcupine proper, and I have no hesitation in stating that it is possible, under intelligent direction, to place this property upon a paying basis with a comparatively small expenditure of money for necessary machinery and labor, and I am equally confident that upon further surface explorations upon this hitherto but partially prospected area, other argentiferous veins of equal merit will be discovered.

The present company took possession in July, 1901. The mine was pumped out, and after a very small amount of exploration work was done, shipping ore of the very highest grade was found to exist in several places. In one place in particular there exists 6 inches of ore that is as nearly solid silver as it is possible to be. From one place a small piece of ground was stoped out, and a test shipment of 13 tons made to the smelter at Omaha. The ore was roughly sorted into two grades, the higher grade running 396.72 ozs., and the lower 60.20 ozs. of silver to the ton. The development work since July has consisted of the extension of the second level, both east and west, in driving which some very rich ore has been encountered; one chute in particular was struck November 4th carrying a 12-inch pay streak of ore assaying 8,866 ozs. to the ton. This development has increased the amount of ore blocked out by some 3,000 tons. It is proposed to sink the main shaft 30 feet deeper and to open up another level immediately, as rich ore exists in the bottom of the shaft, which is at present 40 feet below No. 2 level. The total amount of development on the main Porcupine consists of 1,690 feet of drifting and 250 feet of shafting.

PLANT.

When the company took over the property in July, no plant existed on the property. Since then an excellent hoisting plant, capable of handling 200 tons or more per diem has been installed, with engine house, shaft house and ore houses, all constructed of good design and

workmanship. The engine house, landing stage in the shaft house, and the underground workings, are lighted by electricity, the electric plant having a capacity of 50 lights.

There are also on hand some 300 cords of wood. The steam capacity, being 80 horse power, is sufficient to supply power for a 10-stamp mill in excess of what is now being used for the hoisting plant. The mine being a particularly dry one, no trouble is experienced with water, although a duplex pump of 170 gallons per minute capacity is installed, and would be capable of handling the water even when the workings are largely increased.

A number of the houses which stand on the Badger property were repaired, so that ample housing capacity is available even for a much larger force of men, and a small outlay will further increase this to a capacity of 150 men if required. There are in all some 40 buildings, including houses, stores, stables, sleeping and cook camps, and offices on the Badger and Porcupine properties.

The engine house and blacksmith shop is thoroughly equipped with all the necessary tools to handle what work is met with in the ordinary course of events. For heavier work, a machine shop and foundry at Port Arthur are easily available, and prompt service is rendered.

The transportation problem, which in the early history of the mine was a very serious and expensive one, necessitated a haul by team a distance of 12 miles, over bad and hilly roads, of supplies coming in and ore going out. This is now a very simple matter, as a good wagon road of 1½ miles connects the mine with Silver Creek station, on the line of the Canadian Northern Railway, Duluth extension, from which point trains run into Port Arthur, a distance of 28 miles.

As to this important matter, conditions here are exceedingly favorable to the miner. The rock, unlike the usual rock met with in gold and silver mines, is comparatively soft, and work can be accomplished as quickly here by hand drilling as in some other localities by machine drilling. Transportation expenses are reduced to a minimum, being only $2 to $7 per ton. Mining labor is paid $2 per shift of ten hours; no labor union or labor troubles exist. Fuel costs from 90c. to $1.10 per cord, delivered at point of usage. Drifting contracts can be made for $5 to $6 a foot; sinking, $8 to $12. Dynamite costs 15c. per lb. The mines being in a farming community, cheap farm produce is therefore available. In view of all these favorable facts, the total mining and milling costs, with proper management, ought not to be in excess of $2 per ton, with a milling capacity of 50 tons a day, and as the ore is expected to run between $8.50 and $11.50 per ton, the margin for profit is ample.

PORCUPINE JUNIOR.

On this vein a development tunnel was driven some 695 feet, from which some very rich silver ore was taken out as a result of the work, amounting to $20,000. Three years ago, when the Porcupine passed into the hands of the owners previous to the present consolidated company, they figured that by driving a cross-cut tunnel at a lower level than the Porcupine Junior tunnel they could intersect this vein, and thereby open up a large amount of shipping ore, which would be available without the expense of any plant whatever. They therefore drove the tunnel shown on the map some 419 feet, with the result that, not having had any accurate surveys made, when they struck a small stringer of only a few inches wide at the point marked "O," they supposed they had reached the vein they were seeking; they then drifted on it for 137 feet, and not finding anything of value abandoned it. A survey of this tunnel and the Porcupine Junior tunnel shows the two workings to be in the portions as indicated on the plan, and by cross-cutting at the point marked "Proposed Cross-cut," the Porcupine Junior vein will be struck, allowing for the dip of the vein, in about 40 feet.

By cross-cutting from the main shaft of the main Porcupine, a distance of about 200 feet, the Porcupine Junior could be brought into connection with the present hoisting plant, and the ore taken to the mill that way.

Between these two veins there ought not to be the slightest difficulty in keeping a 20-stamp mill, with a capacity of 80 tons per diem, pounding steadily for several years. It is also very probable that a small outlay on diamond drilling would open up other rich veins, as other faults in which all these veins occur are known to exist, but have never been exploited.

THE BADGER MINE.

Consisting of Mining Location 201 T and part of 200 T, contains 200 acres, and joins the Porcupine and Keystone above described. From the fall of 1887 until the close of that year, in addition to the erection of camp buildings, about 100 feet of drifting was done during which initial work an unusually rich body of silver was encountered. Up to the end of March, 1889, the work consisted chiefly of sinking a shaft 280 feet; over 2000 feet of drifting and 190 feet of winzes and air shafts were also carried out, besides some stoping between the first and second levels, where extremely rich ore was struck, some of which assayed over 19,000 ounces of silver to the ton. Up to April 1st, 1889, about $65,000 had been expended, and $267,000 worth of silver taken from the mine. An average of thirty men were employed and the surface buildings, shaft house, shops, stables, officers' quarters, rock house, and a complete stamp mill, with a daily capacity of 30 tons, were completed.

The mine is situated well within the centre of what has been termed the "Silver Constellation," and the general character and strike of the veins correspond very closely with the Porcupine veins.

THE KEYSTONE.

The Keystone was, until the construction of the new colonization road and spur thereto via Badger and Porcupine, not quite so accessible as its immediate neighbours, and preliminary and other work of development carried on there was done in a quiet way. The Keystone has an area of 160 acres of splendidly wooded land, and has three veins upon it, known as Nos. 1, 2, and 3. upon which the development work up to date consists of drifting 325 feet first level on No. 1, and about 330 feet of sinking and drifting in No. 2. Vein No. 1 is a most pronounced one, and its ores are rich in native silver. Veins 2 and 3 have produced some of the richest native silver that was as remarkable for its variety and beauty as anything yet brought to light in this or any other known district. It is estimated that about 20,000 ounces of silver in the smelting ore were extracted from the different workings, while at least 950 to 1,000 tons of milling ore remain upon the dumps, all of which shows rich in silver.

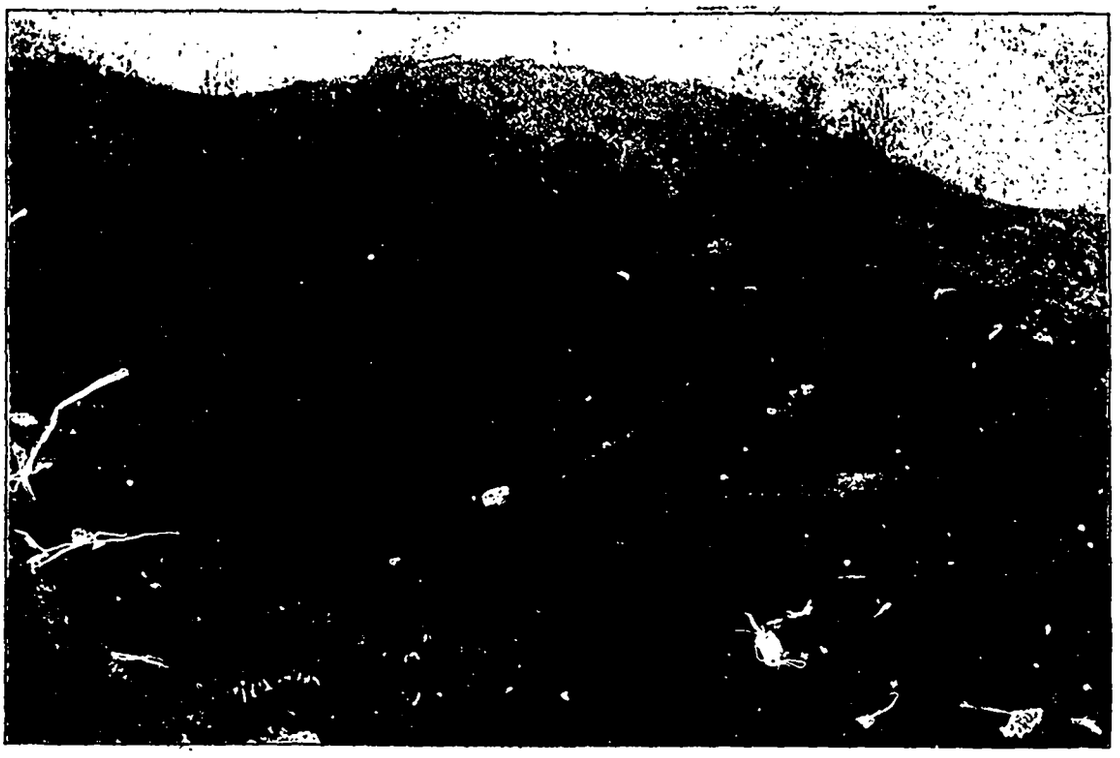
SILVER MOUNTAIN WEST.

Silver Mountain West, or "West End Mine," consists of Mining Location R 55, R 56, R 57, and 178 T. The mine is equipped with a modern 10-stamp Fraser and Chalmers gravity mill, with a capacity of forty tons per day; one Copeland & Bacon double cylinder hoist, 8 x 10, and locomotive type forty horse power boiler; one single drum, 8 x 10, hoist, one vertical boiler, thirty horse power; pumps of the capacity of 250 gallons per minute; fully equipped blacksmith shop, all necessary tools, etc.; fine office building, large boarding house, sleeping camp, also twenty dwellings, one store building, stocked with merchandise and supplies for the men, stables, two teams of horses, with the necessary harness, sleighs, wagons, etc., etc.

An exceedingly strong vein cuts nearly squarely through the ridge of summit of Silver Mountain in its almost east and west course, dipping towards the north. This vein is the direct extension of the well known "East End" of Silver Mountain, to which the original Indian

(Continued on page 218.)

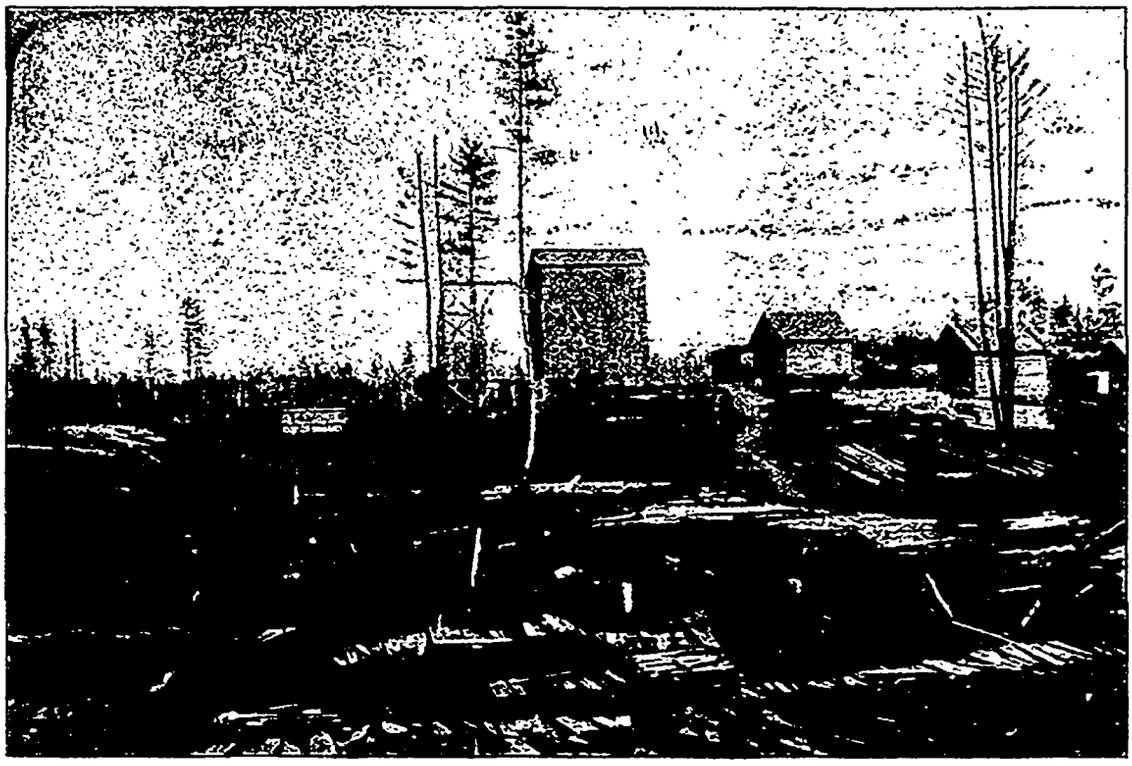
THE SULPHIDE ORE BODIES OF THE SUDBURY REGION.



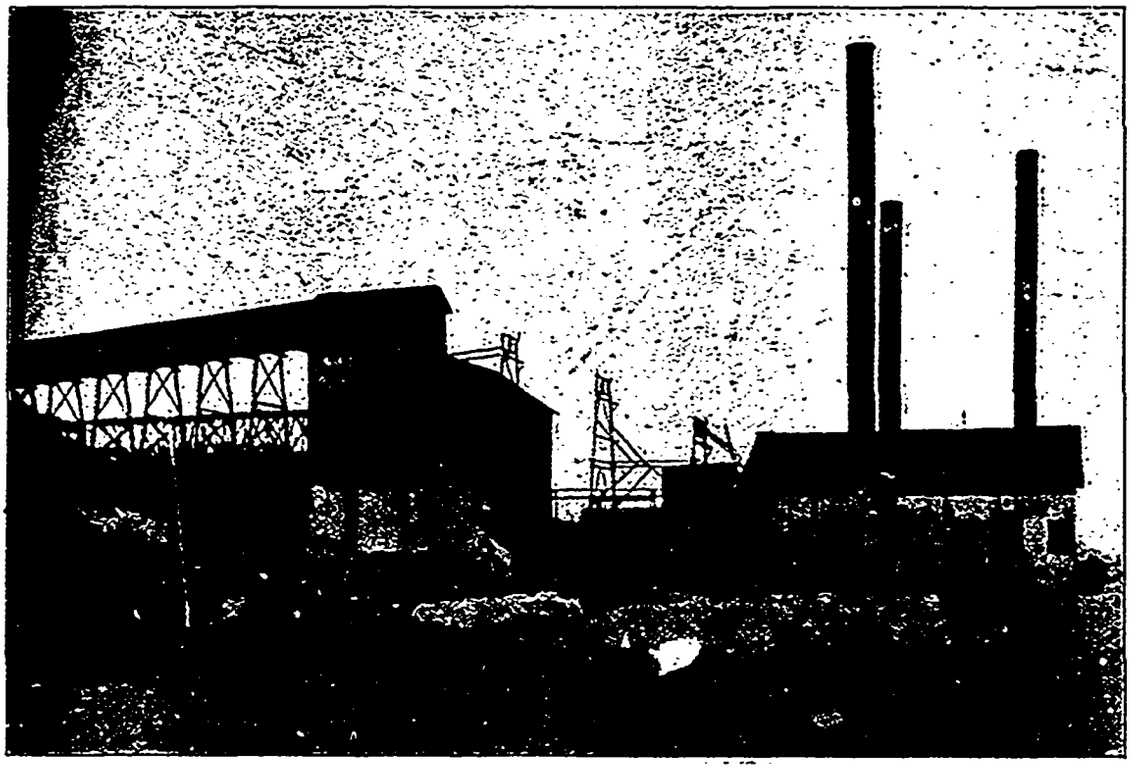
Canadian Copper Company's Froude Mine, five miles from Sudbury, Ont.

Shaft House Creighton Mine, eight miles from Copper Cliff, Ont.

THE SULPHIDE ORE BODIES OF THE SUDBURY REGION.



The Gertrude Nickel Mine of the Consolidated Lake Superior Co., situated thirteen miles from Sudbury, Ontario.



Matte Yard at West Smelter, Canadian Copper Co., 1,000 tons of matte ready for shipment. No. II Mine rock-house in background.

THE SULPHIDE ORE BODIES OF THE SUDBURY REGION.

West Smelter of the Canadian Copper Co., showing Slag Heaps in the foreground.

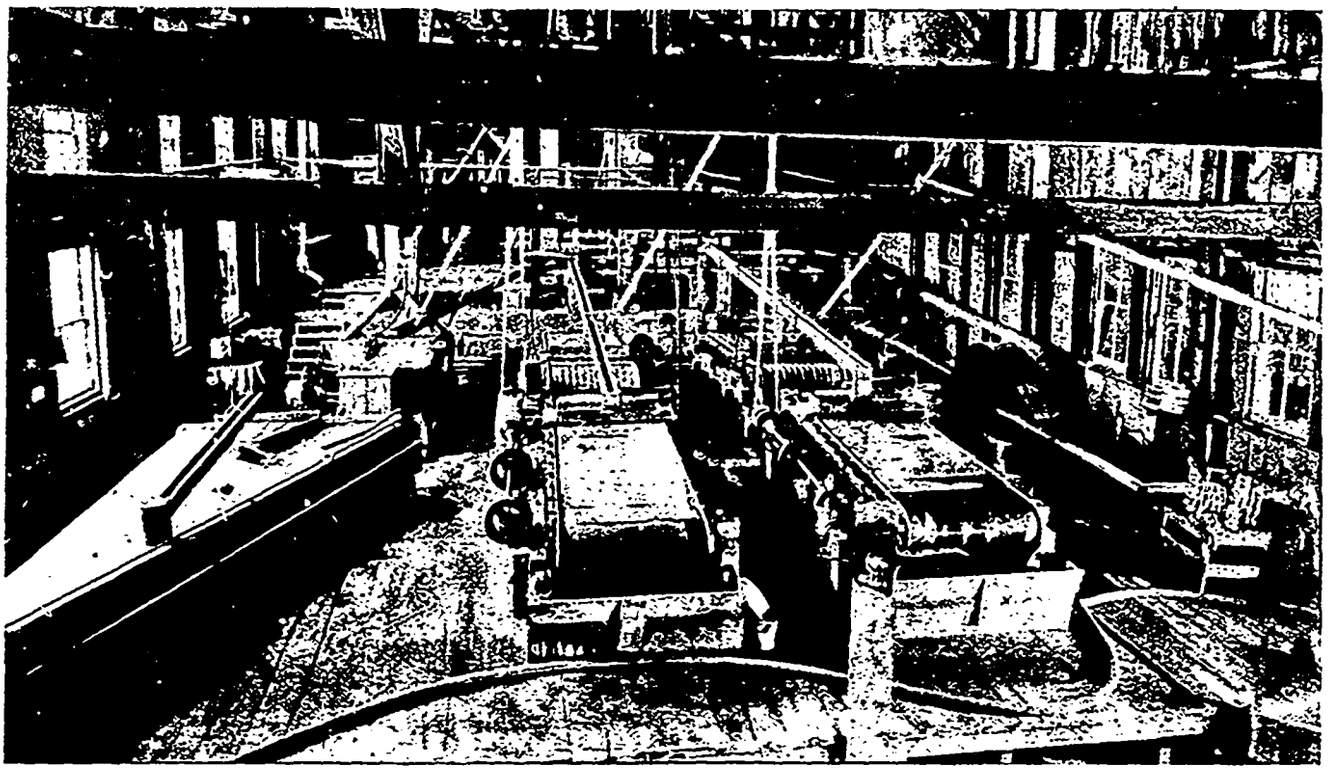
Partial view of East Smelter of the Canadian Copper Company, Copper Cliff, Ont.

THE SULPHIDE ORE BODIES OF THE SUDBURY REGION.

Interior of West Smelter, Copper Cliff, Ontario.

Construction of Canadian Copper Company's branch line to Creighton Mine.

SILVER MINING IN ONTARIO.



Consolidated Mines Co. of Lake Superior—Interior of Battery at West End Silver Mine.

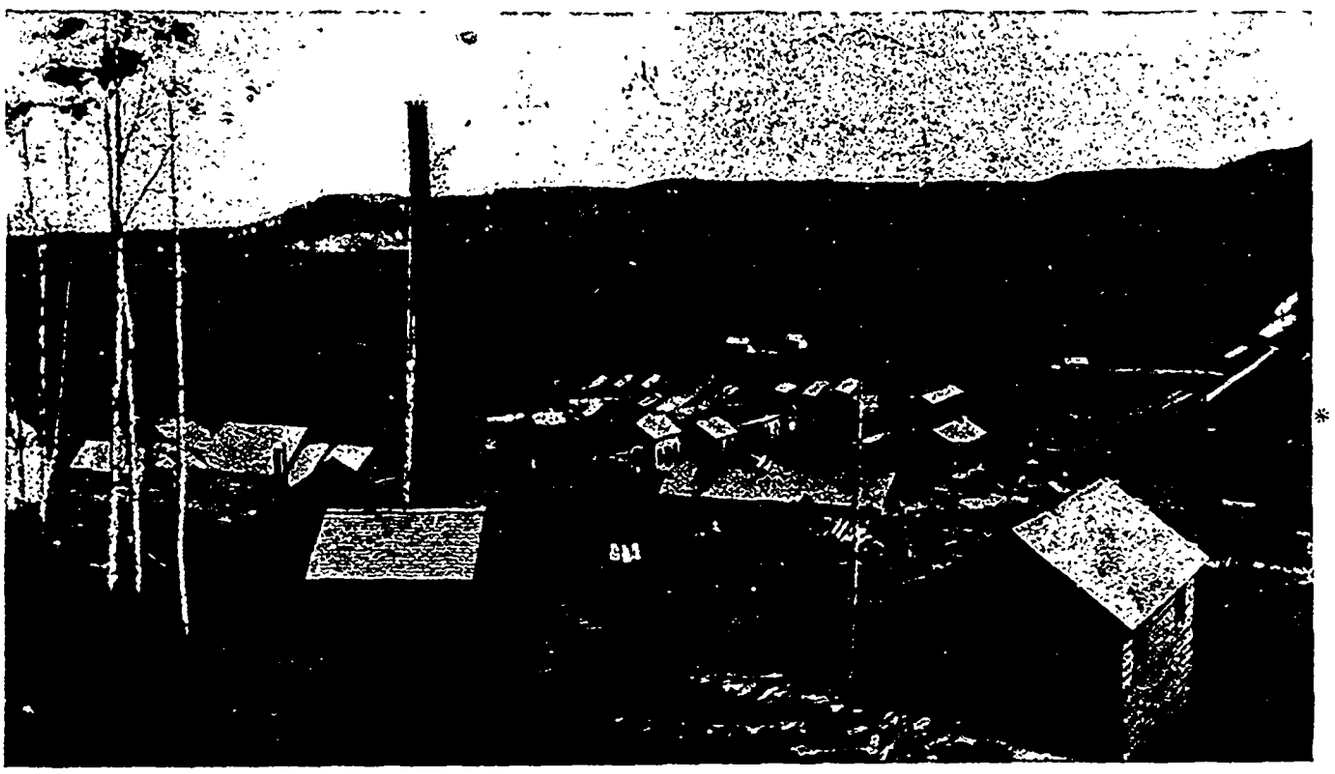
Consolidated Mines Co. of Lake Superior—East End Mine.

SILVER MINING IN ONTARIO.

Consolidated Mines Co. of Lake Superior—West End Silver Mine.

Consolidated Mines Co. of Lake Superior—Stamp Mill at West End Mine.

SILVER MINING IN ONTARIO.

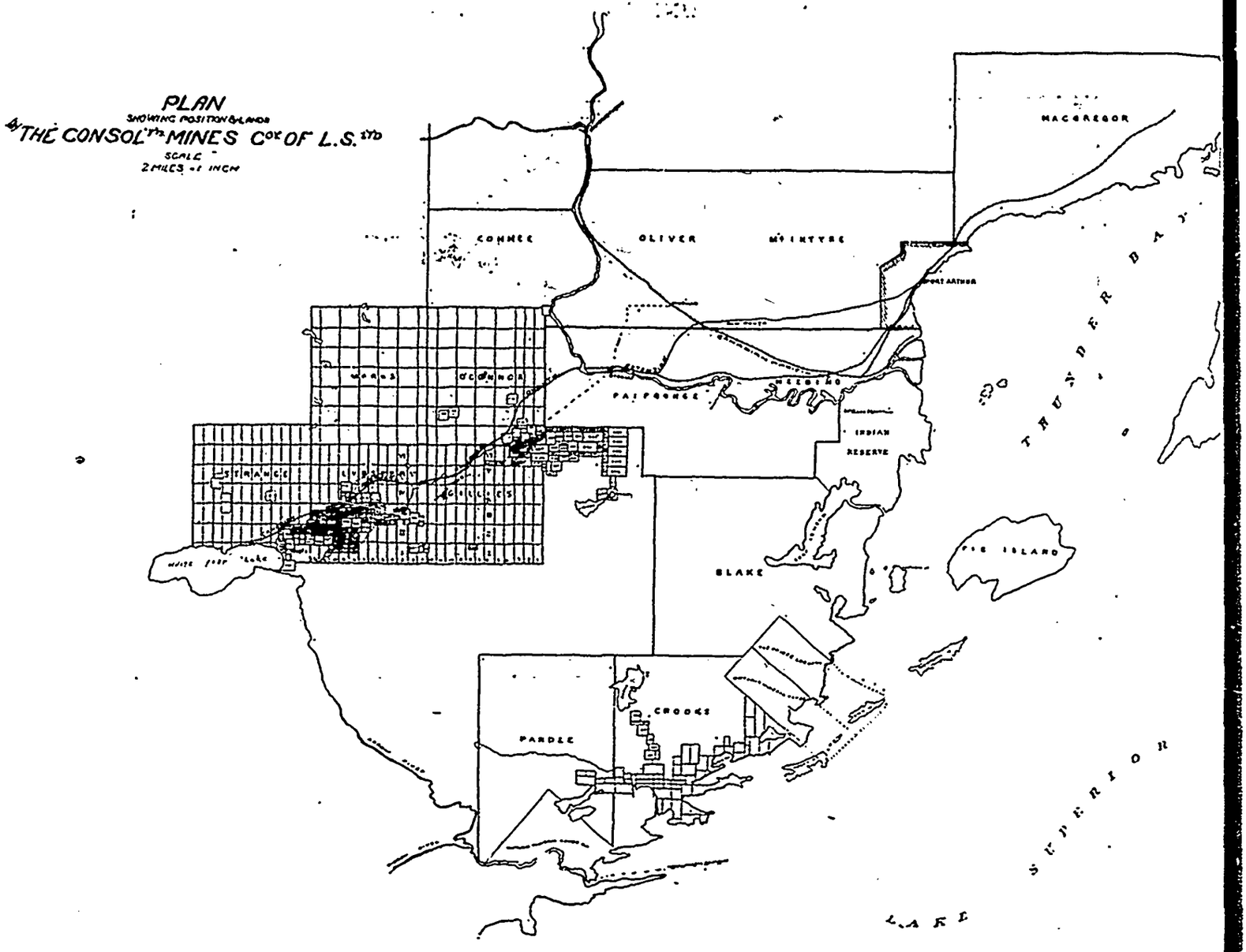


The Badger Mine.

*Showing Stamp Mill and Tramway.

Consolidated Mines Co. of Lake Superior—Badger Stamp Mill.

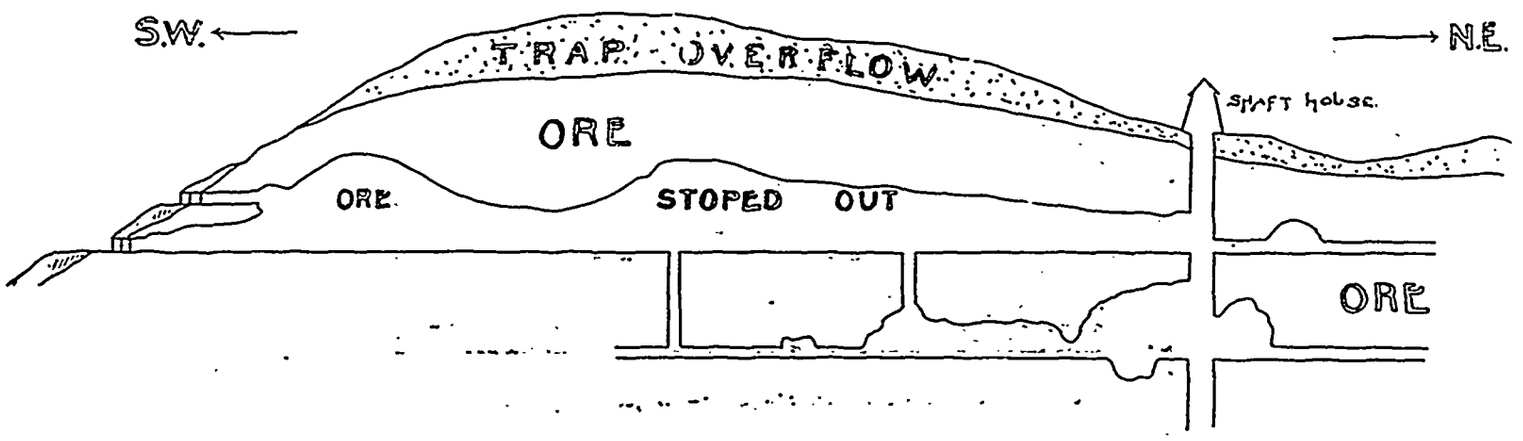
SILVER MINING IN ONTARIO.



THE PORCUPINE MINE

SHOWING THE UNDERGROUND WORKINGS

SCALE - 50 FT. = 1 INCH

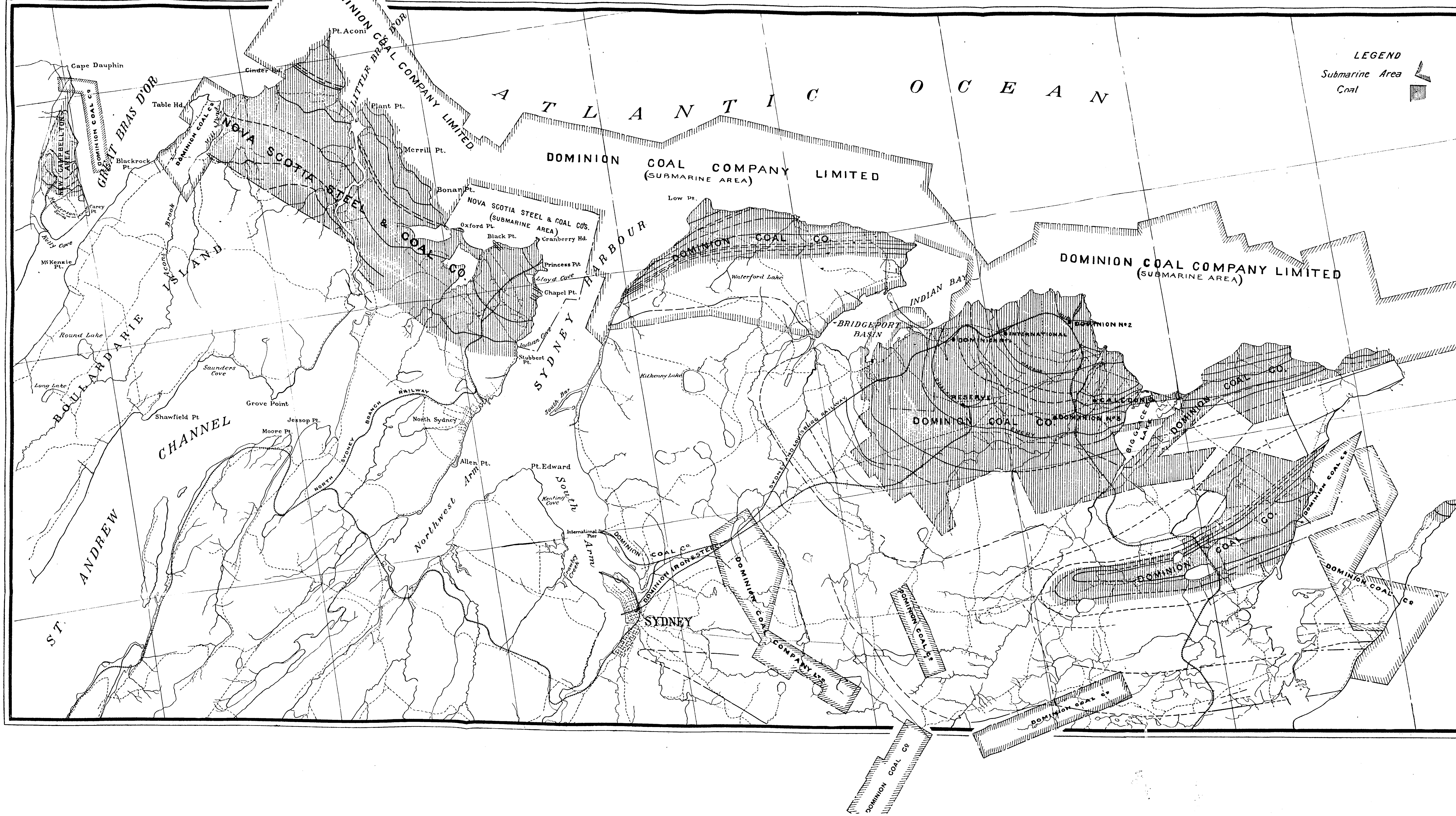


THE SYDNEY COAL FIELD, CAPE BRETON, N.S.

This map showing the land and sub-marine areas and the location of the various Collieries of the Dominion Coal Co., Limited, the Nova Scotia Steel and Coal Company, Limited, the Dominion Iron and Steel Company, Limited, and other operations, has been specially drawn for the REVIEW from the records and surveys of the Geological Survey of Canada.

The land area occupied by coal-bearing rocks in the Sydney Coal Field has been estimated at two hundred square miles, while an immense sub-marine area contains large seams of coal in workable condition, easily accessible. The coal measures have been folded into subordinate basins so as to bring the coal seams to the surface under the most favorable conditions for their extraction and shipment. The whole coast is deeply indented by bays and channels approximately coinciding with the axes of these folds, affording in the sea cliffs numerous natural exposures of the coal seams and accompanying strata, and constituting excellent harbors, one of which, Sydney Harbor, situated towards the centre of the district, is one of the finest in the world.

Taking the average of all the sections, the total number of seams in the productive measures is twenty-four, of which six are three feet or upwards in thickness, and the total average thickness of coal may be stated at forty-six feet. The similarity and persistency of the seams over great areas is very remarkable, although local variations are frequent. There is, therefore, no great uncertainty in regard to the equivalency of the various seams at different points. They generally dip at a very low angle, and are little affected by faults and disturbances. The coal is of the soft, or bituminous variety, with comparatively little diversity in the quality of the different seams, all of which yield a coal exceedingly well adapted for steam and domestic purposes, while that of some of them is especially applicable to the manufacture of gas.



Comparison of Costs of Compressing Air with Steam and Electricity at Rossland, B.C.*

By Mr. Wm. Thompson, Rossland, B.C.

Compressed air has become so generally used in connection with mining operations, and so well recognized as the most useful and economical power, with its unlimited range of uses, and special adaptability to underground work, that an introductory to this paper on the subject would be superfluous to mining engineers.

The comparative economy of prime movers for air compressing engines is, however, of great interest to all, and a subject on which any engineer can read with interest. This is particularly the case with engineers practicing in British Columbia, where a large number of the mining problems include the extraction and reduction of large bodies of low-grade ores and the consequent necessity for a thorough study of economical methods for mechanical handling.

The general mobility of compressed air as a power allows a wide range of generators, or prime movers, but we can, in nearly all cases, rely upon having to adopt primarily, one of two sources of power, viz., water or heat.

Water, the first of these can, as we know, be used in many ways, each terminating finally at the mine, as compressed air ready for service. The initial water power may come from one or more sources situate either at the mines or many miles distant, and can be used either as a directly connected unit of power for the compression of air, or as a prime mover for some intermediary power.

British Columbia has been fortunately blessed with magnificent water power, more particularly in the Kootenays. In many cases these water powers are situated close to the mines; in others, as at Rossland, they are several miles away.

Distances over which power can be economically transmitted by electricity are yearly becoming greater, until it seems that distance is no longer an obstacle, and it has become simply a question of capital investment to successfully transmit the power generated by water almost any distance.

Heat, the second great source of power for the generation of compressed air, has been successfully used as steam for many years, even in places which seemed to be utterly inaccessible either for the erection of the necessary machinery, or the securing of fuel after the machinery had been installed and made ready for operation. So accustomed have we become to surmounting difficulties of this kind, that we are apt to look with suspicion upon any suggestion to utilize distant water powers, preferring to resort to steam as being the power we best understand, and one which has been successfully installed and economically operated under very adverse circumstances.

British Columbia has been abundantly provided with fuel, in fact, we can say the supply of coal is practically unlimited. Enterprising capitalists, year after year, extend railways between the coal fields and the consumers, so that no producing or promising mining district has long to wait for an unlimited supply of this fuel. The mines at Rossland are exceptionally favored in this respect, all the leading mines having access to two lines of railways, and, through them, the coal fields of both British Columbia and the State of Washington.

Rossland is also favored by having the immense water power at Bonnington Falls, less than 40 miles distant, immediately available. The enterprise of Sir Charles Ross and associates in the West Kootenay Power and Light Co. have rendered this available for any service at each mine, as a competitor of the steam power, which mine managers would otherwise be compelled to adopt.

The question of the selection of power supply to be made by mine managers at Rossland is almost entirely removed from chance, and may be based on ascertained facts. Railways being at hand for the transportation of any kind of machinery, reasonably cheap fuel in quantities required is assured, and electric power for any size machinery or service is available. Therefore the problem simply resolves itself into *"Which of these powers will give the best service in operating the machinery used in connection with mining operations?"*

The same privilege applies to nearly every other mining district in Southern British Columbia; therefore, the writer feels that the results obtained in the air compressing plants at Rossland will be of special interest to the members of the British Columbia section of the Canadian Mining Institute, and mining engineers.

The steam and electric plants described below were modelled on the design and erected under the personal supervision of Mr. Bernard Macdonald, then general manager of the Le Roi and Nickel Plate mines, assisted by the writer. The steam plant was erected for the Le Roi Mining Company, Limited, and consists of the following, viz.:

Boiler Plants.—Two 250 horse-power Heine safety water tube boilers, arranged to burn coal as fuel. These were intended to generate steam to run the air compressors, and were set so as to work, if desirable, in connection with the nine 125 horsepower steel shell return tubular boilers, designed to operate the hoisting and surface plants. These boilers are arranged to be interchangeable to either service. A general description of this plant will be found in volume V., page 309, of the Journal of the Canadian Mining Institute.

During the test, the water-tube boilers were used at a guage pressure of 150 pouuds per square inch, using Crows Nest coal as fuel, which cost, laid down in front of the boilers, $5.55 per ton of 2000 pounds.

Air Compressing Plant.—The steam driven plant consisted of two compound condensing Corliss valve engines, direct connected to two stage air cylinders, equipped with intermediate cooling devices, each machine having a rated capacity of 4000 cubic feet of free air per minute, or a combined capacity of 8000 cubic feet of free air per minute at sea level.

A more detailed description of these engines would be as follows:

	No. 1 Engine inches.	No. 2 Engine inches.
Diameter, high pressure steam cylinder ..	22	22
" low " " " ..	36	36
" high " air " .	22	22
" low " " " .	36	38
Length of Stroke.....	48	48

Intercoolers, horizontal multitubular type; condensors, independent jet.

The Electrically Driven Air Compressing Plant.—This plant was erected by the Rossland Great Western Mines, Limited, and was originally intended to be operated in connection with the steam plant previously described, the intention being to supply power from a central station to four mines, owned by different companies. This arrangement would have given each mine power at the lowest possible cost, and have ensured continuous operations by reason of the compressing plant being arranged in separate units. Each company would pay its share of operation, maintenance, of plant, *pro rata* to its consumption of air.

When it was found necessary to erect the third unit to the compressing plant, unforeseen difficulties presented themselves in the shape of shortage of water for condensing and cooling purposes. On examination, it was found that a satisfactory supply could not be secured without heavy capital expenditures for erection of flumes, etc, to convey the water to where it was required for use.

It was, however, found that a supply of water, barely sufficient for the intercoolers and waterjackets, was available about three-fourths of

* Paper to be read at the Nelson meeting of The Canadian Mining Institute, 10th September, 1902.

a mile distant from the steam plant. This supply was so located that it must either be pumped or else the plant located at this distance away from the main steam plant. By conserving this water supply, cooling, and re-using, it was decided a sufficient supply of water for the air cylinder jackets, and intercoolers could be secured.

The results obtained from the steam plant had proven so satisfactory, that it was considered questionable if any electric plant could be installed that could successfully compete with steam, even when running non-condensing, unless very favorable rates for power could be secured. After negotiations with the Power Company, it was decided to erect an electrically driven plant, a short description of which is as follows:

Electrical Equipment.—Three phase, S.K.C., synchronous motor, designed for 2200 volts, with a rated capacity of 660 kilo watts, equivalent to about 825 horse-power. The motor is provided with a separate starting motor, mounted on the main frame, exciter and Italian marble switch-board, on which all operating switches and instruments are mounted.

There is a 54 inch Frisbee clutch set intermediate between the driving pulley and the motor. The motor is of a four bearing type, fitted with self-aligning and self-oiling sleeves. The entire machine is mounted upon a solid cast iron base set upon massive concrete foundations. The driving pulley is 60 inches in diameter, grooved for 22 1½in. ropes, and runs at 270 revolutions per minute.

The three compressors were built by the Canadian Rand Drill Company, of Sherbrooke, Quebec, and are especially designed for constant service.

The electrical equipment is also entirely of Canadian manufacture, the entire apparatus being manufactured by the Royal Electric Company, of Montreal, who are the Canadian manufacturers of the S.K.C. apparatus.

All tests were conducted under the personal supervision of the writer, and extreme care was taken to arrive at actual facts. Indicator diagrams were taken off both the steam and air cylinders every half-hour, and the results tabulated. Coal consumed was weighed, and all other supplies, such as waste, oil, etc, charged as used.

Readings were also taken and recorded by means of a delicately adjusted kilo watt metre, connected to the primary mains, of the amount of electric power used. The test extended over a period of thirty days, without interruption, both plants being run under exactly similar conditions as to air pressure.

Each of the plants tested being modern and representative of their respective types, gave an opportunity for a comparative test that rarely falls to the lot of an individual engineer under such favorable conditions, as to work being performed, and for this reason is the more valuable as data for basing calculations as to problems of power.

The average results of the thirty days' test is recorded in Tables I, II, III, IV, and V following:—

TABLE I.

Work Performed by Steam Plant.

Average indicated horse power at steam cylinders of the combined machines	730 h.p.
Free air compressed per minute from atmospheric pressure to 95 lbs. per square inch	5432 cubic ft.
Free air compressed per hour	325,920 "
Average horse-power required at steam cylinders to compress 100 cubic feet of air per minute, to guage pressure	13.4 h.p.
Pounds of coal consumed during test	1,038,000 lbs.
Pounds of coal consumed per day of 24 hours	36,400 "
Average pounds of coal consumed per horse-power per hour during test	1.9 "

TABLE II.

Work Performed by Electric Plant.

Average horse-power registered at switch-board	540 h.p.
Free air compressed per minute from atmospheric pressure to 95 pounds gauge pressure	3,319 cubic ft.
Free air compressed per hour	199,140 "
Average horse-power required at motor to compress 100 cubic feet of free air per minute to 95 lbs. gauge pressure	16.3 h.p.

TABLE III.

Cost of Operating Steam Plant.

Total cost of fuel consumed during test	$2,880 45	
" " wages for employes	710 00	
" " oils, waste, etc	147 30	
" " for 30 days, exclusive of maintenance and depreciation		$3,737 75
Cost per horse-power per month for fuel	3 96	
" " " oil, etc.	0 20	
" " " wages	0 97	
		$5 15
Cost per horse-power per annum		$61 56
Cost for each 100,000 cubic feet of free air compressed		$1 56
Cost per drill shift		$1 25

NOTE:—80,000 cubic feet taken as the average consumption per shift of one 3¼" drill

TABLE IV.

Cost of Operating Electric Plant.

Cost of current for thirty days	$1,744 26	
" employees' wages	270 00	
" oils, waste, etc	73 00	
Total cost for 30 days, exclusive of maintenance and depreciation		$2,087 86
Average cost per horse-power per month		$3 87
" " " annum		$46 44
Cost for each 100,000 cubic feet of air compressed		$1 46
Cost per drill shift		$1 17

NOTE:—80,000 cubic feet taken as the average consumption per shift of one 3¼" drill.

TABLE V.

Showing Comparative Results between the Two Types of Compressors, based on each 100,000 cubic feet of air compressed from Atmospheric Pressure to 95 pounds Receiver Pressure.

Cost for each 100,000 cubic feet of free air compressed by steam plant (see Table III)	$1 56
Cost for each 100,000 cubic feet of free air compressed by electric plant (see Table IV)	$1 46
Result, saving by electricity over steam	6.4 per cent.

The saving shown in Table V would be affected adversely if the electric plant was operated singly and the entire air compressed was not used. For the reason that electrically driven compressors must be operated at constant speed, and loss of air at safety valve would be considerably increased over the same loss at steam plant, which could be run at the speed required to compress the amount of air actually required. This loss would, however, be slightly off-set by the increased cost per horsepower by working the steam compressors on underload.

I wish to draw special attention to the noteworthy results obtained from the system of intercooling used on the compressors tested.

In Table I it is shown that the steam plant required 13.4 horse-power to compress 100 cubic feet of air to 95 pounds gauge pressure per minute. The best power factor recorded that has come under the writer's notice, for doing the same amount of work by a two stage compressor, is 14.5 horse power, which shows a saving of 8 per cent. resulting from the use of specially designed intercoolers, for which the manufacturers are entitled to receive the credit.

How this result is obtained can be best understood by reproduc-

ing the average of a number of tests made on the efficiency of the intercooler during the progress of the power test. The results of these tests are shown in Table VI. .

TABLE VI.

Temperature of cooling water at inlet of intercooler.....	42°F.
Temperature of cooling water at outlet of intercooler.....	50°F.
Rise in temperature of cooling water while passing through intercooler.....	8°F.
Temperature of air at outlet of low pressure cylinder and before passing through intercooler.....	196°F.
Temperature of air at inlet of high pressure cylinder, after passing through intercooler.....	54°F.
Reduction in temperature of air after passing through intercooler.....	142°F.

In conclusion, permit me to state that this paper has not been prepared with the idea of recording the performance of these two plants, except, in so far as comparisons can be drawn between the relative efficiency of the two systems, so that engineers, knowing local conditions, can have some record of actual performance before them.

The Sulphide Ore Bodies of the Sudbury Region.

By L. P. SILVER, School of Mining, Kingston, Ont.

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 for 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. This being 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.

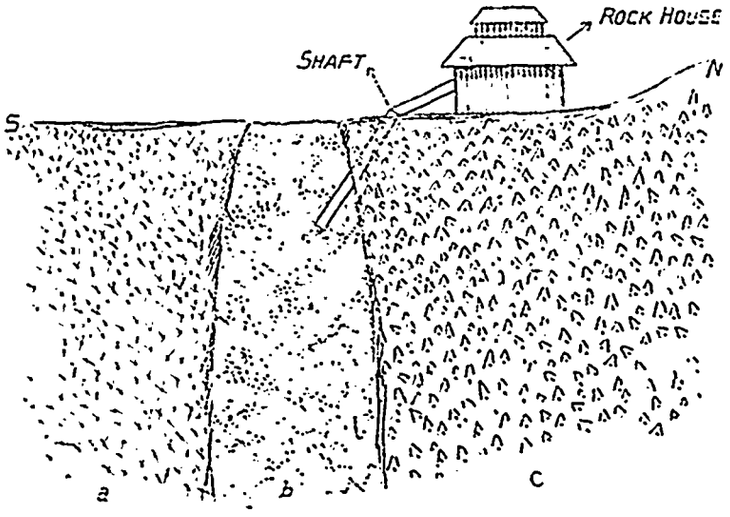
The chemical compositions of three typical samples of greenstone are:

	I	II	III
SiO_2	48.95 per cent.	49.83 per cent.	62.75 per cent.
Al_2O_3	16.21 "	17.28 "	18.21 "
Fe_2O_3 FeO.	12.15 "	14.85 "	4.64 "
CaO	7.41 "	7.01 "	3.61 "
Mg O	6.25 "	6.01 "	2.91 "
Na_2O	3.25 "	1.85 "	3.72 "
K_2O	2.70 "	2.20 "	1.31 "
Total...	96.92 "	99.03 "	97.15 "
Sp. Gr.....	2.88	.01	2.81

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) Granite.

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 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 Crighton mine, and is easily detected by its perfect octahedral cleavage or parting 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 ock. 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.

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 of 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 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.

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. 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 foundation of cordwood, stamps, etc., is made through which are arranged canals filled with kindling wood communicating to chimneys for the supply of draught. The interstices are then 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 and copper which is 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:

Fe O ..... 67.6 per cent. Cu..... 1.2 per cent.
Si O_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, when 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.

Notes on the Geology and a Few Ore Deposits of South Eastern British Columbia.

By C. V. Corless, McGill.

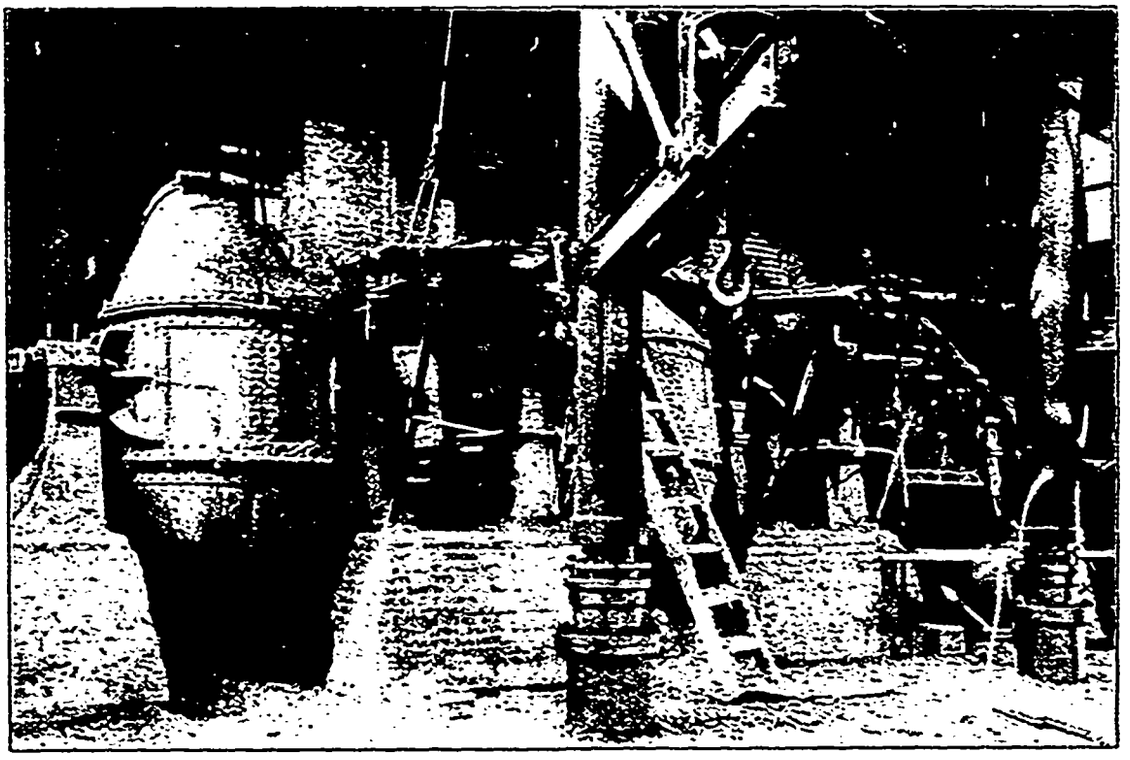
PREFACE.

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 out-



Converters at East Smelter, Copper Cliff, Ontario.

line 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.

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 most 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 limestones, 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 erup-

tive 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, 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.

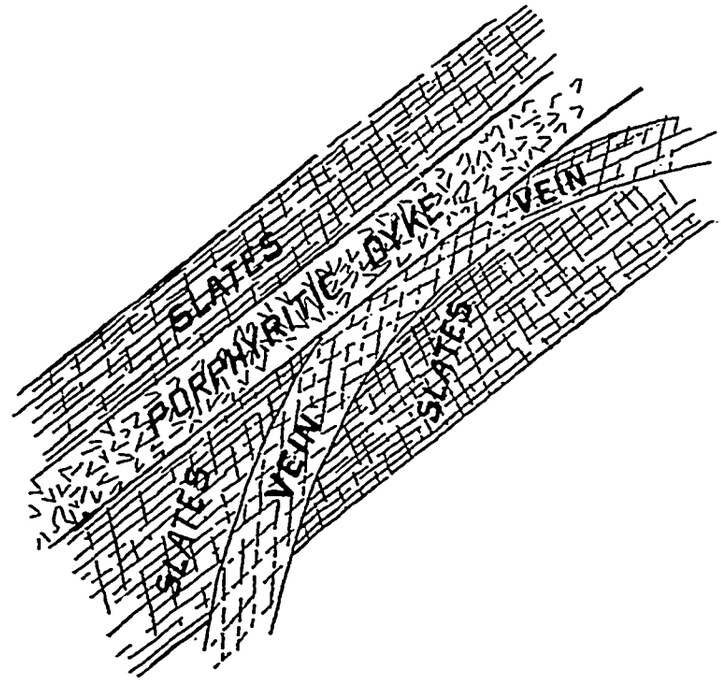
3. Veins carrying argentite with native silver and gold, in quartz gangue.

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



Sketch showing suggested origin of the North Star Ore Bodies.

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 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.

*Paper by Mr. Brock in the Journal of the Can. Min. Inst., 1897.
†Bulletin III, Bureau of Mines, Victoria, B.C., 1897.

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 British 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.

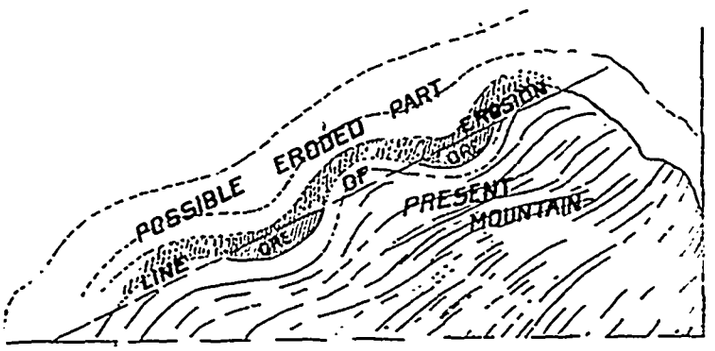
Example 3.—The North Star. This unique ore deposit, situated about one mile from Kimberley on Mark creek, is reached by the recently constructed branch of the Canadian Pacific Railway from Cranbrook.

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 microcrystalline 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 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

* Report by Mr. McConnell to the C.G.S., 1896.

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 combination of agencies, found in the ascending waters of such regions of igneous intrusion, the formation of most metalliferous veins is probably due."

SILVER MINING IN ONTARIO.

(Continued from page 204.)

discoverer of this long-hidden treasure gave the appropriate title of "Shunia Weachu," or "Mountain of Silver," and is referred to in the special geological reports of the Geological Survey of Canada, as "a very strong and persistent fissure, showing at frequent intervals right across the mountains for over a mile." Along this outcrop (now embraced in the east and west sub-divisions) and for some distance below, the vein is large and solid and from 8 to 10 feet wide, while in the argillites lower down its width is more persistent, averaging sometimes from thirty to forty feet in width. The gangue consists mostly of calcite, with some baryta and a little colorless quartz and greenish fluorite.

The "West End," during its early bonding period, produced magnificent results in ore, even under the very worst conditions as regards transportation and accessibility, but it was not until 1888 that anything like even partially opening up a portion of the claim was seriously contemplated. During that year work was resumed on the property, camps erected, pumps and hoists installed, and development work carried on to a greater or less extent. In April of the following year several hundred feet of drifting and sinking had been done, and two shafts had been sunk at intervals of 500 to 600 odd feet apart. The main shaft had rich ore continuously from the surface. No. 2 shaft had also rich ore from near the surface, and the first adit level had a rich ore body that assayed as high as 3,000 to 18,000 ounces in silver to the ton.

The Canadian Northern Railway (Duluth branch) now runs directly through the silver region, and a very cheap rate of freight obtained for merchandise and supplies to the different mines, while ore and concentrates are very cheaply transported to the smelters.

In a word, the "West End" of Silver Mountain has produced, approximately, in the short time that it has been operated, 350,000

* Trans. Am. Inst. Min. Engineers, Vol. 30, p. 692.

ounces of silver, and when opened up to connect with the upper and lower adit levels of the "East End mine," will but commence the brightest and most interesting page in the history of silver mining in this district.

THE EAST END MINE

The East End Silver Mountain mine is composed of Mining Location R. 53, one hundred and sixty acres, R. 54, eighty acres, R. 60, eighty acres, R. 151, sixty-eight acres, the north half of Lot 8, Concession 1, one hundred and sixty-one and a half acres (161½) acres, north half of Lot 9, Concession 1, one hundred and fifty-seven acres, north half of Lot 10, Concession 1, one hundred and nine acres, Lot 8, Concession 2, one hundred and forty-nine acres, in all 964½ acres, all in the Township of Lybster, in the district of Thunder Bay, and Province of Ontario, Canada.

The main vein on these properties is a continuation of that of the West End Silver Mountain, and development consists of a series of shafts, Nos. 1, 2, 3 and 4, upon which considerable work has been done. No. 4 shaft is 237 feet in depth, and is situated about 130 feet from the eastern boundary of the West End mine property. About five hundred feet of drifting in two levels has been done from this shaft. Other development consists of an adit level about 1,800 feet in length, connecting shafts Nos. 1 and 2, about 500 feet of intermediate levels and shafts have also been driven on the vein, and it is estimated from these workings that at least 9,000 tons of milling ore are now on the dumps ready for treatment, and there is now developed and available for stoping several thousand tons of ore of sufficient value to warrant a large increase in the present milling capacity, and it would seem wise for the company to install an additional plant at an early date.

In the centre of the property, and at the highest altitude, are two lakes, which will furnish an inexhaustible supply of water for all purposes. All the lands owned by the company are well wooded, as is the country adjoining, and this assures an ample supply of timber at a very reasonable cost for all mining and fuel purposes.

COMPANY NOTES.

Enterprise (British Columbia)—Cablegram from the company's representative at Nelson, British Columbia:—"Final June returns give a profit of $2,900 (£598). Estimated profit for the entire month of July $3,750 (£773), in each case exclusive of zinc production."

Ymir.—Cablegram from the manager at Nelson, British Columbia:—"During last month 50 stamps ran 631 hours (26 days, 7 hours); estimated profit on operating, $3,460 (£713). Above was arrived at after development, $1,300 (£267); repairs, $750 (£154); fighting fire, $1,300 (£267, etc, written off; total amount crushed, 3,330 tons (dry weight). Commencing 29th July.—Mine mill have been obliged to shut down three days owing to bush fires. The total loss is $3,000 (£618), flume, cordwood, labor. Do not apprehend any further danger from forest fires except to timber land. The mine continues to look about the same. We are at present running on better grade ore." (June.—Estimated profit, £1,412.)

Le Roi No. 2.—Manager cables, Rossland, 7th August:—"The shipments last month amounted to 5,675 tons. Contents, 2,949 ozs. gold, 7,235 ozs. silver, 135 tons 15 cwts. copper. The return from ore, after making a deduction of all smelting charges, amounted to $49,450. Cost of mining may be taken at $21,500. Profits for last month, $27,950 (equivalent sterling, £5,763). No shipments for three days on account of wreck on railway." (June shipments, 6,316 tons.)

McDonald's Benanza (Klondike).—Cablegram from Dawson dated 6th August:—"Skookum Claims—Total returns to date, 679 ozs. No. 2 Bonanza Clean up after six days, 161 ozs. From Bench Claims to date, 172 ozs. The estimated value is $13,250."

Slough Creek.—The following cable was received from the Company's consulting engineer, dated Barkerville, B.C., the 28th July:—"During the present week in East drift have met with feeder water—is not at all large, but having considerable force—face was securely timbered, upper part being in the gravel—no damage was caused—water rapidly draining off—there is not one-third at the present time—have decided to allow East drift to stand for a few days so as to relieve pressure—have recommended driving crosscut to the south—with difficulty have been able to secure one-half cubic yard gravel—has been washed in presence of Chairman—yielded one-half of an ounce gold, the size of wheat—the approximate value may be taken at £32 per sett—some of it supposed to have been lost owing to water—very fine washed, rounded gravel—it looks as if channel must be very rich—prospects are most encouraging—the most important feature is the water is gradually lessening—pumping one hour in each six hours, one pump."

Rossland Great Western.—Manager cables.—"Have struck good body of ore 600 ft. level Nickel Plate mine.—MacDonald."

Le Roi.—Cable from the manager at Rossland:—"Shipped from mine to Northport smelter during past month 14,500 tons of ore, containing 8,400 ozs. of gold, 14,000 ozs. of silver, 672,000 lbs. of copper. Shipped from dump to Northport during the past month 1,677 tons, containing 1,000 ozs. of gold, 1,350 ozs. of silver, 55,000 lbs. of copper. Estimated profit on this ore $100,000." (June return:—Shipped 11,475 tons, estimated profit $72,641, and from dump 3,353 tons, estimated profit $21,761.)

Report of Le Roi Mining Company, Ltd., for June, 1902:—

"Tonnage shipped, together with contents and gross values per ton:—

	Dry Tons.	Ozs. Au.	Ozs. Ag.	Lbs. Cu. wet.	Value per ton.
1st class.....	11,475	6,841	11,065	505,408	$17.70
2nd class dump..	3,353	1,627	1,760	75,829	$12.68
	14,828	8,468	12,825	581,237	....

"Mine expenditure:—The expenditure for the month on mine account was $47,823; the expenditure not charged to mine account was $895—48,718. The cost of breaking and delivering ore on the railroad cars for the month was $2 91 per ton. The cost of loading the second-class ore from dump, including putting on tramways and shutes, was $3.97. The cost of delivering first class ore on the railroad cars, including all mine expenditure other than cost of loading second-class dump ore, was $4.05 per ton.

"Northport smelter:—The expenditure for the month was $156,220. The following statement gives the details of the ore received at the smelter during the month, and the contents:—

	Dry Tons.	Ozs. Au.	Ozs. Ag.	Lbs. Cu. wet
Public ores:				
Le Roi No. 2..	5,750	3,012	6,172	215,728
Le Roi ores:				
1st class.....	11,475	6,842	11,065	505,408
2nd class dump.....	3,353	1,626	1,760	75,829
	20,578	11,480	18,997	796,965

The tonnage treated during the month was as follows:—Roasted ores, 19,103; raw Le Roi No. 2, 5 725; raw Rossland Great Western, 52; raw Le Roi first class, 625, raw Le Roi second class, 1070; total, 26,575.

Profit for the month—

The gross value of the first-class ore shipped from the mine was equal to a value per ton of.....	$17.70	equal to	$203,117
From this deduct difference between gross value and refiner's settlement rates and interest on gold and silver values for 90 days and copper 60 days.....	$2,88	equal to	$33,050
11,475 dry tons, net value, per ton.....	$14.82	equal to	$170.067
Cost of mining..... $4.05			
Freight ..... .40			
Interest .... .06			
	$4.51	per ton, equal to	$51,754
Cost of smelting 3.95			
Interest..... .03			
	$3.98	per ton, equal to	45.673
			$97.427
Net estimated profit.....			$72,540
The gross value of the second-class dump shipped was equal to a value per ton of	$12.68	equal to	$42,516
From this deduct difference between gross value and refiners' settlement rates and interest on gold and silver values for 90 days, and copper 60 days	1.55	equal to	5,197
3,353 dry tons at	$11.13	equal to	$37,319
Cost of loading on cars, laying tracks, and making chutes.....	.40		
Freight	.75		
Interest for 90 days	.01		
Cost of smelting	3.95		
Interest.....	.03		
Equal to.....	4.64		$15,558
Net estimated profit.....			$21,761

Monitor and Ajax Fraction, Limited—Report for the month of June:

June 30—Ore shipped and settled for—		
Crude, 76 tons, net proceeds.....		$3,158.39
June 30—Ore in hand—		
Crude, 78 tons, estimated net value.....	$5,000	
Screenings, 20 tons, estimated net value...	400	
Ore mined during the month—		
Crude, 23 tons, estimated net value	$1,625	7,025.00
Cost of mining, per ton.....$8.28		
Cost of mining, per ton 3.65		previous month.
Development, 236 feet.		
Cost of development, per foot.....$6.57		
Cost of development per foot..... ..... 7.10		previous month.

The mine manager has been unable to make larger shipments this month

owing to the scarcity of cars. The leading "stopes" are now reported dry and in "good shape," and large quantities of carbonates, as well as crude galena will now be taken out.

Since the important strike in crosscut tunnel No. 5, reported last month the level has been driven 26 feet to the south, and a fine body of ore 3 feet in thickness has been encountered. Twenty tons clean ore have already been taken out of this short drift, and appearances show the paystreak to be improving in dimensions and in value.

During the month a good waggon load has been made from the portal of No. 5, which is carried over to the north bank of Carpenter creek by a strong wooden bridge, and practically connects the mine with the C. P. R. track. Arrangements have been made for a siding which will enable the company to ship direct from the mine in bulk, and thus effect an important saving in handling the ore and in transport charges.

The total net value of ore shipped *and settled for*, at the 30th June, gained during the previous nine months, was $44,989—say £9,000—and this, seeing the low prices which have ruled for silver and lead during the period, must be considered satisfactory.

The following report has just been received:—"Drifting on the ledge is proceeding very slowly on account of the large amount of ore which has to be saved. Since last weekly report the payshoot has widened to over 30 feet, 27 inches of it being solid galena of very high grade; this shoot lays against the footwall, on the hanging wall there is 4 inches of mixed ore, which is separated by the other streak, a horse being in the middle. This horse is getting smaller as we advance, and I expect to lose it altogether within a few feet." . . . "I have taken many average assays of the new strike, but am not yet far enough advanced to know the exact value. The iron assays 38 oz., the zinc 118 oz., and the galena from 149 oz. to 210 oz. . . . The ore comes in so fast that we cannot handle it."

NEW COMPANIES.

BRITISH COLUMBIA.

The Canadian King Consolidated Gold Mining Compa y.—Incorporated 4th August, 1902. Authorized capital, $150,0.0, divided into 1,500,000 shares of 10 cents each, Head office: Cheyenne, Wyoming, U.S.A. Canadian office: Erie, B.C.

The Canadian Ore Concentration, Limited.—Incorporated 6th Aug, 1902 Authorized capital, £150,000, divided into 150,000 shares of £1 each. Head office: Vancouver, B.C.

The Iowa Lillooet Gold Mining Company, Limited.—Incorporated 4th August, 1902. Authorized capital, $3,500,000, divided into 3,500,000 shares of 10 cents each.

The Willow River Mining Company, Limited.—Incorporated 6th August, 1902. Authorized capital, $50,000, divided into 500 shares of $100 each.

The Rossland-Kootenay Mining Company, Limited.—Incorporated 2nd August, 1902. Authorized capital, £150,000, divided into 150,000 shares of £1 each. Head office: Rossland, B.C.

The Chicago and British Columbia Mining Company, Limited.—Incorporated 19th July, 1902. Authorized capital, $1,000,000, divided into 1,000,000 shares of $1.00 each.

ENGAGEMENT WANTED BY MINING ENGINEER.

Mining Engineer of sixteen years' experience requires position as Superintendent or Consulting Engineer, preferably for a gold mining concern. Has had extensive experience in gold mining, milling and treatment of refractory ores, by amalgamation or cyanide processes. Also in coal, iron, and chromite mining. Is a good mine surveyor, mechanical engineer, and has a thorough knowledge of mine accounting. Address "REFRACTORY," *Canadian Mining Review*, Ottawa, Ont.

CANADIAN MINING INSTITUTE.

A PUBLIC MEETING of Canadian Mine Managers, Mining Engineers and others interested in the mining industries of British Columbia and the North-West will be held under the auspices of the Institute,

IN THE BOARD OF TRADE, NELSON, B.C.

On Wednesday and Thursday Evenings, 10th and 11th September, 1901.

SINGLE FARE ON RAILWAYS.

Mining men and Members of the Institute will, by special agreement made with the Canadian Pacific and Grand Trunk Railways, be carried on these lines to Nelson and return for SINGLE FARE on obtaining standard Convention Certificates from their ticket agents and on having their certifcates vized by the Secretary at the meeting.

A programme of papers of interest to Western mining men will be presented.

R. R. HEDLEY, *Chairman.* CHARLES FERGIE, *President.* B. T. A. BELL, *Secretary.*

The Crystal Gold Mine for Sale.

The undersigned offers for sale Mining Location W.D. 43 in the Township of Rathbun. A large amount of development has been done upon this property. A ten-stamp mill has been erected, with five stamps working. Bullion to the value of $7,500 has been produced, on an average of $12.00 per ton. The ore is free milling. Tenders for above property will be received by the undersigned, from whom full particulars can be obtained.

WM. R. WHITE,
Liquidator of The Crystal Gold Mining Co. of Rathbun, Limited.

Dated PEMBROKE, June 26th, 1902.

MICA PROPERTIES FOR SALE.

ADDRESS:

GEO. S. DAVISON,

193 Sparks Street - - - - OTTAWA, Canada.

CANADIAN MINING INSTITUTE.

BRITISH COLUMBIA SECTION.

A PUBLIC MEETING of Mine Owners, Mine Managers, Mining Engineers, Assayers, and all who may be interested in promoting the welfare of the profession and industry of mining in British Columbia, will be held in the **CITY OF NELSON**, on

TUESDAY and WEDNESDAY, 9th and 10th SEPT., 1902

(AFTERNOON AND EVENING SESSIONS)

for the purpose of completing the British Columbia Section of the Institute.

A programme of papers of interest to mining men in the Province will be submitted for discussion.

B. T. A. BELL, *General Secretary.* CHARLES FERGIE, *President.* R. R. HEDLEY, *Chairman.*

TWELFTH EDITION

The Canadian Mining Manual

FOR 1902

Up to date particulars of the Organisation, Equipment, Operations, Output, Balance Sheets and Dividends of all Canadian

Collieries Metal Mines Stamp Batteries
Blast Furnaces Smelting Works

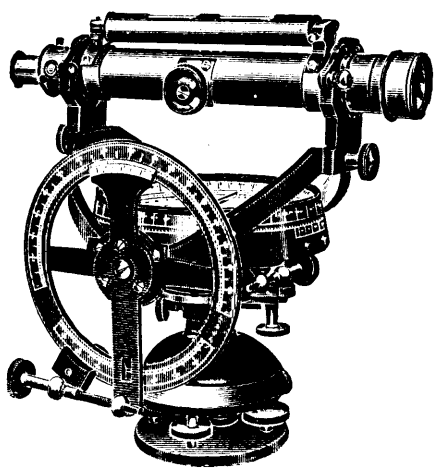
600 PP.—HANDSOMELY BOUND

The most complete and handily arranged work of reference to Canadian mining undertakings extant.

..PRICE FOUR DOLLARS..

THE CANADIAN MINING REVIEW

OTTAWA, CANADA.



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Stanley's Patent Mine Staff, 6 feet, closing to 20 inches, very portable. ..... £2 5s.
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Of every description, of the highest Quality and Finish, at the most moderate Prices.

SPECIALTY FOR MINING SURVEY INSTRUMENTS.

PRICE LIST, POST FREE.

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GREAT TURNSTILE, HOLBORN, LONDON, W.C., ENG.

Telegrams—"TURNSTILE, LONDON."

Gold Medals, Inventions Exhibitions, 1885, and Mining Exhibition, 1899.

SCHOOL of MINING

Practical Science Faculty of Queen's University

Kingston, Ontario.

THE FOLLOWING COURSES ARE OFFERED

1. THREE YEARS' COURSE FOR A DIPLOMA IN
   - (*a*) Mining Engineering.
   - (*b*) Analytical Chemistry and Assaying.
2. FOUR YEARS' COURSE FOR A DEGREE B.Sc. IN

   GROUP I.
   - (*a*) Mining Engineering.
   - (*b*) Chemistry and Mineralogy.
   - (*c*) Mineralogy and Geology.
   - (*d*) Chemical Engineering.

   GROUP II.
   - (*e*) Civil Engineering.
   - (*f*) Mechanical Engineering.
   - (*g*) Electrical Engineering.

   GROUP III.
   - (*h*) Biology and Public Health.
3. COURSES IN CHEMISTRY, MINERALOGY AND GEOLOGY for degrees of Bachelor of Arts (B.A.) and Master of Arts (M.A.

For further information see the Calendar of Queen's University.

4. POST-GRADUATE COURSE FOR THE DEGREE OF Doctor of Science (D.Sc.)

For further information see the Calendar of Queen's University.

Next Session begins October 1st, 1902.

MATRICULATION EXAMINATIONS HELD AT QUEEN'S UNIVERSITY, SEPTEMBER 16TH

THE SCHOOL is provided with well equipped laboratories for the study of Chemical Analysis, Assaying, Blowpiping, Mineralogy, Petrography and Drawing. It has also a well equipped Mechanical Laboratory. The Engineering Building will be ready for occupation next session and the Geology and Physics Building the following session. The Mining Laboratory has been remodelled at a cost of some $12,000 and the operations of crushing, amalgamating, concentrating, chlorinating, cyaniding, etc., can be studied on a large scale.

For Calendar of the School and further information, apply to

The Secretary, School of Mining, Kingston, Ont.

PROVINCE OF NOVA SCOTIA.

Leases for Mines of Gold, Silver, Coal, Iron, Copper, Lead, Tin

—AND—

PRECIOUS STONES.

TITLES GIVEN DIRECT FROM THE CROWN, ROYALTIES AND RENTALS MODERATE.

GOLD AND SILVER.

Under the provisions of Chap. 1, Acts of 1892, of Mines and Minerals, Licenses are issued for prospecting Gold and Silver for a term of twelve months. Mines of Gold and Silver are laid off in areas of 150 by 250 feet, any number of which up to one hundred can be included in one License, provided that the length of the block does not exceed twice its width. The cost is 50 cents per area. Leases of any number of areas are granted for a term of 40 years at $2.00 per area. These leases are forfeitable if not worked, but advantage can be taken of a recent Act by which on payment of 50 cents anuually for each area contained in the lease it becomes non-forfeitable if the labor be not performed.

Licenses are issued to owners of quartz crushing mills who are required to pay Royalty on all the Gold they extract at the rate of two per cent. on smelted Gold valued at $19 an ounce, and on smelted Gold valued at $18 an ounce.

Applications for Licenses or Leases are receivable at the office of the Commissioner of Public Works and Mines each week day from 10 a.m. to 4 p.m., except Saturday, when the hours are from 10 to 1. Licenses are issued in the order of application according to priority. If a person discovers Gold in any part of the Province, he may stake out the boundaries of the areas he desires to obtain, and this gives him one week and twenty-four hours for every 15 miles from Halifax in which to make application at the Department for his ground.

MINES OTHER THAN GOLD AND SILVER.

Licenses to search for eighteen months are issued, at a cost of thirty dollars, for minerals other than Gold and Silver, out of which areas can be selected for mining under lease. These leases are for four renewable terms of twenty years each. The cost for the first year is fifty dollars, and an annual rental of thirty dollars secures each lease from liability to forfeiture for non-working.

All rentals are refunded if afterwards the areas are worked and pay royalties. All titles, transfers, etc., of minerals are registered by the Mines Department for a nominal fee, and provision is made for lessees and licensees whereby they can acquired promptly either by arrangement with the owner or by arbitration all land required for their mining works.

The Government as a security for the payment of royalties, makes the royalties first lien on the plant and fixtures of the mine.

The unusually generous conditions under which the Government of Nova Scotia grants its minerals have introduced many outside capitalists, who have always stated that the Mining laws of the Province were the best they had had experience of.

The royalties on the remaining minerals are: Copper, four cents on every unit; Lead, two cents upon every unit; Iron, five cents on every ton; Tin and Precious Stones, five per cent.; Coal, 10 cents on every ton sold.

The Gold district of the Province extends along its entire Atlantic coast, and varies in width from 10 to 40 miles, and embraces an area of over three thousand miles, and is traversed by good roads and accessible at all points by water. Coal is known in the Counties of Cumberland, Colchester, Pictou and Antigonish, and at numerous points in the Island of Cape Breton. The ores of Iron, Copper, etc., are met at numerous points, and are being rapidly secured by miners and investors.

Copies of the Mining Law and any information can be had on application to

THE HON. C. E. CHURCH,
Commissioner Public Works and Mines,
HALIFAX, NOVA SCOTIA.

PROVINCE of QUEBEC

The attention of Miners and Capitalists in the United States and in Europe is invited to the

GREAT MINERAL TERRITORY

Open for investment in the Province of Quebec.

Gold, Silver, Copper, Iron, Asbestos, Mica, Plumbago, Phosphate, Chromic Iron, Galena, Etc.

ORNAMENTAL AND STRUCTURAL MATERIALS IN ABUNDANT VARIETY.

The Mining Law gives absolute security to Title, and has been specially framed for the encouragement of Mining.

Mining concessions are divided into three classes :—

1. In unsurveyed territory (*a*) the first class contains 400 acres, (*b*) the second, 200 acres, and (*c*) the third, 100 acres.

2. In surveyed townships the three classes respectively comprise one, two and four lots.

All lands supposed to contain mines or ores belonging to the Crown may be acquired from the Commissioner of Colonization and Mines (*a*) as a mining concession by purchase, or (*b*) be occupied and worked under a mining license.

No sale of mining concessions containing more than 400 acres in superficies can be made by the Commissioner to the same person. The Governor-in-Council may, however, grant a larger extent of territory up to 1,000 acres under special circumstances.

The rates charged and to be paid in full at the time of the purchase are $5 and $10 per acre for mining lands containing the superior metals* ; the first named price being for lands situated more than 12 miles aud the last named for lands situated less than 12 miles from the railway.

If containing the inferior metal, $2 and $4 according to distance from railway.

Unless stipulated to the contrary in the letters patent in concessions for the mining of superior metals, the purchaser has the right to mine for all metals found therein ; in concessions for the mlning of the inferior metals, those only may be mined for.

*The superior metals include the ores of gold, silver, lead, copper, nickel, graphite, asbestos, mica, and phosphate of lime. The words inferior metals include all other minerals and ores.

Mining lands are sold on the express condition that the purchaser shall commence *bona fide* to mine within two years from the date of purchase, and shall not spend less than $500 if mining for the superior metals ; and not less than $200 if for inferior metals. In default, cancellation of sale of mining lands.

(*b*) Licenses may be obtained from the Commissioner on the following terms :—Application for an exploration and prospecting license, if the mine is on private land, $2 for every 100 acres or fraction of 100 ; if the mine is on Crown lands (1) in unsurveyed territory, $5 for every 100 acres, and (2) in unsurveyed territory, $5 for each square mile, the license to be valid for three months and renewable. The holder of such license may afterwards purchase the mine, paying the prices mentioned.

Licenses for mining are of two kinds : Private lands licenses where the mining rights belong to the Crown, and public lands licenses. These licenses are granted on payment of a fee of $5 and an annual rental of $1 per acre. Each license is granted for 200 acres or less but not for more ; is valid for one year, and is renewable on the same terms as those on which it was originally granted. The Governor-in Council may at any time require the payment of the royalty in lieu of fees for a mining license and the annual rental—such royalties unless otherwise determined by letters patent or other title from the Crown, being fixed at a rate not to exceed three per cent. of the value at the mine of the mineral extracted after deducting the cost of mining it.

The fullest information will be cheerfully given on application to

THE MINISTER OF LANDS, MINES AND FISHERIES,

PARLIAMENT BUILDINGS, QUEBEC, P. Q.

DOMINION OF CANADA

SYNOPSIS OF REGULATIONS

For Disposal of Minerals on Dominion Lands in Manitoba, the North-West Territories, and the Yukon Territory.

COAL.

Coal lands may be purchased at $10.00 per acre for soft coal, and $20.00 for anthracite. Not more than 320 acres can be acquired by one individual or company. Royalty at such rate as may from time to time be specified by Order-in-Council shall be collected on the gross output.

QUARTZ.

Persons of eighteen years and over and joint stock companies holding Free Miner's certificates may obtain entry for a mining location.

A Free Miner's Certificate is granted for one or more years, not exceeding five, upon payment in advance of $10.00 per annum for an individual, and from $50.00 to $100.00 per annum for a company, according to capital.

A Free Miner having discovered mineral in place may locate a claim 1500 x 1500 feet by marking out the same with two legal posts, bearing location notices, one at each end of the line of the lode or vein.

The claim shall be recorded within fifteen days if located within ten miles of a Mining Recorder's Office, one additional day allowed for every additional ten miles or fraction. The fee for recording a claim is $5.00.

At least $100.00 must be expended on the claim each year or paid to the Mining Recorder in lieu thereof. When $500.00 has been expended or paid the locator may, upon having a survey made and upon complying with other requirements, purchase the land at $1.00 per acre.

Permission may be granted by the Minister of the Interior to locate claims containing iron and mica, also copper in the Yukon Territory, of an area not exceeding 160 acres.

The patent for a mining location shall provide for the payment of royalty on the sales not exceeding five per cent.

PLACER MINING, MANITOBA AND THE N.W.T., EXCEPTING THE YUKON TERRITORY.

Placer mining claims generally are 100 feet square; entry fee, $5.00, renewable yearly. On the North Saskatchewan River claims are either bar or bench, the former being 100 feet long and extending between high and low water mark. The latter includes bar diggings, but extends back to the base of the hill or bank, but not exceeding 1,000 feet. Where steam power is used, claims 200 feet wide may be obtained.

DREDGING IN THE RIVERS OF MANITOBA AND THE N.W.T., EXCEPTING THE YUKON TERRITORY.

A Free Miner may obtain only two leases of five miles each for a term of twenty years, renewable in the discretion of the Minister of the Interior.

The lessee's right is confined to the submerged bed or bars of the river below low water mark, and subject to the rights of all persons who have, or who may receive entries for bar diggings or bench claims, except on the Saskatchewan River, where the lessee may dredge to high water mark on each alternate leasehold.

The lessee shall have a dredge in operation within one season from the date of the lease for each five miles, but where a person or company has obtained more than one lease one dredge for each fifteen miles or fraction is sufficient. Rental $10.00 per annum for each mile of river leased. Royalty at the rate of two and a half per cent., collected on the output after it exceeds $10,000.00.

DREDGING IN THE YUKON TERRITORY.

Six leases of five miles each may be granted to a free miner for a term of twenty years, also renewable.

The lessee's right is confined to the submerged bed or bars in the rivers below low water mark, that boundary to be fixed by its position on the 1st day of August in the year of the date of the lease.

The lessee shall have one dredge in operation within two years from the date of the lease, and one dredge for each five miles within six years from such date. Rental, $100.00 per mile for first year, and $10.00 per mile for each subsequent year. Royalty ten per cent on the output in excess of $15,000.00.

PLACER MINING IN THE YUKON TERRITORY.

Creek, Gulch, River, and Hill claims shall not exceed 250 feet in length, measured on the base line or general direction of the creek or gulch, the width being from 1,000 to 2,000 feet. All other Placer claims shall be 250 feet square.

Claims are marked by two legal posts, one at each end bearing notices. Entry must be obtained within ten days if the claim is within ten miles of Mining Recorder's office. One extra day allowed for each additional ten miles or fraction.

The person or company staking a claim must hold a Free Miner's certificate.

The discoverer of a new mine is entitled to a claim 1,000 feet in length, and if the party consists of two, 1,500 feet altogether, on the output of which no royalty shall be charged, the rest of the party ordinary claims only.

Entry fee $15.00. Royalty at the rate of 2½ per cent. on the value of the gold shipped from the Territory to be paid to the Comptroller.

No Free Miner shall receive a grant of more than one mining claim on each separate river, creek, or gulch, but the same miner may hold any number of claims by purchase, and Free Miners may work their claims in partnership, by filing notice and paying fee of $2.00. A claim may be abandoned and another obtained on the same creek, gulch, or river, by giving notice, and paying a fee.

Work must be done on a claim each year to the value of at least $200.00, or in lieu of work payment may be made to the Mining Recorder each year for the first three years of $200.00, and after that $400.00 for each year.

A certificate that work has been done or fee paid must be obtained each year; if not, the claim shall be deemed to be abandoned, and open to occupation and entry by a Free Miner.

The boundaries of a claim may be defined absolutely by having a survey made, and publishing notices in the *Yukon Official Gazette*.

HYDRAULIC MINING, YUKON TERRITORY.

Locations suitable for hydraulic mining, having a frontage of from one to five miles, and a depth of one mile or more, may be leased for twenty years, provided the ground has been prospected by the applicant or his agent; is found to be unsuitable for placer mining; and does not include within its boundaries any mining claims already granted. A rental of $150.00 for each mile of frontage, at the rate of 2½ per cent. on the value of the gold shipped from the Territory. Operations must be commenced within one year from the date of the lease, and not less than $5,000.00 must be expended annually. The lease excludes all base metals, quartz, and coal, and provides for the withdrawal of unoperated land for agricultural or building purposes.

PETROLEUM.

All unappropriated Dominion Lands shall, after the first of July, 1901, be open to prospecting for petroleum. Should the prospector discover oil in paying quantities he may acquire 640 acres of available land, including and surrounding his discovery, at the rate of $1.00 an acre, subject to royalty at such rate as may be specified by Order in Council.

JAMES A. SMART,

Deputy of the Minister of the Interior.

OTTAWA, 9th Dec., 1901.

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