THE CANADIAN MINING JOURNAL

VOL. XXXVII. TORONTO, August 15, 1916. No. 16

The Canadian Mining Journal

With which is incorporated the

"CANADIAN MINING REVIEW"

Devoted to Mining, Metallurgy and Allied Industries in Canada.

Published fortnightly by the

MINES PUBLISHING CO., LIMITED

Head Office - - - 263-5 Adelaide Street, West, Toronto
Branch Office - - - - - - - 600 Read Bldg., Montreal

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SUBSCRIPTIONS — Payable in advance, $2.00 a year of 24 numbers, including postage in Canada. In all other countries, in cluding postage, $3.00 a year.

Advertising copy should reach the Toronto Office by the 8th, for issues of the 15th of each month, and by the 23rd for the issues of the first of the following month. If proof is required, the copy should be sent so that the accepted proof will reach the Toronto Office by the above dates.

CIRCULATION

"Entered as second-class matter April 23rd, 1908, at the post office at Buffalo, N.Y., under the Act of Congress of March 3rd 1879."

CONTENTS

ONTARIO'S NICKEL-COPPER INDUSTRY

Ontario has three wonderful mining camps—Cobalt, Porcupine and Sudbury. Cobalt, since its discovery in 1903, has produced nearly a quarter of a billion ounces of silver worth about $125,000,000. Porcupine gold deposits, discovered since Cobalt became famous, have yielded about $25,000,000 and the gold mines have just got nicely started on a long and prosperous career. The Sudbury district, a big mining camp before Cobalt was discovered, has produced matte containing about 250,000 tons of nickel and 150,000 tons copper. The value of the nickel-copper matte, assuming a value of 25 cents per pound for the nickel and 10 cents per pound for copper, is about $155,000,000.

The nickel-copper mines are now producing ore at an unprecedented rate and the output for 1916 is expected to contain about 40,000 tons nickel and 22,000 tons copper. The nickel-copper deposits have been proven to be of enormous extent and production could doubtless be maintained at the present rate for many years.

While Cobalt and Porcupine mines are well known to the public, the Sudbury mines appear to be well known to comparatively few Canadians. To some extent this is due to the fact that while a large number of companies are operating at Cobalt and Porcupine only two are producing and smelting ore in the Sudbury district. Cobalt and Porcupine mining stocks are much traded in and news from the silver and gold camps is of special interest to a large number outside of those directly connected with the industry. Of the companies operating at Sudbury one, the Mond, is an English company, in which few Canadians are financially interested. The other company, Canadian Copper, is a subsidiary of the International Nickel Co. This company has a very large number of shareholders, most of whom are Americans.

The Sudbury nickel-copper mines are the backbone of Ontario's mining industry. The Canadian Copper and Mond companies operating in the Sudbury district employ as many men as all the Cobalt and Porcupine companies together do. The nickel companies are employing in Ontario about 5,500 men and the wages paid this year will probably total $5,000,000. The companies spend millions for plant and supplies. Thousands of people in the Sudbury district are directly supported by the nickel industry and thousands of others in Sudbury and other parts of Ontario are benefitted by the market made by the operation of the mines and smelters.

The interest of Canadians in the nickel industry has been greatly increased by the war and the problem of controlling the export of nickel so that none may reach the enemy. The war has directed attention to the disadvantages arising from the fact that the nickel-copper matte from the furnaces of the Sudbury district is not refined in Canada.

The Mond company ships matte from its smelter at Coniston to Wales. The Canadian Copper Co. ships matte from its smelter at Copper Cliff to New Jersey. Neither company refines nickel in Canada.

The Mond is a British company and the product of its refinery is, of course, absolutely in British hands. The International Nickel Co. is, however, not under British control and it has been therefore necessary for our Government to make special arrangements to prevent Canadian nickel from reaching the enemy. The nickel company has, under this arrangement, been doing work of great importance to the Allied cause. Canadians have, however, learned their lesson, and are endeavoring to provide against any possible recurrence of present conditions.

The desirability of refining metals in our own country has been impressed on Canadians during the war, and the demand for control of export of nickel has been especially strong. Interest in the nickel question has created a demand for information concerning the Sudbury nickel-copper industry. We have therefore devoted a considerable portion of this number of the "Journal" to the nickel industry.

NICKEL CONTRACTS

According to the Toronto World the British Government has cancelled its big contract with the International company, and is only bound to them now for the present year. The World says:—"The British Government has guaranteed the bonds of the British-American Nickel Co. to the extent of $2,000,000 and has made a contract with them to use up to half a million tons of nickel within ten years, and at the present price this, we take it, would amount to $5,000,000 a year. All this money that goes to the miners and refining process will be spent in Canada, and apparently profits will come to Canadians that happen to own shares in this company, whereas now most of the profits of and most of the work in International Nickel go to shareholders and workmen of that company in the United States, where most of the shares are held for Germany. If the British Government are so satisfied with the arrangement with the International Nickel Co., why this change? It will take our contemporaries some time to explain this and they will have further things to explain later on."

If the "World" had any idea of the extent of the known ore reserves of the British-American Nickel Co. and of the company's ability to produce nickel it would not so readily believe that the British Government has contracted with the British-American company for 500,000 tons of nickel. Having swallowed the statement the "World" goes on to make comments which are equally foolish.

At present the nickel companies operating in Ontario are producing at the rate of about 40,000 tons nickel per year. The "World" professes to believe that the British-American company has made a contract for half a million tons to be used by the British Government within ten years.

Half a million tons of nickel is just about twice the total production to date of Ontario's nickel mines. And yet the "World" would have its readers believe that the British Government has contracted for that amount with a company which is not yet producing.

HALF-WAY MEASURES

Commenting on our objection to the suggestion that the present refinery of the International Nickel company be scrapped, the "Toronto World" says:—

"The 'Canadian Mining Journal' starts out with the statement that International Nickel has a big, expensive plant at Constable Hook, New Jersey, which it should be permitted to utilize for a term of years in refining nickel at least in sufficient quantities to supply the demands of the United States market. So long as it adheres to that position it can never advocate anything but half-way measures in dealing with nickel export and the nickel question generally. We appreciate what the 'Journal' has to say of the 'World' and we are glad to have it journey with us a little way. We would like to see it come out for a resolute national policy. It would be cheaper to buy that refinery at Constable Hook and scrap it than to have it stand in the way of our immediately adopting a truly national policy in regard to nickel."

Is the national policy in regard to nickel thus advocated worthy of support? Are we to begin by spending millions to compensate owners of plants which we do not intend to use and which may be as good as we could build here? Is such waste warranted? We think not.

We agree with the "World" in believing that changes in our methods of dealing with mine products are to be desired. We are ever ready to support reasonable suggestions which may lead to the utilization of our mineral resources in such a way that finished articles rather than raw materials may be exported. Suggestions which involve the needless expenditure of large sums of money and the disruption of industry are, however, deemed scarcely worthy of consideration. Waste of public funds or private investments should be avoided. We believe that a change should be made so that Canada may absolutely con-

trol the export of nickel, and we believe that this should and can be brought about without disregarding the rights of investors and the needs of manufacturers.

The "World" would kill off the New Jersey nickel refining industry before the Canadian is born.

U. S. CONSUMPTION OF NICKEL

In its issue of August 8 the "Toronto World" says:—"The 'Canadian Mining Journal' declares itself against an embargo upon the export of nickel, and repeats, impliedly at least, what so many public men in this country have said expressly, namely, that all the Canadian nickel refined in New Jersey by International Nickel is either exported to allied countries or directly furnished to American manufacturers actually engaged in making munitions for the Allies."

The "World" is mistaken in interpreting anything which has appeared in these columns to mean that all or nearly all the nickel exported to the United States is re-exported to allied countries or used in the manufacture of munitions for the Allies. We have repeatedly stated that the United States is the largest consumer of nickel. The consumption for war purposes has been large, and for peace purposes also large quantities are used.

We have referred to the nickel used for war purposes in considering the proposal to prohibit export of matte. We have never, however, intimated that all the nickel in the matte exported to the United States is used for war purposes. It is surely no secret that nickel is being used in the United States in the manufacture of a countless variety of articles, some of which are to be found in almost every home.

If we remember rightly some member of Parliament has made the statement that all the nickel exported is used for war purposes or re-exported to allied countries. The statement is, of course, absurd, and we are not surprised that the "World" has objected to it. It rather surprises us, however, to find ourselves made to appear as believing such nonsense.

MR. WILKIE ON THE NICKEL INDUSTRY

Writing in the "Canadian Magazine," Mr. George Wilkie says: "Nickel has been the subject of speaker and writer for years. The nickel ore is Canadian, but the nickel metal is entirely non-Canadian. The nickel ore is part of the very soil of Canada. It is torn from the Canadian rock and raised to the surface in Canada, for that is inevitable. But the moment it has been detached, the ore is out of the control of Canada and Canadians, and is sent out of her borders, having contributed to Canada the privilege and profit of operating the boarding-house at which the miners live while blasting and raising the ore. Some of the employed are Canadians residing permanently in Canada. Many are foreigners who are imported into Canada by the foreigners who control the industry. The nickel-mining community is no exception. It is hard to govern. It produces more than its share of disorder and crime. The population it gathers about it is vigorous for good or evil. That population we provide for—doubtless at a profit, and we govern and keep it in order—at an expense. A little tax on the value of the ore at the mine goes to the Province of Ontario. When you have cast up the account of those items the balance, if any, will show the profit and loss to Canada on this natural resource."

From Mr. Wilkie's article we assume that he has depended on "speaker and writer" for his information concerning the nickel industry. His knowledge of it does not seem to extend far beyond the contents of some few letters written by Government officials. His opening paragraphs make us wonder whether he visited the Sudbury district before venturing to write about it in what should be a first-class magazine. His knowledge of the nickel industry leads him to conclude his article with this: "So far as the advantage to Canada at large is concerned we are but little better off for the nickel that is in Canada than we would be if it were in Oklahoma."

Mr. Wilkie's article does not impress us as being a serious attempt to present the facts. It is to be regretted that the nickel mines are not controlled by Canadians and that the refining is not done here. That, however, does not warrant the publication of the writings of Mr. Wilkie.

COMPOSITION OF NATURAL GAS

Mr. James Ashworth in the "Coal Age" (Vol. 10, No. 4) objects to our criticism of the report on "Petroleum and Natural Gas Resources of Canada," in so far as this referred to analyses of natural gas. We admit that all he says regarding gas found in coal mines may be true, but this has no necessary connection with the composition of natural gas unless Mr. Ashworth is prepared to prove that these two kinds of gas have the same origin.

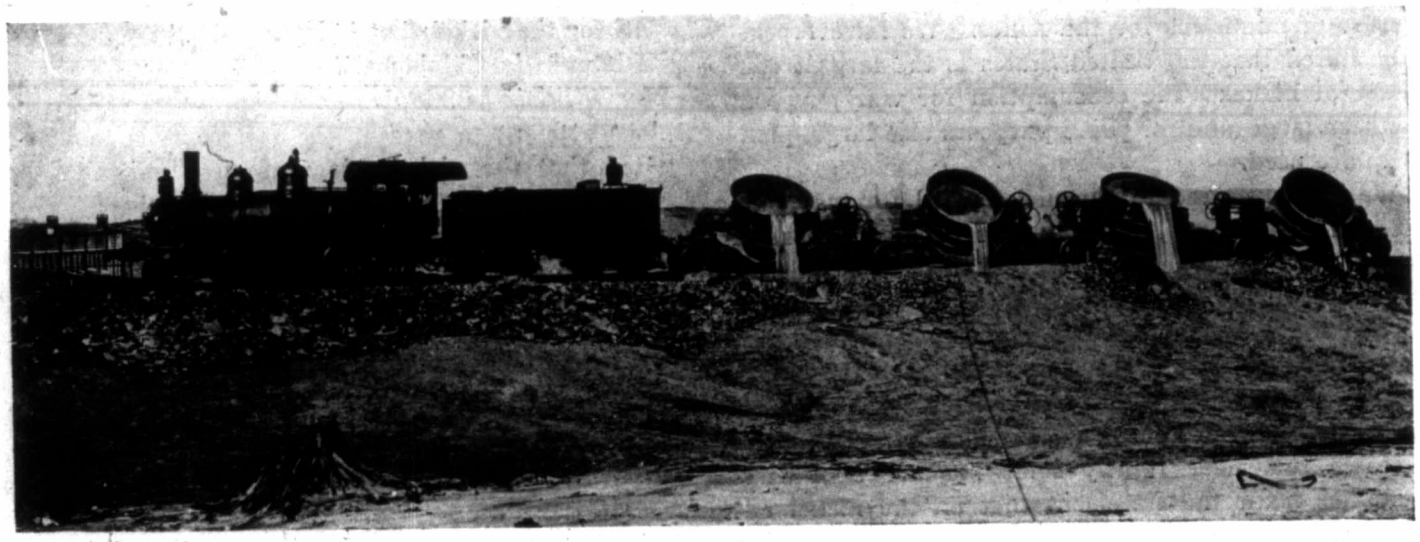
Bulletin 42 of the United States Bureau of Mines not only gives analysis of natural gas from many districts, all of which show no hydrogen, carbon monoxide or heavy hydro-carbons, although previous analysis of gas from some of these localities by others have given hydrogen, etc., but it also explains the details of the methods of analysis and shows that the apparent presence of these constituents is due to a faulty mode of analysis. As this Bulletin is the most complete study of the composition and methods of analysis of natural gas up to the present, it is absurd for Mr. Ashworth to characterize it as "slight support." The most complete work of this nature published in Canada is in the Report for the Bureau of Mines (of Ontario) for 1914. This corroborates the results given in Bulletin 42 entirely, and shows the complete absence of the constituents referred to above in the large number of samples involved.

It is difficult to see by what process of reasoning Mr. Ashworth comes to the conclusion that we are of the opinion that "real natural gas is or should be pure methane." There is not a word in our criticism which would directly justify any such conclusion. The fact that Bulletin 42, to which we refer as an authority, gives a great number of analyses nearly all of which show methane should be indirect proof enough that we hold no such opinion.

In the last paragraph of Mr. Ashworth's article he states that "analysts of mine gases have failed to look for other hydro-carbon gases but have included them under the general term methane, which would appear to be the accepted conclusion of the writer of the editorial to which I have referred." There is absolutely not one word in the editorial Mr. Ashworth objects to about the composition of mine gases, any more than there was about the nature of artificial gas, although we are aware that both hydrogen and carbon monoxide are found in artificial gas in large quantities.

In 1883 the Canadian Pacific Railway reached the Sudbury region, and the stretch of flat plain in the interior of the nickel basin attracted the railway engineers, who brought the line by a steep grade up from Sudbury to what later became the Murray mine, from which the railway descends to Azilda between hills belonging to the acid edge of the eruptive. It is said that at this time Dr. Howie discovered on the summit of the pass a low hill of pyrrhotite with some chalcopyrite. Specimens shown to Dr. Selwyn, then Director of the Geological Survey, were pronounced valueless, since pyrrhotite from Canadian localities had not hitherto been found to contain more than a fraction of a per cent. of nickel.

Early in 1884 the railway reached this deposit and a cutting disclosed copper pyrites at what was afterwards known as the Murray mine. Other discoveries soon followed at what became the Lady Macdonald, Evans, Copper Cliff, Stobie and Blezard mines; all taken up for copper, the presence of nickel being at first overlooked. The Creighton mine was rediscovered not long after by another land surveyor, John McAree, who surveyed an adjoining township, though



Pouring furnace slag, Copper Cliff

THE DISCOVERY OF COPPER-NICKEL ORES IN SUDBURY DISTRICT.

According to Professor A. P. Coleman nickel was first reported from the Sudbury region by Wm. Murray, in 1856. The well known land surveyor, Salter, had found a disturbance of the compass on a meridian line north of Whitefish lake, and suggested that Murray should examine the place. He found "an immense mass of magnetic trap," specimens of which were sent to Sterry Hunt for analysis. Magnetic pyrites was found disseminated through the rock and the analysis showed the presence of some nickel and copper. Salter's line is now the boundary between Creighton and Snider townships, and the rock with pyrrhotite was obtained a little west of the famous Creighton mine, the greatest nickel mine in the world. However, the discovery attracted little attention, since at that time the metal nickel was a rarity of little practical importance and the region was a wilderness without roads, where canoes were the only practicable means of travel..

the mine was not opened up till several years later owing to its difficulty of access.

Prospectors swarmed over the region searching everywhere for the gossan which showed the presence of ore, and men like Thomas Frood, Henry Ranger, William McVittie, A. McCharles and others quickly learned that gossan and ore accompanied only one kind of rock, then called diorite, but now known to be norite. In a short time almost all the main deposits had been located, and two ranges, a southern or main range, and a northern, began to be distinguished.

The first important mining was done in 1886 at the Copper Cliff, where an open cut was made against the side of a steep gossan covered hill, the work being carried on by the newly formed Canadian Copper Co., which soon opened up also the Stobie and Evans mines. The first ore mined was supposed to be simply copper ore, as the name of the mine and company suggest; and until 3,000 tons were shipped to Constable Hook for treatment, the presence of nickel was not suspected. There, however, difficulties were met in smelting the ore, and assays showed that nickel was the disturbing element.

SEPARATION OF NICKEL AND COPPER SULPHIDES

The chief sulphides of the nickel-copper ores of the Sudbury district are chalcopyrite (a sulphide of copper and iron), pentlandite (a sulphide of iron and nickel), and pyrrhotite (a sulphide of iron). The copper values are in the chalcopyrite. The nickel values are chiefly in the pentlandite. Some nickel occurs in the pyrrhotite, possibly in the form of small particles of pentlandite, or possibly actually replacing some of the iron in the pyrrhotite.

One of the main problems in treating the nickel-copper ores is the separation of the nickel and copper.

Views of Converters, Copper Cliff, Ont.
Product is a matte containing 77 to 82 per cent. copper-nickel

In the methods in use no attempt is made to separate the nickel and copper sulphides before smelting, and it has been generally assumed that separation is difficult. Recent investigations carried on at the University of Toronto, by Professor H. E. T. Haultain and Mr. F. C. Dyer, have shown, however, that the nickel and copper minerals can be easily separated by flotation. The flotation product is a high grade concentrate containing about 25 per cent. copper and a little nickel. The other sulphide product contains most of the nickel and only a trace of copper. A middlings product contains copper and nickel in about the proportions in which they occur in the ore.

The nickel concentrate is remarkably free from copper. The pentlandite and pyrrhotite sink together, giving a mixture of the sulphides of nickel and iron that might possibly be used for the direct formation of nickel steel. The copper concentrate is not so free from nickel as is the nickel from copper.

The method used in the University laboratories in treating the Sudbury ores will be described in a later issue. It is an original one and uses no oils nor acids nor modifying agents, but it is quite possible that similar results might be obtained by the Callow or Minerals Separation Co.'s processes.

TONOPAH OFFICIALS AT THE PAS.

The Pas, Man., Aug. 4.—Philadelphia officials of the Tonopah Mining Co. are in The Pas to meet Mr. J. E. Spurr for a consultation. The latter will get in today from a trip from Flin-Flon through the Cranberry lakes to Herb lake. The officials arrived here yesterday, and they are J. H. Whitemen, C. B. Evans and Dr. J. A. Ellegood. Mrs. Whitemen and Mrs. Evans accompanied their husbands. The company's engineers, L. W. Garbrecht, H. C. Carlisle and George Bancroft, will be present at the meeting. The diamond drill continues at work on the Mandy claim at Schist lake, and considerable satisfaction is expressed with the results obtained to date. An indefinite drilling programme has been outlined for work throughout the fall and winter.—The Pas Herald.

MINING DRILL STEEL.

Armstrong-Whitworth of Canada, Ltd., has recently installed a new electric furnace. This, with the crucible furnaces which have been in operation during the past year, enables the company to supply a complete line of carbon and alloy steels. Mining drill steel is now being made in Canada.

CHIEF MINERALS OF THE SUDBURY NICKEL ORES.

By A. P. Coleman.

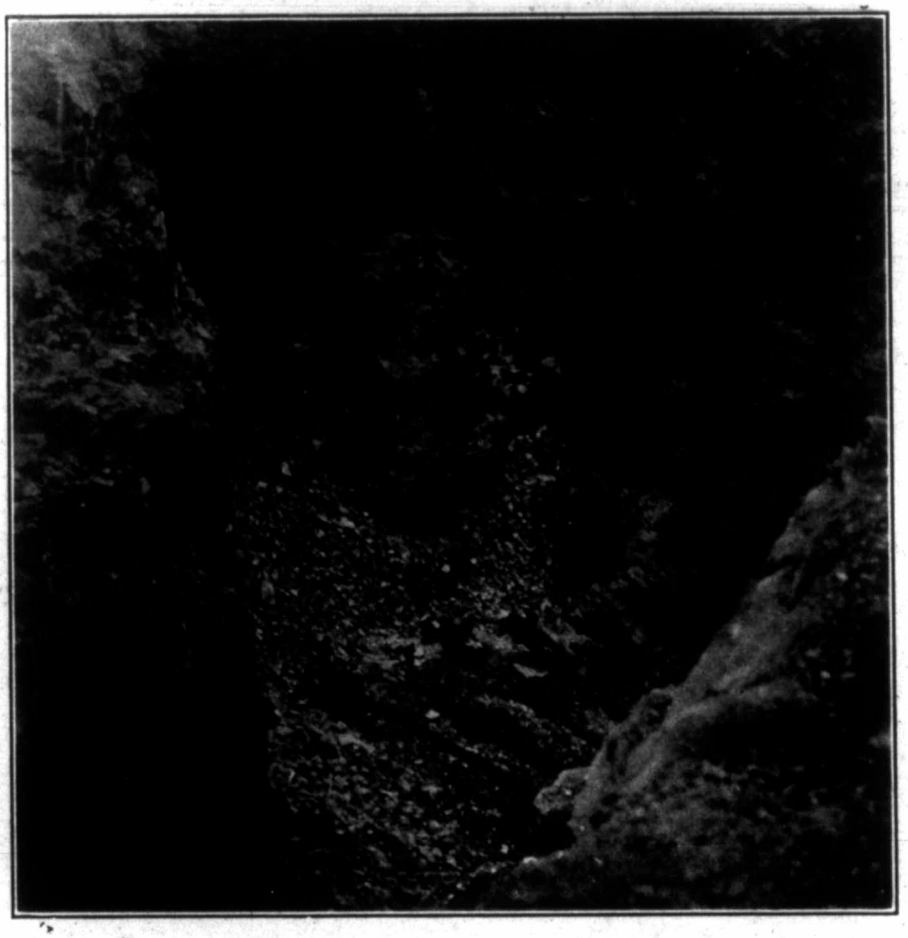
A considerable number of nickel-bearing minerals have been reported from the Sudbury region, the list including pyrrhotite, pyrite, marcasite, pentlandite, polydymite, gersdorffite, millerite and nickelite; but the number having any important relation to the ore deposits is very small, pyrrhotite and pentlandite being the only ones comonly found, and pyrrhotite the only one visibly present in all the ore deposits. There is some doubt, however, as to whether pyrrhotite is nickel-bearing in itself, since its nickel contents may be due to finely disseminated pentlandite. If this is correct the latter is the only nickeliferous mineral of importance in the region, though it cannot be seen in the ore at most of the mines.

It will be observed that all of the minerals mentioned are compounds of iron or nickel or both metals with sulphur or arsenic. Secondary nickel minerals are almost unknown in the region, though the green silicate genthite is reported from the Wallace mine farther west. In this respect the Sudbury deposits resemble those of Norway and differ fundamentally from the next source of nickel in importance, New Caledonia, where sulphides or arsenides of nickel seem almost unknown.

Pyrrhotite.

As the commonest of all the metallic minerals, pyrrhotite is naturally discussed first. Pyrrhotite or magnetic pyrites, forms much the largest part of the sulphides at every mine in the district, with the one exception of the Vermilion, a remarkably rich but small deposit, unique in many ways. The composition of pyrrhotite is somewhat variable, running, according to Dana, from $Fe_5 S_6$ to $Fe_{16} S_{17}$, the iron atoms never quite equaling in number those of the sulphur. It is difficult to separate the pyrrhotite from small amounts of other ingredients, such as pentlandite, chalcopyrite, and magnetite, which occur more or less in most specimens of the ore. After careful magnetic separation repeated several times, followed by treatment with dilute nitric acid to dissolve the pyrrhotite, leaving any magnetite behind, Dr. C. W. Dickson found that most analyses of the Sudbury pyrrhotite worked out to $Fe_8 S_9$, which may be looked on as the typical proportion of iron to sulphur in the region.

As pure pyrrhotite contains 60 per cent. of iron, it surpasses in percentage many workable ores of that metal and might naturally be looked on as a possible source of iron as well as nickel. The only attempt thus far made to use it so proved a failure, however. Ore from the Gertrude mine in its earlier days was unusually free from copper pyrites, and was smelted on a small scale for ferro-nickel by the Lake Superior Power Co., after it had been roasted sweet and the SO_2 used in the plant for sulphite pulp. However, it was found that copper pyrites increased so much in amount as the mine was developed that the process was given up. A small amount of copper is no longer looked upon as specially injurious in steel, and it may be that deposits will yet be found low enough in copper to be used in this way. The ore from one of the northern range properties is thought to be suitable for such uses. It certainly seems unfortunate that a metal destined to be combined with iron should first have all the iron with which it naturally occurs carefully slagged off from it by expensive processes.



Mining copper-nickel ore in open pit, a method recently abandoned

If the chalcopyrite found with pyrrhotite were not so intimately mixed as it is in most cases, the two minerals might be separated magnetically.

As the Sudbury pyrrhotite always contains small amounts of rock or of rock-forming minerals, even when carefully selected, probably 40 or 45 per cent. of iron is all that could be hoped for from any of the mines worked on a large scale; but this is equal to many iron ores which are now mined and smelted in other parts of the world.

Pentlandite.

By all means the most important mineral in the Sudbury deposits is pentlandite (Fe Ni) S, since in the great majority of cases this is considered to be the real nickel-bearing mineral; nevertheless it is rather rarely seen in the ores and has not been found in quite a number of mines. If carefully looked over, the Crean Hill and Creighton ores often show it, and the old Evans and Worthington mines furnished it also. The pentlandite of the Sudbury region is without crystal forms, but has a characteristic octahedral cleavage which distinguishes it from the enclosing pyrrhotite, which generally has no definite cleavage planes. On fresh surfaces the two minerals are almost the same in color, and the pentlandite is hard to recognize unless ones eye is well trained; but it soon weathers to a brassy yellow easily picked out from the bronzy background of pyrrhotite. Cleavage surfaces are sometimes an inch or more in diameter, though this is by no means common.

The proportions of iron to nickel in pentlandite are quite variable, the mineral as first described by Scheerer having only 18.35 per cent. of nickel, while some Sudbury examples contain nearly 40 per cent, of the metal.

Pentlandite was first recognized in Sudbury ores in 1891, by Prof. T. L. Walker, then chemist at Murray mine, who identified a specimen sent to him from Worthington by Dr. Barlow.

As pentlandite is practically non-magnetic and pyrrhotite is usually decidedly attracted by the magnet, it was natural to think that the two minerals could be separated magnetically, and elaborate attempts at such a separation were made by Browne, Barlow, Dickson and others; but it has been found that the minerals are too intimately mixed to permit of a complete separation except by methods too costly to be of practical value.

Some of the analyses show that 0.78 to 0.85 per cent. of cobalt occurs in the pentlandite, accounting probably for the cobalt contents of the standard matte of the region. The three closely related metals, iron, nickel and cobalt, replace one another more or less in their compounds.

Chalcopyrite.

In addition to the sulphides containing nickel and iron there is one very important ore of copper almost invariably present, chalcopyrite or copper pyrites, Cu Fe S_2. Unlike most of the nickel minerals mentioned above chalcopyrite is practically constant in composition, containing when pure 34.5 per cent. of copper, 30.5 per cent. of iron, and 35 per cent. of sulphur. Chalcopyrite comes next in amount to pyrrhotite and pentlandite and is always a more conspicuous component of the ore than the latter mineral because of its striking greenish brassy hue and its liability to tarnish with irridescent colors. Good crystals of the minerals appear to be lacking. Copper pyrites may either be intimately mixed with the pyrrhotite or form considerable masses by itself. It appears to be more easily dissolved and redepositd than pyrrhotite and so is more frequently found in fissures in the country rock; and it is especially common near the walls of orebodies or associated with masses of rock enclosed in the sulphides, so that as a rule rocky ore contains a higher percentage of copper than ore rich in sulphides. In two important mines, the Copper Cliff and the Crean Hill, copper is present in larger amounts than nickel, and at Garson and Victoria mines it about equals the nickel; but all the other mines contain more nickel than copper. As the percentage of copper in chalcopyrite is about equal to the precentage of nickel in pentlandite, we may assume according to the usual theory, that pentlandite occurs in larger quantities than copper pyrites in most of the ores, though it is so rarely seen.

THE NICKEL-COPPER OUTPUT.

The following table shows the production of nickel-copper ore for each year since 1890, and the contents of the matte obtained on smelting the ore.

The matte produced up to the end of 1915 contained 237,202 tons nickel and 146,661 tons copper and a considerable amount of platinum, palladium, gold and silver. The value of the matte is estimated at $147,933,200. The refined products would be worth over $200,000,000.

The ore smelted during the past ten years has yielded about three per cent. nickel and over one and one-half per cent. copper. This is exceptionally high grade ore. Under present conditions it might be treated profitably for its copper content alone.

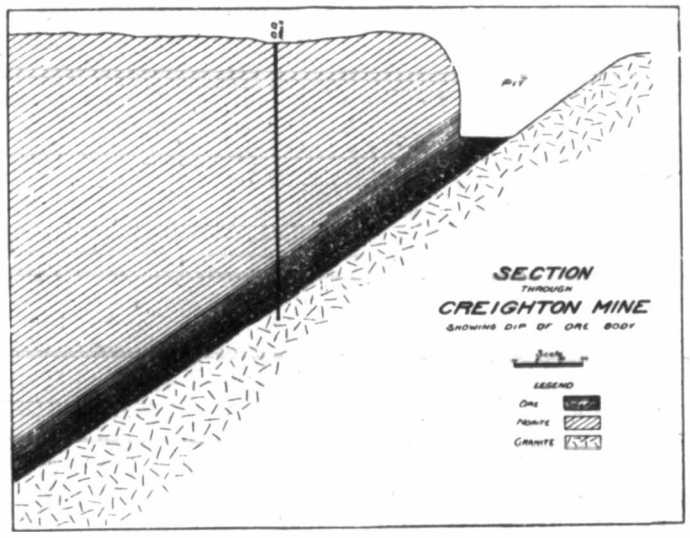
In addition to nickel and copper the Sudbury ores contain small quantities of the precious metals, gold, silver, platinum and palladium. The actual quantities are not reported. According to the International Nickel Company there was no production of these metals from Canadian ores at their works in 1913 and 1914.

Production of Nickel and Copper in Ontario.

	Tons Ore Raised.	Tons Ore Smelted.	Tons Nickel in Matte.	Tons Copper in Matte.
Before 1890	100,000	....	....	....
1890	130,278	59,329	....	....
1891	85,790	71,480	....	....
1892	72,340	61,924	....	....
1893	64,043	63,944	1,653	1,431
1894	112,037	87,916	2,570½	2,748
1895	75,439	86,546	2,315¾	2,365½
1896	109,097	73,505	1,948½	1,868
1897	93,155	96,094	1,999	2,750
1898	123,920	121,924	2,783¾	4,186¾
1899	203,118	171,230	2,872	2,834
1900	216,695	211,960	3,540	3,364
1901	326,945	270,380	4,441	4,197
1902	269,538	233,388	5,945	4,066
1903	152,940	220,937	6,998	4,005
1904	203,388	102,844	4,729	2,042
1905	284,090	257,745	9,503	4,524
1906	343,814	340,159	10,776	5,260
1907	351,916	359,076	10,602	7,003
1908	409,551	360,180	9,563	7,501
1909	451,892	462,336	13,141	7,873
1910	652,392	628,947	18,636	9,630
1911	612,511	610,788	17,049	8,966
1912	737,656	725,065	22,421	11,116
1913	784,697	823,403	24,838	12,938
1914	1,000,364	947,053	22,759	14,448
1915	1,325,973	1,272,313	34,039	19,608

ORIGIN OF THE SUDBURY NICKEL-COPPER ORES

The generally accepted explanation of the origin of the Sudbury nickel-copper deposits is that they were formed by magmatic segregation. Put in other words, it is believed by many that the ores crystallized out of the molten magma from which the norite was formed. It is held that the sulphide settled to the bottom of a supposed molten sill of norite, and collected in hollows on the underlying rocks. The settling of the heavy sulphides, it is further considered by some, was due



---After A. P. Coleman

largely to gravity. This idea regarding the settling of sulphides by gravity was advanced many years ago in connection with the Meinkjar nickel mine in Norway.* The idea was later applied by A. P. Coleman to explain the formation of the Sudbury ores.

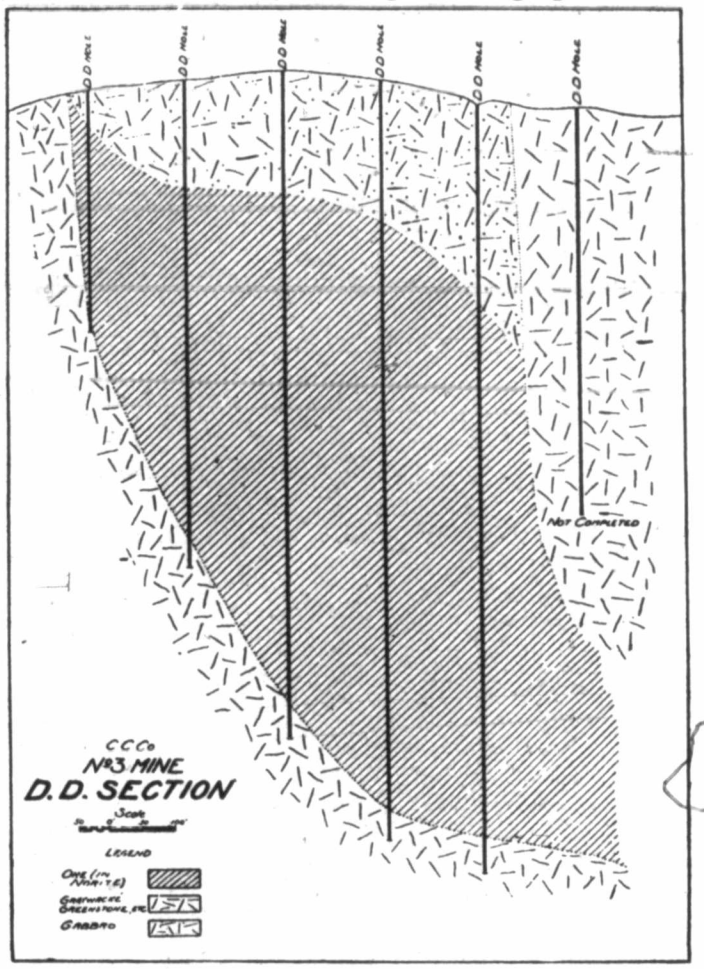
There have always been some geologists, however, who were not inclined to accept the theory outlined above. These workers preferred to believe that the ores were deposited from solutions.

Recently the theory of gravity has been questioned by C. W. Knight in an article in the Engineering and Mining Journal of May 6th. A serious objection was raised regarding this explanation in connection with the Creighton mine. It was shown by Knight that the coarse grained granite, which forms the footwall of the mine, is younger than the norite—the latter forming the hanging-wall. If this is true it is clear that the settling of the sulphide in the molten norite by means of gravity, so that they came to rest on the granite footwall, did not take place.

Less than two years ago the gravity segregation theory was discarded by E Howe† as an explanation of the origin of the Creighton orebody. He pointed out the fact that the norite near the contact with the ore is fine grained. He found it difficult to understand how this fine grained texture could develop where the cooling norite was separated from the footwall by a mass of molten sulphide. He also noted that the norite, at its contact with the orebody, was invariably brecciated for a distance of 3 to 12 ft. from the contact. The norite fragments in this brecciated zone were found to be cemented together by the sulphide. He considered, therefore, that the sulphides were evidently formed after the norite had solidified, and he suggested that they were introduced in a molten condition as a later intrusive.

There are other objections to the gravity segregation hypothesis. Some years ago, for instance, F. D. Adams‡, though a believer in this theory, pointed out that, while the hypothesis suggested that the sulphides settled to the bottom of the molten norite, it was a curious fact that the iron ores in some unaccountable way did not settle, although magnetite is invariably present in the norite. The amount of magnetite in the ore is stated by A. E. Barlow to be about 1 per cent. Rarely does it exceed that amount, except in one or two instances cited by A. P. Coleman. There are no large deposits of magnetite associated with norite in the entire nickel field.

It appears, indeed, that there are so many valid objections to the theory of magmatic segregation that



---After A. P. Coleman

perhaps geologists must after all revise their ideas regarding the origin of the Sudbury nickel-copper ores. Theoretically the idea is a beautiful, and, at the same time, a very plausible hypothesis; but its application to the orebodies meets with serious difficulties. The Canadian Mining Journal will welcome any discussion regarding this interesting subject, particularly if new points of view are brought forward.

CONIAGAS.

The Coniagas will instal a 100 ton a day flotation plant. The machinery and other equipment has been ordered, and it is expected that the plant will be in operation in about six weeks. The plant will be along the lines of the plant installed at the McKinley-Darragh. It will operate behind the tables. Tanks will not be put in just now and the slimes will run direct to a mixer, then to the cells.

* Ore Deposits, by Beyschlog, Vogt and Krusch, 1914, Vol. I., page 292.
† Economic Geology, Vol. IX., September, 1914.
‡ Journal Canadian Mining Institute, Vol. IX., 1906, page 234.

RECENT DEVOLOPMENTS IN THE SUDBURY DISTRICT

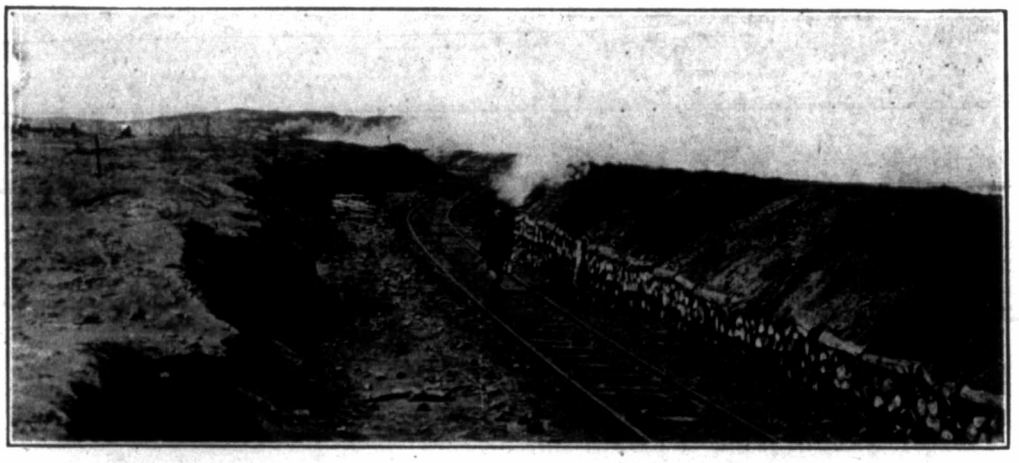
The Murray mine, which is owned by the British American Nickel Co., is being unwatered, and it is expected that operations will start in the near future. Mr. George Johns, formerly of the Dome mines, is at present in charge of the property. It is expected that the construction of the smelter and refinery will be started in the course of a few months.

Considerable construction is going on at Creighton mine. Fifty odd residences are in the course of construction, and a new club is to be built and a new business block is projected. The town is becoming one of the largest in the district and the streets are being improved and sidewalks extended around the town. The trolley system has not yet been extended from Copper Cliff to Creighton, but no doubt this will be done in the course of another year.

and will be equipped with an excellent draughting room.

At Copper Cliff the new Recreation Club is in use. This is fitted as fine as any of the best clubs in our large cities and is provided with a swimming pool and other apparatus for amusement. Certain days are reserved for the ladies, so that the wives of employees as well as the employees themselves may take advantage of the fine building. A nominal fee is charged employees for their membership. Outsiders are permitted to join, but are charged an initiation fee.

The beds at the old roast yards of the Canadian Copper Co., at Copper Cliff, are burning out, and no new beds are being put down here. Beds are being put down at the new roast yards at mileage 17 on the Algoma Eastern Railway. This makes a much longer haul for the ore, as it must be hauled from Creighton South to the roast heaps and the roasted ore has to be



Roasting nickel-copper ore

The new steel headframe and rockhouse at the Creighton mine are nearing completion, and it is thought that they will be ready for use within the next six months. It will take considerable work to get the shaft in shape for hoisting by this time, as all the concreting has to be done and the latter has not been started yet. It is planned to push the work. A trestle will be run from the new rockhouse to the open pit, and the waste rock will be disposed of in this way, being dumped into the open pit. The new power house is completed and ready for the installation of machinery. The shops are completed. A large underground crusher is being installed.

Foundations for the new office building have been started. This will house all the various departments

hauled back north to Copper Cliff to the smelter. It frees Copper Cliff and Sudbury from the sulphur fumes, but the smoke seems to be causing considerable damage to the property along the C.P.R. (Soo branch) and Nickel City, that was the pleasure resort of the district, is suffering. tI will probably not be long before this part of the country will be as devoid of foliage as the parts around Copper Cliff are at present.

The nickel question is a big thing now in all parts of the country, and it is only natural that the people of Sudbury are especially interested, since this industry is so all important to the town. The town is naturally very desirous of having the projected refineries located in the vicinity, and resolutions have been introduced to have both the International and the Brit-

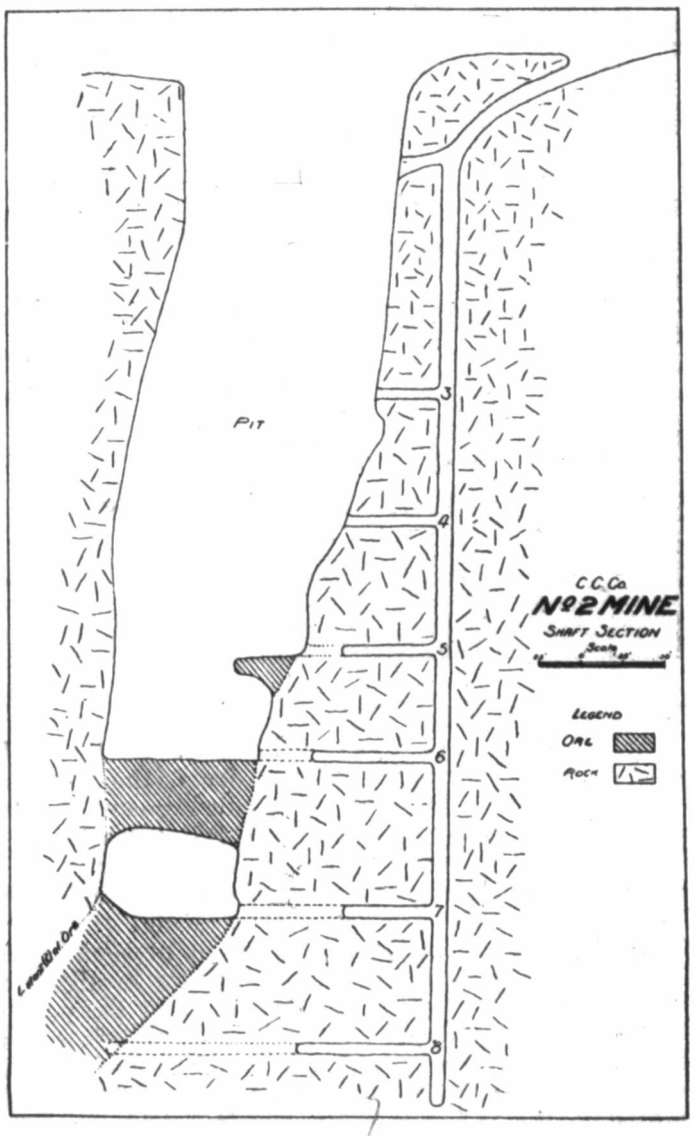
ish American companies consider Sudbury for the smelter and refineries.

F. Black, M.P., is interested in a company known as the Sudbury Nickel Refineries, with headquarters at Ottawa. The process is supposed to make nickel steel direct from iron and nickel ores.

Mr. P. Kirkegaard has made an examination of the property and mill of the Sable River Copper Co., located at Massey, Ont. Mr. Jas. Flynn is president of the company, and Mr. A. E. Hall is superintendent. The ore is chalcopyrite, and is being concentrated by flotation methods. Several cars of ore have been shipped to the smelter, as well as several cars of concentrates from the mill. While the company is reorganizing operations are temporarily discontinued.

Mr. Robert Bryce has made an examination of the Sable River Copper Co.'s mine and mill. Mr. J. Johnson, of Mine Centre, visited the Sable River Copper mine the past week. He is interested in seeing what ore could be depended upon for the erection of a smelter at the Soo or other convenient place ,and is himself interested in a chalcopyrite property at Mine Centre, west of Fort William.

The forest fires that have been taking such a toll up north have not been very severe in the Sudbury district ,although they have been felt. The Canadian Copper Co. lost a large quantity of wood, and there are many fires burning along the Soo branch of the C.P.R. The town of Blind River suffered heavily.



A Sudbury Nickel Copper Deposit--After A. P. Coleman

THE INTERNATIONAL NICKEL COMPANY.

Consolidated General Balance Sheet, June 30th, 1916.

Assets.

Property	$43,679,367.94
Investments	1,510,033.87
Inventories	4,649,941.34
Accounts and bills receivable	2,246,387.22
Loans on call	1,015,000.00
Certificates of deposit	2,030,000.00
Cash	4,137,633.15
	$59,268,363.52

Liabilities.

Preferred stock	$8,912,600.00
Common stock	41,834,600.00
Accounts payable	1,728,186.94
Preferred Dividend No. 43, payable Aug. 1st, 1916	133,689.00
Accident and insurance funds	193,208.08
Surplus April 1st, 1916	3,294,194.67
Profit and Loss (balance as per statement)	3,171,884.83
	$59,268,363.52

Consolidated General Profit and Loss Statement.

3 Months ending June 30th, 1916.

Earnings	$3,959,134.58
Other income	66,261.89
Total income	$4,025,396.47
Administration and general expense	222,422.35
Net income	$3,802,974.12
Depreciation and mineral exhaustion	497,400.29
Profits	$3,305,573.83
Dividends—	
Preferred No. 43, payable Aug. 1, 1916	133,689.00
Balance	$3,171,884.83

New York, July 24th, 1916.

MOND NICKEL.

At the annual meeting of the Mond Nickel Co., Ltd., which operates extensively in the Sudbury district, held in London this month, the chairman of the company, Right. Hon. Sir Alfred Mond, Bart., M.P., said that profits during the year were £322,000, the progress was the most satisfactory, and that the mines were developing beyond expectations. The company had never been given any special encouragement to develop their supplies for war needs and had gone through a prolonged struggle to get permission to have used in British armaments the only nickel manufactured within the Empire. The regular 7 per cent. dividend on the preferred stock was paid and 20 per cent. dividend for the ordinary shares.

The officers and directors of the Hudson Bay Zinc Mines Co., operating the Hudson Bay group of mines on Deer creek, in the neighborhood of Salmo, Nelson mining division of British Columbia, following the purchase of the control of that company by a syndicate organized by Hayden, Stone & Co., of New York City, are as follows: President, M. W. Bacon, Spokane, Washington; vice-president, James A. Nelson, New York; secretary, A. T. Ronaghan, New York; treasurer, W. E. Cullen, Spokane; other directors, W. Bruce McKelvie, Thos. J. Ryan and Nash Rockwood, all of New York.

NICKEL STEELS

By Henry D. Hibbard.

Alloy steels are bringing about a series of revolutions in various industrial fields in which steel plays an important part. Most elements that could be procured in sufficient quantity have been alloyed with iron in various proportions, either alone or in combination with others, in the search for useful alloy steels.

Probably the first useful alloy steel was Mushet's self-hardening tungsten tool steel, patented in 1868. Fifteen years later chromium steel, really containing chromium, was struggling for recognition for some purposes, the chief of which was for the manufacture of solid shot for piercing armor. In both of these steels the effect of the alloying element as used was in a way proportional to the amount contained. In 1882 Hadfield made his epoch-making discovery of manganese steel and demonstrated that in iron metallurgy it is not safe to take for granted anything as to the properties of an alloy of iron with other elements, basing one's opinion on past experience and knowledge, and that the effect of an alloying element may not be proportional to its content. The development of useful nickel steels followed in a few years and the field thus opened has since then been worked by many able and zealous men, with results of great importance and value.

Simple Nickel Steels.

Nickel steel was chronologically the fourth alloy steel to be introduced, it having been in use for 25 years, and the steels to which nickel is added aggregate a large tonnage. In 1913, including the nickel-chromium steels as well as the simple nickel steels, the total amount of steel produced to which nickel was added was about 150,000 tons in the ladle, of which about 50,000 tons was simple nickel steel. The field for the latter is being steadily narrowed by the substitution of the cheaper or better nickel-chromium steels.

The useful nickel-iron alloys range, with large intervals, from 2 to 46 per cent. of nickel, a greater compass than is covered by any other element alloyed with iron. The addition of less than 2 per cent. of nickel alone does not seem to give enough benefit to make the addition worth while.

Nickel in untreated ordinary nickel steel raises the tensile strength, and in a greater proportion the elastic limit for a given content of carbon without decreasing the ductility.

Manufacture of Simple Nickel Steel.

Nickel steel is made by any of the steel-making processes, but most of it is produced in the open-hearth furnace. The operations are similar to those followed in the production of simple steels, the nickel being either in the materials of the original charge or added in the metallic form at any time long enough before the heat is cast for the nickel to be melted and thoroughly mixed with the metal of the charge. Nickel is negative to iron at steel-melting temperatures and the iron protects it from oxidation and even reduces it from its oxide so that it is not wasted to any considerable extent in melting or working even when iron ore is added to the bath. On the other hand it does not deoxide the metal or decompose carbonic oxide or keep the hydrogen and other gases in solution. It is not added, therefore, for curative purposes as it gives no aid in rendering steel sound, or free from holes. In fact, nickel steel is prone to have seams and surface defects after it has been rolled, which is one reason against its wider use. The service of nickel is merely as an alloying element, to improve the physical properties of the finished steel either in its natural or heat-treated condition.

As might be expected from an alloying metal whose atomic weight, specific gravity, and fusion are so near those of iron, nickel does not segregate much as the steel solidifies, and is claimed to hinder in some degree the segregation of carbon and the other less metallic ingredients. A reasonable explanation of this action of nickel on the other elements has not yet been established.

Working of Simple Nickel Steel.

Ordinary simple nickel steel (3 to 4 per cent. nickel) is worked hot by the usual forging and rolling operations much as simple steel is worked. The higher nickel steels are more difficult to work, having narrower ranges of temperature at which they may be hot-worked without showing signs of redshortness. In the ordinary grades seams and adhering scale give some trouble.

Although molten iron protects molten nickel from oxidation, iron can not protect nickel from oxidation in scale formed on nickel steel, as in the heating furnace. The scale formed sticks much more firmly to the metal than that of simple steel both hot and cold and requires particular measures for its removal. Articles such as plates, having large flat surfaces from which the scale can not escape even if loosened by such means as rolls or the flat dies of the forging press, are sometimes cleaned cold by electrically driven machines which break up the scale by a shower of blows with chisels or hammers. A round article is much more satisfactorily cleaned of scale by the forging operation, as the metal is worked while not in contact with the dies, and the scale is thereby loosened and falls off. The scale naturally escapes more easily from the under side of a rolled plate than from the top in rolling, and some mills are equipped with apparatus for turning the plate bottom up before it is finished, so that the scale which has been repeatedly loosened and then rolled in again by the rolls can drop off when loosened from the under side.

Steels containing useful quantities of nickel are liable to contain seams that appear as dark-colored lines in the metal. The seams doubtless come, sometimes at least, from "skin" gas holes which become oxidized on their walls, and, although such oxidized holes will, if present, form seams in any steel, they seem to persist more in nickel steel because, perhaps, the nickel prevents the welding of such holes, as may happen with holes in simple steels if they are squeezed together while hot enough and the walls are clean and not oxidized. A hole near the surface in nickel steel might conceivably, therefore, be drawn out and the slit formed be opened to the air by the hot working, then oxidized on its inner surface, and form a seam, when a similar hole in simple steel would be welded and therefore not form a seam. Nickel-steel ingots should therefore be made sound and free from gas holes. It is held by some persons that seams develop in rolling without being caused by gas holes, and that this tendency is lessened by rolling at a high temperature, about 1,300 deg. C. (2,372 deg. F.).

* Extracts from a report on Alloy Steels published by the U. S. Bureau of Mines.

Nickel Steel for Structural Purposes.

The great bulk of simple nickel steels contain from 2 to 4 per cent. of nickel, a proportion that affords the most suitable properties for nearly all structural purposes, and the nickel content usually aimed at in steels for structural purposes is 3.25 per cent. This grade might be called ordinary nickel steel as it is usually meant when nickel steel is mentioned without further specification. It has high value for structural purposes such as bridges, gun forgings, machine parts, engine and automobile parts, and any similar line of service that is too severe for simple steels.

The bridges in which it is used are particularly those of great span, and it is nearly always used in the natural or annealed condition when the additional strength and ductility imported is that due to the mere presence of nickel in the metal. Important quantities are used in the Queensboro, Manhattan, St. Louis Municipal, and Quebec bridges, and the Kansas City viaduct. Some nickel-steel tension bridge members have been heat treated by heating and quenching, being immersed in water edgewise with the longitudinal axis horizontal, and afterward drawn back by a second heating to give an elastic limit of 55,000 pounds per square inch, a rather low figure. A relatively low percentage of nickel, or about 2 per cent., is sufficient to afford steel with such a property, when heat treated.

The use of nickel steel in bridges saves some weight, a detail of importance in such bridges as those mentioned, but when the span is moderate a bridge of simple steel is perhaps as good and is less costly even though it contains considerably more weight of metal.

Steel with 2 per cent. of nickel is used in seamless tubes such as are used for bicycles and for other equipment requiring a high-grade tube. They are not heat treated, but higher properties than those of the steel in its natural state are imparted by the cold-drawing operations by which these tubes are finished.

The ordinary grade with 3.5 per cent. nickel is used in cannon, being always heat treated for this use. It is also used in many automobile parts, the variety of high properties obtainable in it by modifying its heat treatment rendering it fit for almost any service demanding a strength and security from breakage that a simple steel will not meet.

In some large dynamos the revolving fields are connected by nickel-steel rings having 3 per cent. nickel, the metal being particularly well suited for the purpose both by its strength and its magnetic efficiency, the permeability being high and the hysteresis losses low.

Nickel Steels Used in Rails.

Nickel-steel rails usually having about 3.5 per cent. of nickel have been tried by many railroads and are generally considered unsatisfactory though small lots are still being made chiefly for use in tunnels and other unusually wet or damp places, both for their ability to resist rusting and for safety from breakage. Their price is nearly twice that of simple steel rails and they sometimes give three times the service but their average life has been much less than that. One lot of Bessemer nickel-steel rails which gave between one to two times the service of simple Bessemer steel rails wore unevenly and the metal flowed over the side of the head on the curve so that it was finally detached in thin splinters, some of which were 3 or 4 feet long. The rails from the upper parts of the ingots were more unsatisfactory than those from the bottom and though the ingots were not examined for their soundness it seems evident that their upper parts were infested with blowholes as well as pipe, and that none of the holes or pipe were welded up in rolling, as the effect of nickel in hindering welding of steel is well established.

Properties of Ordinary Nickel Steel.

The properties of ordinary nickel steel are given below. All the samples consisted of small test pieces, and elongations were measured on 2 inches except as noted.

Properties of Ordinary Nickel Steels.

Sample No.	Composition. C. Pct.	Mn. Pct.	Si. Pct.	S. Pct.	P. Pct.	Ni. Pct.	Condition.	Physical Properties. Tensile strength. Pounds.	Elastic limit. Pounds.	Elongation. Pct.	Contraction. Pct.	Ball hardness.
1a	0.28	0.57	....	0.03	0.02	3.44	Natural state..	95,420	56,670	b21.2	40	...
2c	.40	.64	....	.02	.01	3.43	Annealed.	98,800	51,400	d12.4	33	...
3c	.40	.55	....	.03	.01	3.70	"	93,180	56,060	d15.8	40	...
4e	.20	.65	....	.04	.04	3.5	"	.....	43,000	27	62	170
5e	.20	.65	....	.04	.04	3.5	(f).	.....	95,000	20	72	216
6e	.20	.65	....	.04	.04	3.5	(g).	.....	140,000	14	61	330
7e	.30	.65	....	.04	.04	3.5	Annealed.	.....	63,000	27	63	163
8e	.30	.65	....	.04	.04	3.5	(h).	.....	87,000	25	68	207
9e	.30	.65	....	.04	.04	3.5	(i).	.....	123,000	15	57	269
10e	.30	.65	....	.04	.04	3.5	(j).	.....	187,000	13	57	405
11k	.25	.74	0.21	.01	.01	3.55	(l).	207,000	177,000	14	60	395
12k	.25	.74	.21	.01	.01	3.55	(m).	135,000	117,000	20	67	267

a Sample represented untreated steel for Quebec bridge.
b In 8 inches.
c Full size eyebars for St. Louis Municipal Bridge.
d In 18 feet.
e Figures taken from fourth report of Iron and Steel Division: Bull. Soc. Automobile Eng., Vol. 4, 1913, p. 168.
f Quenched in water at 850 degrees C.; hardness drawn in air at 538 degrees C.
g Quenched in water at 800 degrees C.; hardness drawn in air at 316 degrees C.
h Quenched in water at 800 degrees C.; hardness drawn in air at 593 degrees C.
i Quenched in water at 800 degrees C.; hardness drawn in air at 309 degrees C.
j Quenched in water at 800 degrees C.; hardness drawn in air at 316 degrees C.
k Figures furnished by Halcomb Steel Co.
l Quenched in water at 843 degrees C.; hardness drawn in air at 316 degrees C.
m Quenched in water at 843 degrees C.; hardness drawn in air at 538 degrees C.

One per cent. of nickel in ordinary nickel steel in the natural state raises the tensility about 6,000 to 8,000 pounds per square inch.

The table shows that ordinary nickel steels may be so made as to have a wide range of properties that make them suitable for any structural purposes for which they are not too expensive.

The properties of one grade of nickel-steel castings made for special purposes are as follows: Composition, C 0.20 per cent., Mn 0.50 per cent., Si 0.35 per cent., Ni 2.50 per cent.; tensile strength, 85,000 pounds per square inch; elongation, 25 per cent.; contraction, 40 per cent. This steel was not given treatment involving quenching but was merely annealed.

Steel containing 5 to 8 per cent. of nickel presents a sort of critical point, that proportion being the lowest at which, with the usual range of carbon, the structure is all martensitic and consequently very hard, the martensitic state being equivalent to the hardened state of simple steels. Such steel is difficult to work hot or cold but can be rolled if proper care is used. It finds some usefulness in places where great resistance to shock is required, particularly in thin shield plates about 0.15 inch thick which are used on one side of the caisson of field artillery to protect the ammunition, and the men who serve it, from rifle fire. A sample analyzed for "Tests of Metals" (War Department, 1908) gave the following composition in percentages: C 0.42, Mn 0.49, Si 0.26, S 0.02, P 0.02, Ni 6.68.

The content of carbon determines the minimum amount of nickel which must be present to make the steel wholly martensitic. Thus if the carbon content is low, about 0.20 per cent., 8 per cent. of nickel is required, whereas if the carbon content is about 0.80 per cent. the steel is martensitic when there is 5 per cent. of nickel contained. The analysis given last above represents martensitic steel.

Guillet gives the properties of a similar steel, with 6 per cent. of nickel and 0.38 per cent. carbon, as follows:

Properties of Nickel Steel containing 6 per cent. of Nickel.

Condition.	C.	Ni.	Tensile strength.	Elastic limit.	Elongation.	Contraction.	Shock.
	Pct.	Pct.	Pounds.	Pounds.	Pct.	Pct.	
Annealed.	0.38	6.0	113,760	99,540	20	65	30
Air hardened at 850 deg. C...	....	....	177,750	156,420	11	53	19
Quenched in water	....	....	199,080	177,750	10	50	17

He does not say whether this steel was martensitic, but the high elastic limits indicate that it was probably largely so, even in the annealed condition.

Steel with 8 per cent. nickel has one transformation point at 510 deg. C. (950 deg. F.) where points Ar_3, Ar_2, and Ar_3 are all merged into one. Eight per cent. is the highest useful content of nickel in nickel steel that is amenable to ordinary annealing and quenching operations. Hardening by quenching does not occur in steels containing 10 per cent. or more of nickel which are on the contrary softened by heating and quenching.

Nickel-Iron Alloy Discovered by Arnold and Read.

The 13 per cent. nickel-iron alloy with 0.55 per cent. carbon discovered recently by Arnold and Read is noteworthy as it seems to possess the highest strength of any of the nickel steels. It is so hard as to be unmachinable and the investigators mentioned were not able to drill it even to get some drillings for analysis, the composition mentioned being what they aimed at when making the steel. It has a yield point of about 134,000 pounds per square inch, a tensile strength of about 195,000 pounds, with 12 per cent. of elongation in 2 inches. This gives a merit figure of about 2,300,000 which is very high for such a hard steel though it does not compare with the 7,000,000 of forged manganese steel. Steel of this composition might have been expected to show maximum strength as a result of Hadfield's experiments, though he did not include this grade in his series of samples. He found that low-carbon steels with 11.4 and 15.5 per cent. of nickel each had a tensility of 210,560 pounds, which was more than was possessed by the steels next above and below. The curve therefore should have reached a maximum between them with a nickel content of about 13.5 per cent.

Arnold and Read's steel should, of course, have a higher tensility, or about 215,000 pounds, to harmonize with Hadfield's, and further tests are needed to establish the exact path of the curve. Arnold and Read note that the composition of this steel nearly corresponds with the formula Fe_7Ni. With such properties as it possesses this steel is likely to find at least a limited field of usefulness.

Other Nickel Steels.

Before Arnold and Read's discovery of the 13 per cent. grade, 15 per cent. nickel steel was thought to have the greatest strength of all the nickel steels—that is, in the natural state. This variety has been employed in a few instances for shafting and similar service for which other steels failed, but the amount of it used is negligible in statistics. It is hard to machine, and heating followed by slow cooling does not soften it, though heating and quenching does enough to allow it to be machined slowly. It has a tensility of about 170,000 pounds and an elastic limit of 150,000 pounds per square inch, according to one observer, though, as stated above, Hadfield obtained 210,560 pounds tensility, with little ductility. It is likely that the properties desired when this steel was used, particularly its ductility, could now be surpassed by the much cheaper heat-treated ordinary nickel or nickel-chromium steels.

Eighteen per cent. nickel-iron alloy, although not useful, is worthy of note here because of its anomalous action (according to Sexton and Primrose) when cooled from 200 deg. C. (392 deg. F.). At first it contracts uniformly until its temperature falls to 130 deg. C. (266 deg. F.). Then it expands while cooling to 60 deg. C. (140 deg. F.), when it again contracts as the temperature falls farther.

Twenty-two per cent. nickel steel is used when resistance to rusting or corrosion is desired. A noted example is the valve stems of the salt-water fire-protection service of the city of New York where the apparatus may not be allowed to become inoperative or hard of action from the formation of rust. It is also sometimes used for the spark poles in the spark plugs of internal-combustion engines, including automobiles, though commercial nickel wire is more commonly used.

High-nickel steels having 25 per cent. or more of nickel and low carbon content (about 3 per cent.) are austenitic in structure and in the natural state are softer and tougher than the medium-nickel martensitic steels.

High-nickel steel containing 24 to 32 per cent. nickel in the form of wire is used for electrical resistance in small quantity, probably between 5 and 10 tons per year in this country.

The analysis and resistance of samples of Krupp nickel-steel resistance wire are shown below. This wire is used in electric toasters, cookers, irons, and similar devices.

Steel with 27 per cent. of nickel is used in bits, stirrups, and spurs in riding harness because of its resistance to rusting. It will nevertheless rust slowly at ordinary temperature under conditions that strongly induce oxidation.

Steels containing more than 24 per cent. of nickel are practically nonmagnetic in their ordinary condition, a rather remarkable fact when the high magnetic susceptibility of both iron and nickel alone is considered. The explanation that the critical point marking the change from the nonmagnetic to the magnetic state of iron is lowered by the nickel from about 700 deg. C. (1,292 deg. F.) to below ordinary atmospheric temperatures is, no doubt, sound as far as it goes. When 25 per cent. nickel steel is cooled to —40 deg. C. (—40 deg. F.) it becomes magnetic, and retains its magnetism at ordinary atmospheric temperatures. On being heated to 580 deg. C. (1,076 deg. F.), however, the alloy reverts to the nonmagnetic state. This separation of 620 deg. C. between the critical points marking the magnetic states in heating and cooling is great in comparison with the 25 deg. to 50 deg. C. of simple steels, and because of it this steel is classed as irreversible.

The nonmagnetic quality of high-nickel steels is not utilized chiefly because of its capacity for becoming magnetic, as described above, for if it happened to be cooled enough to make it magnetic it could not in most cases be easily demagnetized.

The fact that high-nickel austenitic steels have a somewhat lower modulus of elasticity than the low-nickel or simple steels does not affect their value for the uses made of them. These steels also have low elastic limits though they are tough and show up well in the shock test. Nevertheless they are generally used not because of superior physical properties but because of their resistance to rusting and corrosion or their electrical resistance. With a carbon content of 0.25 to 0.30 per cent. and 32 per cent. nickel they are used in valves for gasoline motors with good results.

Nickel steel with 30 per cent. of nickel is used in boiler tubes, particularly in marine boilers, for which it is admirable. These tubes are in the natural, not heat-treated state. They resist corrosion better than simple steel tubes and last three times as long. Hence their use is sometimes economical in spite of the much higher cost.

Invar.

The 36 per cent. nickel steel known as Invar is used to the extent of perhaps a few hundred pounds a year in clock pendulums, rods for measuring instruments, and such parts for which its exceedingly slight expansion and contraction when heated and cooled within the atmospheric range gives it a particular value. Nevertheless, its coefficient of expansion, even though small, is not negligible, and compensating means must be used in Invar clock pendulums and in the Invar balance-wheels of watches. A watch with an Invar balance-wheel varied 20 seconds per day during a temperature change of 40 deg. to 90 deg. F., the usual test change, a variation too great for a good watch. Some Invar has as low a coefficient of expansion as 0.0000008 per degree centigrade, and samples have been made that contracted slightly when warmed. The coefficient given indicates an expansion of 0.05 inch in a mile per degree C.

When Invar is heated to about 300 deg. C. (572 deg. F.) and higher its coefficient of expansion is greatly increased and its lack of expansion at ordinary temperatures appears to be merely a belated and not destroyed function. With excessive cold there is likewise a resumption of contraction.

Platinite.

Forty-six per cent. nickel steel with 0.15 per cent. carbon known as platinite, has about the same coefficient of expansion as platinum and glass and for that reason may be imbedded in glass without breaking the latter by a difference in expansion. It has been used in leading wires in the glass bases of electric incandescent lamp bulbs as a substitute for platinum which was formerly held to be indispensable. In those lamp bulbs the preservation of the vacuum is necessary and the joint between the wire and glass must be kept tight. Platinite has not been found wholly suitable for this purpose and is not now so used, a compound wire with a 38 per cent. nickel-steel core encased in copper and sometimes coated with platinum now being generally employed. The nickel-steel core if free will expand less than the glass and the copper more, so that each resists the other and the wire as a whole will have the desired rate of expansion. About 2 tons of nickel steel per year is used in this wire.

Many other alloys of iron and nickel have been studied by Guillet and others. In fact the whole range has received more or less thorough attention, and much knowledge of scientific value has been gained concerning the varieties that so far have not found useful application.

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NICKEL-CHROMIUM STEELS

Nickel-chromium steels known in the trade as chrome-nickel steels are perhaps the most important of the structural alloy steels. Their field of usefulness is continually being enlarged by their application for new purposes and also by encroachment on the premises of some of the other alloy steels, notably of simple nickel steel, and they have almost wholly displaced nickel-vanadium and nickel-chromium-vanadium steels, which several years ago were in some considerable demand.

The amount of nickel-chromium steels produced in 1913 was thought to be about 100,000 tons of ingots, all made in the open-hearth furnace with the exception of 2,000 or 3,000 tons melted in crucibles and electric furnaces. The steel is made by 10 or 12 companies, 2 of which make it at several different plants.

Nickel-chromium steels are seldom used in any but a heat-treated condition. By suitable treatment pieces of small mass can be made to have as high physical properties as any steels known, with any elastic limit between 40,000 and 250,000 pounds per square inch, accompanied by ductility that is high as compared with its strength, as the ductility naturally lessens as the elastic limit increases.

Nickel-chromium steels can be made somewhat more cheaply than simple nickel steel of the same strength and ductility containing a smaller total of the alloying elements, and chromium is less costly than nickel.

Most of the nickel-chromium steel goes into armor plate, projectiles, and automobile parts.

For automobiles—and the practice might be advantageously extended to other fields—three grades of nickel-chromium steel are used. They are called low, medium, or high according to their contents of nickel and chromium. The carbon content may be varied for each grade within the limits shown in the following table:

Analysis and Resistance of Samples of Krupp Nickel-Steel Resistance Wire.

Sample No.	C. Pct.	Mn. Pct.	Si. Pct.	S. Pct.	P. Pct.	Ni. Pct.
1	0.52	0.75	0.10	0.035	0.024	30.6
2	.39	1.00	.70	.035	.025	24.2

These steels are almost invariably heat treated for use in automobiles, a wide range of properties being attainable by varying the heat treatment with each steel. The properties overlap those of steels of both harder and softer grades, so that a wide choice of properties is afforded as well as a choice of steels for the set of properties desired.

Armor Plate.

An important use for chrome-nickel steel is in both thick and medium armor plate for war vessels. The thick heavy side armor, 6 to 14 inches thick, is face hardened by the well-known methods. A recent analysis of the body of a plate gave: C 0.33 per cent., Mn 0.32 per cent., Si 0.06 per cent., S 0.03 per cent., P 0.014 per cent., Ni 4 per cent., Cr 2 per cent., and its tensile properties after treatment were:

Tensile strength, pounds per square inch	101,000
Elastic limit, pounds per square inch	77,500
Elongation in 2 inches, per cent.	24
Contraction of area, per cent.	60

The results from such a great mass of metal were excellent.

Medium armor, between 3 to 5 inches thick, is rather similar in composition. It is not face hardened, but is given high properties as a whole by the heat treatment to which it is subjected. An analysis lately made gave: C 0.30 per cent., Mn 0.34 per cent., Si 0.13 per cent., S 0.03 per cent., P 0.03 per cent., Ni 3.66 per cent., Cr 1.45 per cent.

Its physical properties were those given below as sample 1. Sample 2 represented another chrome-nickel steel made for the same purpose, containing 3½ per cent. of nickel.

	Sample 1.	Sample 2.
Tensile strength, pounds per sq. inch	119,000	138,000
Elastic limit, pounds per sq. inch	106,000	119,000
Elongation in 2 inches, per cent.	22	22
Contraction of area, per cent.	61	49

Such steel is most excellent for use on warships to form protective decks and barriers to protect from secondary battery fire. Chrome-nickel-vanadium steel is also used for this purpose.

Projectiles and Rails.

Nickel-chromium steel is used in the manufacture of most armor-piercing projectiles.

Cubillo cites a steel for projectiles, having 0.48 per cent. C, 0.58 per cent. Mn, 0.75 per cent. Cr, 2.55 per cent. Ni, 0.40 per cent. Si, 0.04 per cent. P. A test piece quenched in oil and tempered had an elastic limit of 129,400 pounds per square inch, a tensile strength of

150,300 pounds per square inch, and an elongation of 19 per cent.

For large projectiles Girod prefers chromium-tungsten steel having 0.50 per cent. C, 4 per cent. Ni, 0 to 1.5 per cent. Cr, and 0.25 per cent. W.

It is curious that nickel is considered to improve the quality of shot although generally held to injure the quality of high-speed tool steels. In use there seems to be a parallel between the requirements of the two, except for the important and vital difference as to the required speed at which they respectively meet the metal to be penetrated. The speed of impact of the shot enables it to enter when no amount of pressure will effect the same result.

Chrome-nickel steel rails having 2 per cent. of nickel and 0.7 per cent. of chromium have been tried by several railroads, but with unsatisfactory results. They resisted wear well as compared with simple steel rails, but broke badly both traversely and lengthwise, so that they were considered unsafe and consequently were removed. They were made by the Bessemer process and were not heat treated.

Mayari Steel.

A so-called natural chrome-nickel steel is now made from certain ores mined at Mayari, Cuba. The ores carry enough nickel to give 1.3 to 1.5 per cent. of nickel, and enough chromium to give 2½ to 3 per cent. of chromium in the crude iron smelted therefrom. When the iron is converted into steel by the pneumatic or open-hearth processes, the nickel is practically all present in the steel, but the chromium is of necessity largely wasted by being oxidized.

Steel made of Mayari iron is giving good service in rails and particularly in track bolts, which are heat treated to give the metal an elastic limit of 75,000 pounds per square inch.

Why these rails are satisfactory when other chrome-nickel steels were not has not been explained. The chief differences seem to be (1) that these Mayari steel rails have less of the alloying elements because Mayari iron is used only in part in them, and (2) that the steel is made in the open-hearth furnace.

The use of steel containing Mayari iron is increasing, and the demand is enough to induce the production synthetically of steels of the same composition by adding nickel and chromium to simple steels in the Mayari proportions.

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The Kootenay Ore Co.'s sampling works at Kaslo, Kootenay Lake, B.C., is being transformed into a silver-lead-zinc ore concentrator by Mr. M. S. Davys and associates, and it is expected will be in operation before the end of August. In one part of the mill crude ore will be concentrated and its silver, lead and zinc contents separated, and in another concentrates will be roasted to eliminate objectionable constituents and be otherwise made marketable. The mill will be a custom plant, but its chief source of ore supply is for the time likely to be the Lucky Jim mine.

McRAE.

The McRae Mining Co., whose property is in Deloro, is going ahead with the installation of a compressor plant. The machinery is expected to arrive within the next ten days. The new plant will be of three-drill capacity. The shaft is down a depth of 25 ft., and in addition to this there have been several test pits sunk. Work has been under way on this property all through the winter.

The main shaft is about 150 ft. away from the main vein. This will be put down several hundred feet and levels established every 100 ft., and crosscutting gone on with. The Porphyry dike is from 40 ft. to 60 ft. wide. The property is located about four miles from South Porcupine. Mr. Ed. P. Montague is manager.—Cobalt Nugget.

DOME LAKE.

Cobalt, Aug. 5.—Mr. G. G. Thomas, manager of the Dome Lake mine, at South Porcupine, arrived back from Toronto on Thursday afternoon, where he had been purchasing machinery for the new addition to the mill to be constructed. The machinery, Mr. Thomas expects, will arrive within about two weeks. The work of erecting piers and foundations for the new mill building will be commenced immediately ,and a start will be made right away in framing the timbers, etc., for the building. The cyanidation system will be employed. The present hoist is considerably larger than is necessary for the present needs, so that when the increased mill capacity calls for a greater tonnage no change will be required. The mill, when the addition is completed, will have a capacity of 200 tons a day.—Cobalt Nugget.

A press despatch from San Francisco, California, dated July 31, states that the United States Government suit for the recovery of $400,000 from the Western Fuel Co., operating large coal mines near Nanaimo, Vancouver Island, British Columbia, which amount is said to have been withheld illegally in connection with the importation into California of coal from British Columbia, has been postponed indefinitely by Judge Wm. C. Van Fleet in the United States District Court at San Francisco. When asked following the court session why there had been an indefinite postponement, Mr. Edward F. Jared, assistant United States attorney, said, "I understand there will be a settlement."

The following news of the operation of the Granby Consolidated Co. in the Pacific Coast district was published in Vancouver, B.C., at the end of July: The agglomerator which has been in operation at the Granby Consolidated Co.'s smelting works at Anyox, Observatory inlet, for some time has been giving a good account of itself, by adding to the copper output at Anyox. This euipment has demonstrated its ability to extract 4 lb. of copper from each ton of fluedust at a minimum of cost. The company's mine employees now number about 400, and its smeltery hands about 200. Ore shipments from the company's mine near Valdez, Alaska, will be commenced as soon as transportation shall be available; steamers are scarce just now.

At a meeting of the Kennecott Copper Corporation, held in New York City early in July, it was announced that cash on hand, after having paid a dividend of $4,500,000 on June 30, was $18,073,000.

BOSTON CREEK GOLD AREA

By A. G. Burrows and P. E. Hopkins.

That part of Boston, Pacaud, McElroy and Catharine townships in the vicinity of Boston creek is spoken of here as the Boston Creek gold area. The region is situated in the district of Timiskaming, about 45 miles northwesterly from Cobalt, and is traversed by the T. and N. O. Railway. Boston Creek station, mileage 153.5, is approximately in latitude 48 deg. north and longitude 80 deg. west. By rail, Boston Creek station is 382 miles north of Toronto.

Claims were staked for gold in this area in 1906 and 1907 during the days of the Larder Lake gold rush. Again in 1913, during the activity at Kirkland lake twelve miles to the northwest, many claims were restaked and some work was done on them. Since May, 1915, John Papassimakes has had a number of men at work on what is known as the Kenzie vein, on claims L 3665 and L 5163, in the south central part of Boston township. The promising development work on the Kenzie vein attracted many prospectors to the area, and several other gold discoveries were made in the four townships. Considerable prospecting, particularly on the surface, was done during 1915, but as yet no bullion has been shipped. A railway station has

Boston Creek Station

been erected near the crossing of Boston creek, around which has grown a small settlement.

General Geology.

The rocks of the Boston Creek area are all pre-Cambrian in age, the nearest younger formation being an exposure of Niagara limestone about ten miles to the south in lot 10, concession 4, Evanturel township.

The Keewatin rocks have the widest distribution, and are important since they contain gold-bearing veins. They consist chiefly of greenstones with some volcanic fragmental rocks and iron formation. A band of clastic sediments is mapped as grey schist. The original constituents are so entirely altered that many exposures may be spoken of as serpentine, hornblende and chlorite rocks. Cutting the greenstones is a felsitic rock which may be post-Keewatin in age.

Timiskamian.

A few small, isolated patches of conglomerate schist, slate and greywacke, standing in a vertical attiude, occur along the Larder Lake road in Boston and McElroy townships. The rocks are similar to the sediments classed as Timiskamian on the map of the Kirkland Lake and Swastika gold areas. The pebbles of the conglomerate, which are elliptical in outline, consist largely of green stone and felsite and some iron formation. A grey magnesian limestone occurs both as pebbles and matrix in the conglomerate in McElroy township about a mile east of the three-mile post on the west boundary.

The Algoman rocks include batholiths and stocks of granite and syenite, and dikes of feldspar porphyry, quartz porphyry and lamprophyre. They are massive, fresh-looking and are probably Algoman in age, since similar granite in Boston and Lebel townships to the north was found cutting the Timiskamian series.

Quartz diabase dikes are rare in this area; however, they were noted cutting the greenstones and Timiskamian (?) sediments. To the northwest, in Teck township, the diabase was seen to cut the red feldspar porphyry. These dikes are classed as Keweenawan, since they are fresh looking and resemble the diabase at Cobalt.

The region has been heavily glaciated, the ice having moved in a general S. 20 deg. E. direction, astronomic.

The area lies at the northern edge of a tract of farming land, which extends from Haileybury to Round lake, and is covered in places with stratified clays, sand and gravels. At Boston Creek station one can see the vertical section of a morainic deposit which has been cut into by Boston creek. The central part of McElroy township to the east of the Blanche river is one vast area of sand, representing probably large terminal moraines and outwash plains.

Gold Deposits.

Gold, the chief mineral sought for in the area at the present time, occurs usually native, but occasionally combined with tellurium in quartz veins and veinlets in the Keewatin greenstone and later intrusions of granite and porphyry. The veins, which have a varying strike and dip, are well mineralized with varying quantities of pyrite and molybdenite, and sometimes with chalcopyrite, galena, specular hematite, bismuthinite, gold and a telluride. The gangue consists largely of quartz of several generations, with considerable calcite and chlorite. The gold is found along the dark streaks of chlorite and calcite.

There are various types of gold deposits, viz.:

(a) Fissure quartz veins in the greenstone and porphyry, with well defined walls. Examples, Miller-Independence, McRae and Authier.

(b) Replacement veins. The country rock, including altered greenstone and porphyry, has been brecciated and partly replaced by vein-forming solutions of quartz of several generations, and by calcite and other carbonates. Example, the Kenzie vein on the R. A. P. property.

(c) A stockwork in granite and porphyry. Examples, Charest claim (McElroy township), Authier (L 4737) and Papassimakes (L 5133).

The chief deposits will be described later in the report when dealing with the gold claims.

Pyrite.

Pyrite occurs in two narrow bands, and disseminated through the grey schist at mileage 153 on the railway in Pacaud township. About 100 ft. east of the 153-mile post, two shallow pits were sunk several years ago, and at present one can see a little pyrite on the dumps, but the deposit "in place" is covered with debris. In the deep railway cut there are two bands of pyrite 10 and 20 inches wide respectively, which will carry about 35 per cent. of sulphur; samples from each band were found to contain no gold values. The de-

posits did not appear to be large enough to work, although wider orebodies might be revealed by further trenching. Iron pyrites is used in the manufacture of sulphuric acid.

Copper.

Several calcite veins with some quartz, and carrying copper pyrites, occur in the vicinity of the Blanche river in the south part of McElroy township. The Jean Petit copper property, W.R. 97, in this vicinity, has been referred to by W. G. Miller and W. A. Parks. Considerable work has been done on the calcite veins, but as far as known no copper has been shipped. It is reported that gold and silver values occur with the copper.

The Dane Mining Co. has done considerable prospecting and shipped some copper ore from Teck and Lebel, adjacent townships to the north and northwest.

Iron.

The isolated exposures of iron formation along the Larder Lake road in Boston township represent the southern portion of the Boston township iron range. The formation consists of interbanded silica and magnetite, with some black slate. Numerous shallow test pits were sunk in 1902, but the iron proved to be too low grade to be workable at that time. The iron formation is, in places, intruded by quartz veins, some of which carry gold.

R. A. P. Mining Company.

The R. A. P. Prospecting, Developing and Mining Syndicate owns a number of mining claims in the area, the principle ones being L 3665 and L 5163 in the south central part of Boston township. Some work was done on these claims in 1914 by the La Rose Mining Co. Since May, 1915, Mr. John Papassimakes has had a number of men engaged in opening what is known as the "Kenzie" vein, which occurs in a massive pillow lava. The vein, which has been stripped for about 400 ft., strikes 30 degrees north of east, astronomic, and dips from 60 to 70 degrees to the south. It varies from several inches up to five feet in width, with good breaking walls on either side. Spectacular gold showings were obtained from a 28 ft. shaft on the western end of the vein and finely disseminated gold can be seen in many samples on the dump.

When the property was visited in May, 1916, the easterly inclined shaft had reached a depth of 135 ft., and 230 ft. of drifting on the vein had been done on the 100 ft. level. Development has shown the ore to occur in shoots in the vein. The vein material consists of quartz of several generations, silicified rock, reddish calcite and brecciated and partly replaced masses of reddish feldspar porphyry. The occurrence of feldspar porphyry in various parts of the workings suggests that originally the greenstone was intruded by a narrow feldspar porphyry dike, that at a later period was greatly brecciated, and impregnated with vein-forming solutions which carried the gold and other minerals. The gold occurs with a very fine-grained greenish quartz, which has the character of a replacement deposit, while the green color is due to minute inclusions of chlorite. Iron pyrites is finely disseminated in the vein, and copper pyrites, molybdenite and galena occur in minor quantity.

Thin sections of the ore show the gold to be closely associated with the sulphides in chlorite and calcite seams near the footwall part of the vein, where there is a narrow band of fine grained greenish quartz. Certain sections of the vein run as high as $25 or $30 in gold to the ton across five feet.

The property is equipped with a small plant, including a 60 h.p. boiler, 2 drill compressor and hoist.

On the east side of claim L 2631, which lies immediately northeast of that on which the main shaft is sunk, there is an irregular band of mineralized schist with quartz, about 1 ft. wide, which contains visible gold. The showing occurs where the greenstone is intruded by a dike of feldspar porphyry, and near the contact.

About one mile to the northeast, on claim L 5165, there is a red medium grained mica granite intruding the Keewatin. Cutting the granite are several narrow white quartz veins, some of which carry molybdenite and a few specks of native gold.

Currie.

The Currie unsurveyed claim, L 5037, is situated about one-half mile northeast of the R. A. P. property in Boston township. In the west and northwest parts of the claim are rusty schist bands heavily mineralized with iron pyrites, and cut by quartz stringers. No visible gold could be seen in place, but gold colors can be panned from the sulphides. A grab sample showing cubes of pyrite gave $2.40 in gold to the ton, while samples across two feet and three feet seven inches gave $1.60 and 60 cents respectively in gold to the ton. Some trenching has been done.

Miller-Independence.

This property is situated on the south half of lot 1 in the sixth concession of Pacaud. Gold was discovered on the lot by a prospector, Mr. Joseph McDonough, in July, 1915. The vein has been traced on the property for about 600 ft. in an east and west direction, and for several hundred feet easterly into Catharine township. It is narrow, averaging about a foot in width, and has a low dip to the north, usually about 20 deg. or less, at one place being almost horizontal. The vein material is milky white quartz, and the mineralization is more or less concentrated toward the foot wall side of the vein. Telluride, copper pyrites, pyrite specular iron ore and galena are observed in the quartz. Native gold occurs frequently with the telluride and other minerals in a net-like arrangement in the quartz along the foot wall. There are probably several tellurides, but so far only one, a bismuth telluride, containing some selenium, has been recognized. This telluride of a brilliant grey color appears to occur abundantly with the gold.

The country rock is mainly fine-grained pillow lava, associated with which is a coarsely grained basic rock of a hornblendic type. Along the vein there is a dike of grey feldspar porphyry which at two places is two feet wide on the hanging wall side of the vein. The porphyry was also observed on the foot wall side. It contains much calcite and other carbonates, as well as disseminated iron pyrites, and is cut by veinlets of quartz.

The vein has been prospected by means of a number of trenches and pits, from which some high-grade ore has been bagged. A shaft was being sunk to the north of the vein. The property is equipped with a small plant, including boiler, compressor, hoist and a Nissen stamp mill; and a small oil flotation plant was being constructed.

McRae.

The McRae claim is the northeast quarter of the north half of lot 2, concession six, Pacaud township. The vein has a general magnetic north and south strike, with a dip of about 45 deg. to the east. Fine gold can be seen in a number of places, particularly on

the hanging wall part of the milky white quartz vein, which is about one foot in width.

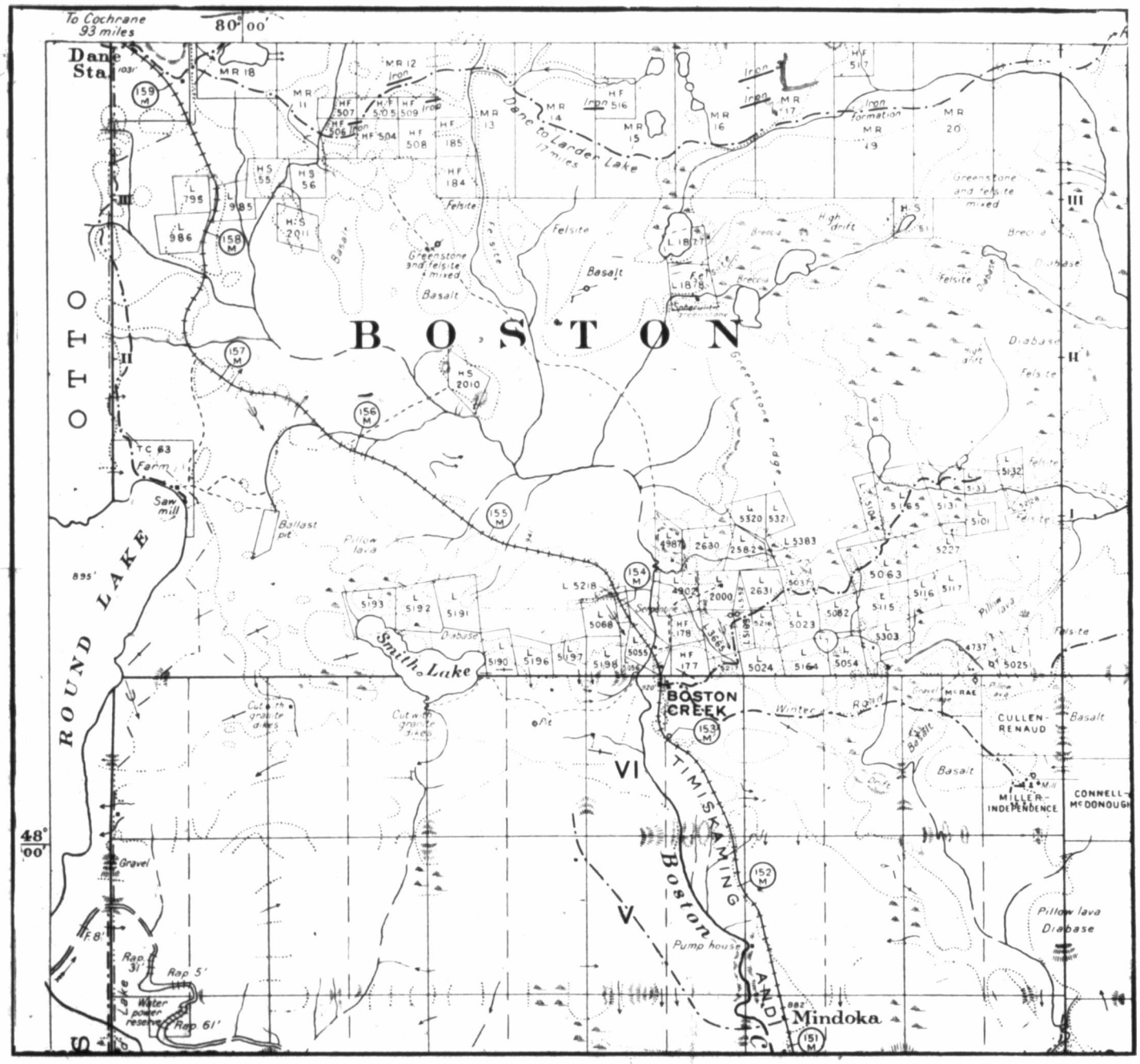
The country rock is pillow lava and massive greenstone showing a diabasic texture, while the wall rock is considerably altered in places next the vein. A shaft is being sunk on the vein to the 100 ft. level. Exposed in the shaft the vein has a somewhat banded structure, showing streaks of dark quartz, with considerable iron pyrite, some films of molybdenite, and dark grey calcite.

The property was being prospected by the Crown Reserve Mining Co. in May, 1916.

ported to occur in several veins which outcrop on the surface. The veins which outcrop on the McRae and Miller-Independence properties, if continued to depth on their indicated dips, would pass into this property at some depth.

Authier-Charlebois.

Mining claims L 4737 and L 5025 are situated in the southeast part of Boston township, just to the north of the McRae property. The quartz veins in the greenstone are similar to the McRae vein, being narrow and dipping about 45 deg. N. Native gold has been dis-



Part of Boston Creek Gold Area

Connell-McDonough.

This property is the south half of lot 12, concession six, Catharine township. The vein on the Miller-Independence which is being prospected can be traced easterly to the Connell-McDonough claim, where there has been considerable trenching along the strike of the vein. Native gold can be observed at several places along the foot wall of the vein.

Cullen-Renaud.

This group of claims is situated in the northesast corner of Pacaud township. Native gold has been recovered in some of them, along with pyrite and a grey mineral bismuthinite.

Toward the north part of the property is a small area of fine grained mica granite which intrudes the greenstone. At one place near the contact there is a quartz vein one foot wide in the granite, on which a shallow pit has been sunk. Molybdenite, pyrite and bismuthinite are disseminated in parts of the quartz vein, and visible gold was reported to have been seen. A sample across eleven inches, taken a few feet from the pit, gave $4.80 in gold. Northwest of this discov-

ery, beyond a ravine, the granite is intersected by numerous quartz veinlets, some of which are several inches wide. In some of the narrow joint-like cracks native gold was observed, along with a grey mineral which gave reactions for tellurium and bismuth and is probably tetradymite. There is also considerable iron pyrites in the granite along some of the veinlets.

Charest.

The Charest unsurveyed claim, L 5305, is situated in the southwest quarter of McElroy township. As shown on the map, the claim is on a small stock of massive, coarse grained, flesh colored hornblende and biotite granite. A quartz vein averaging about one inch in width, and 300 feet long, strikes 30 degrees north of west across the granite. Considerable fine gold, pyrite, chalcopyrite and a grey mineral which proved to be a telluride, were noticed in different parts of the vein. A few pieces of quartz from the vein gave on assay $8.80 in gold to the ton. Other veins on the property contain molybdenite and specular hematite. Some of the veins contain coarse feldspar and are pegmatitic in character, while many of the narrow veins represent the filling of joint cracks. The occurrence of gold in the pegmatitic vein is important, since it strongly points to the formation of the gold-bearing quartz veins following the pegmatitic veins and representing part of the granite intrusion.

Conclusion and Acknowledgments.

The geology and mineralogy of the Boston Creek area is, in a general way, similar to that of the adjoining Swastika, Kirkland Lake and Larder Lake areas. Gold is known to be widely distributed over all the areas. No bullion has, as yet, been shipped from Boston creek. The Tough-Oakes, Swastika, Lucky Cross, La Mine d'Or Huronia and Goldfields Limited properties, which are from 12 to 15 miles from Boston Creek station, have from 1912 to the end of 1915, yielded gold valued at $779,715. Most of this production was from the Tough-Oakes mine. In Boston creek the prospecting, as yet, has been largely confined to the surface, the deepest shaft being 135 ft. (May, 1916). Prospecting is aided by the excellent transportation facilities. In prospecting the area it seems a good rule to trench in the old rocks near the porphyry dikes and small granite areas.

The third annual State-wide first-aid and mine-rescue competitions and demonstrations for the State of Washington will be held in Tacoma, Washington, on August 19. Last year's demonstration, held at Cle Elum, were largely attended, and teams from all the larger collieries in the state took part in the competitions, which were closely contested and aroused general interest among the coal miners and their friends.

The quarterly statement of coal and metal mine fatalities in British Columbia, issued by the Chief Inspector of Mines for that Province, shows that during three months ended June 30 there were four men killed in and about the coal mines and a similar number in and about the metal mines. The totals for the first half of each year were as follows: At coal mines, 9 in 1916 and 45 in 1915 (of the latter number 19 met their deaths by the flooding of a mine and 22 as the result of a gas explosion). At metal mines, 8 in 1916 and 8 in 1915. Falls of roof and rock and coal caused the deaths of 7 at coal mines in the first half of 1916, and falls of ground those of 4 at metal mines; together 11 out of a total of 17 were killed by those wholly preventible causes.

PERSONAL AND GENERAL

Dr. W. G. Miller and Mr. T. F. Sutherland of the Ontario Bureau of Mines visited during June the Mt. Lyell, Mt. Bischoff, Zeehan and Broken Hill mines in Australia. On July 6 they sailed from Sydney for New Caledonia. They arrived at Noumea on July 11.

Mr. H. E. T. Haultain has been at Jewel, Ont., in the Craigmont corundum district, in connection with the erection of a new corundum mill.

J. C. Gwillim, professor of mining, at Queen's University, Kingston, is at Valcartier, having joined the tunneling company.

Dr. D. B. Dowling, of the Department of Mines, Ottawa, was in Toronto on August 1 on his way to Lethbridge, Alberta. He will endeavor to find an artesian water supply in southeastern Alberta. Three wells will be drilled in an area examined by Dr. Dowling last year.

Mr. Seaver, formerly manager of the Canadian branch of the Sullivan Machinery Co., is now manager of the Canadian Rock Drill Co., with office at 42 Scott street, Toronto.

Mr. Fred A. Jordan, formerly manager of the Moose Mountain mine at Sellwood, Ont., is now located at Duluth.

Mr. W. E. Segsworth and Mr. R. E. Hore of Toronto attended the Reunion of of the Michigan College of Mines graduates and staff last week.

Mr. C. E. Hitchcock, of Copper Cliff, has returned from the Rice Lake district, Manitoba, and attended the M. C. M. Reunion at Houghton last week.

Mr. J. S. De Lury has returned to Winnipeg from The Pas district.

Mr. C. W. Knight is at Sudbury.

Mr. Charles F. O. Merriam, of Wallace, Idaho, was at Nelson, B.C., last month examining and reporting on the Granite-Poorman group of gold mines.

Mr. Clarence Cunningham, who is operating the Wonderful, Queen Bess and Slocan Sovereign silver-lead mines in the Slocan district of British Columbia, was a recent visitor to Spokane, Washington.

Mr. Blanchard M. Synder, late of Los Angeles, California, who some years ago was superintendent at the British Columbia Copper Co.'s copper smeltery at Greenwood, Boundary district, B.C., is now at Basin, Montana, with the Cornet mines.

Mr. John B. White, of Spokane, Washington, one of the directors of the Slocan Star Mines, Ltd., was at the company's mines near Sandon, Slocan, late in July.

Mr. A. W. McCune, of Salt Lake City, Utah, who owns several mining properties situated in Ainsworth and Slocan mining divisions of British Columbia, has been on a visit to both Ainsworth and Slocan camps.

Mr. R. A. Carnachan, secretary of the Hayden, Stone Co., which recently bonded the Hudson Bay mine, near Salmo, B.C., was at the Granite-Poorman mines, near Nelson, last month.

Mr. F. J. Longworth, superintendent of the British Columbia Copper Co.'s smelting works at Greenwood, B.C., was in Spokane, Washington, on July 19.

General Charles S. Warren, of Butte, Montana, a pioneer mining operator at Rossland, B.C., the Coeur d'Alene district of Idaho, and in Montana, was in Spokane visiting old friends last month.

Mr. Jerome Drumheller, left Spokane on July 10 for New Hazelton, in Omineca mining division, B.C., where are situated several mining properties on which he holds options to purchase.

Mr. J. B. Tyrrell, of Toronto, has been spending some time in British Columbia.

SPECIAL CORRESPONDENCE

BRITISH COLUMBIA

The temporary check to shipment of ore from Kootenay mines that a few weeks ago interfered with progress, has now been overcome and, generally, transportation facilities having been restored, production has been resumed. The uncertainty that was felt in regard to the outcome of demands for higher wages made on behalf of men employed at the smelting works at Trail and the Consolidated Co.'s mines at Rossland, has also passed away, the negotiations having resulted in an amicable settlement of the question, the company having to some extent met the requirements of its employees. There has also been a little difficulty concerning wages in the Crowsnest coal mining district, but there was only a short cessation of work there, for arrangement has been made for representatives of both operators and the United Mine Workers of America to meet and discuss the questions at issue with a view to arrivng at some decision that will be mutually acceptable. The decrease in prices of some of the metals is having some influence in the direction of lessening activity among those who have been seeking to acquire lead or zinc properties that have been unworked of late years, but on the whole there is no serious interruption to the progress of development work and ore production in the interior mining districts.

EAST KOOTENAY.

During twelve weeks of last quarter, up to the time, late in June, flooded streams caused damage to railways and mine surface equipment, the output of the Sullivan mine averaged 1,666 tons of ore a week, that quantity having been received at the smelting works at Trail. For three weeks following high water in rivers and creeks only 287 tons a week reached Trail from the mine. Now, however, conditions seem to again be normal, for the quantity received during the third week in July was 1,479 tons.

Another carload shipment from the Giant mine, in the northern part of the district, has reached Trail. Preparations were being made early in July to resume work on the Paradise mine, in Windermere division, after a long period of inactivity.

WEST KOOTENAY.

Ainsworth.—During the week ended July 21 ore was received at Trail from six mines in this division. This was the first time this year that there had been that many on the weekly list of shippers. All were small producers, for the total from the six was only 324 tons, still it is satisfactory to find the smaller shippers again on the list. Those that had not sent out ore for several months were the Cork-Province, Retallack & Co. and Utica. The other three were the Comfort, Florence Co. and Highland. The Utica is stated to have more ore opened now for shipping than for some time past. The work of erecting a concentrating mill for the Florence Co.'s Hope mine is being put in hand.

Slocan.—June shipments of the Rambler-Cariboo Mines, Ltd., are reported to have been 30 tons of crude lead ore, 160 tons of lead concentrate and 60 tons of zinc concentrate. The gross profit from the lead product is stated to have been approximately $17,000, and the net earnings about $11,000. Most of the zinc outfit for May and June was still on hand in July, difficulty having been experieneed in marketing it, owing to low grade and excess iron content. Arrangements are being made to re-treat zinc concentrate at the custom mill at Kaslo, and it is expected that they will thereby be rendered more marketable.

Northwest Mining Truth said recently, in reply to an inquiry concerning the Galena Farm Mining Co.: The property of this company is situated near Silverton. It is controlled by the estate of Patrick Clark, under the management of his oldest son, P. W. Clark. About one-fourth interest is held by New York friends of the late Mr. Clark. A concentrating mill of 100 tons daily capacity was completed a few months ago, and it is running successfully. Twenty years ago the property was acquired by Charles Callahan, a well-known English engineer who came from Australia, but when the price of silver declined so precipitately in 1893 work was discontinued. Until the late Mr. Clark reopened it nothing hal been done on the property for many years. Some high grade zinc orebodies of magnitude, containing good values in silver, have been exposed and there is said to be enough ore in sight to keep the plant running at capacity for several years.

The Lucky Thought mine, on Four-mile creek, near Silverton, which is under option of purchase to the Consolidated Mining and Smelting Co., is looking sufficiently well for it to be thought probable that company will eventually complete purchase. Owing to the wagon road to Silverton having been damaged by floods in June, it was not practicable to ship ore in July, but repairs having been effected hauling will be done in July, with something like 200 tons awaiting shipment. Ore recipts at the smelting works at Trail from this mine during the first half of the year totaled 260 tons.

The Ottawa, in Slocan City division, owned by the Consolidated M. and S. Co., recently sent to Trail 43 tons of silver ore, this being the first lot shipped this year. Some years ago this mine was one of the important producers of Slocan City division. The Black Prince, in the same division, recently shipped to Trail a car of high grade silver ore, which was its first shipment since last January.

Nelson.—The Granite-Poorman group of gold mines, situated within half a dozen miles of Nelson, has been bonded by Messrs. W. E. Cullen and R. A. Carnochan, of Spokane, Washington; John Maginnis and H. I. Wilson, of Butte, and T. B. Miller, of Helena, Montana. These mines have been intermittent producers over a comparatively long period, probably for twenty years. Some years ago they were operated by the Duncan United Mines Co.; then they were for some time worked by Thos. Gough and associates, who eventually sold them to a company organized locally as the Kootenay Gold Mines, but which finally got into financial difficulties, and the property has since been looked after by a receiver, until it was leased to several local men, who are understood to have operated profitably for the last year or more. Now these lessees have passed their option of purchase on to the syndicate first-above mentioned. The group embraces 13 mineral claims, having a total area of about 350 acres, a mill site of 15 acres and a 20 stamp mill. The Nelson Daily News recently published the information that the average value of all ore (unsorted) milled during the period 1899-1912 was $6.12 a ton. Latterly the ore has

been sorted before being milled, and the grade raised to an average of between $12 and $13 a ton. The last mill run, of 100 tons, gave an average of $12.10 a ton.

Mr. J. L. Bruce, of Butte, Montana, general manager of the Butte & Superior and Hudson Bay Zinc Companies, when in Spokane on July 12, on his way home from the Hudson Bay mine, near Salmo, B.C., said: "While we have been shipping zinc ore from the Hudson Bay mine at the rate of about 45 tons daily, and may increase our output somewhat now that the roads are in good condition, we are concentrating our energies principally on getting the crosscut tunnel to the ledge. It has already been driven 900 ft., with approximately 800 ft. yet to go to reach the vein, which it will cut at a depth of 850 ft. below the outcrop, or more than 500 ft. below our present level. We shall try working three shifts of men, and if it does not prove too expensive we shall keep them on until the vein shall be reached, for we are anxious to complete the driving of this tunnel within three months." The Hudson Bay mine, which latterly has shipped little if any other than an oxidized zinc ore, is situated on Deer Creek, a tributary of Sheep creek, in the southern part of Nelson mining division. In 1914 there was shipped to Trail from this mine 2,094 tons of lead ore and in 1915 429 tons. This year only 116 tons of ore reached Trail from this mine. Its zinc-ore output last year was estimated at approximately 4,000 tons, stated to have averaged about 30 per cent. zinc, shipped to the United States. Much zinc ore has also been shipped this year.

Rossland.—The Premier of British Columbia (Hon. W. J. Bowser) and others of his party who have been making a tour of the Okanagan, Boundary and West Kootenay districts, on July 23 visited the Consolidated Mining and Smelting Co.'s Centre Star, War Eagle and Le Roi mines, in Rossland camp. They were lowered in a cage down the Centre Star incline shaft to a depth of 2,300 ft. The Nelson Daily News correspondent, in his account of the visit, stated that "750 men are employed in these three mines. Members of the visiting party declared that the mines with their modern equipment of electric train and lighting and the miles of tunnels made one of the most impressive evidences of the natural resources of the country they had seen throughout their tour."

The Josie mine report for the month of May has been made public by the London office of the Le Roi No. 2, Ltd., as follows: "Shipped to Trail, 1,515 tons of ore. The receipts from the smeltery were $22,201, being payment for 1,967 tons of ore shipped; umpires, etc., $1,443; sundries, $431; total receipts, $24,075. Estimated working costs for the corresponding period were: Ore production, $7,800; capital expenditure, $636; development (including diamond drilling), $3,600; total, $12,036." Adding figures published earlier, it is seen that the total receipts for five months of 1916 to the end of May have been $92,297, and expenditures $76,790, leaving a credit balance of $15,507.

GENERAL NOTES.

On July 5 the "Spokesman-Review," of Spokane, Washington, published the following: "The clean-up at the Union Hydraulic mine, near Vernon, B.C., was a great disappointment,' said Russell H. Hanauer on his return yesterday from a visit to that property.' Though we moved six times the volume of gravel that was handled last season, the yield of gold was only $4,500, or not quite twice what was gained last season. We lost about $4,000 on the season's operations."

Last month the Railway Commissioners heard arguments in favor of the contention of those interested in the Lardeau district of West Kooteney that the Canadian Pacific Railway Co. should be required to maintain a regular train service on its branch line from the head of Kootenay lake to Gerrard at the foot of Trout lake, and a steamer service on Trout lake between Gerrard and Trout Lake City, as it had done for many years until recently. One of the advocates in the interest of mining in Trout Lake mining division said that without assurance of a railway service it would be impossible to obtain capital for the development of the many mining properties in the Lardeau district. He mentioned the Triune, Great Northern, Silver Cup, Lucky Boy as mines that would ship ore if suitable transportation facilities were provided. The Triune, he stated, has from 1,200 to 1,500 tons of ore available for shipment, which ore could be marketed while the prices of metals were high, as at the present. He did not contend that there was sufficient business in sight to make the operation of the branch railway and steamer service profitable, but such service should be discontinued the Lardeau country could not be developed. Another speaker pointed out that if the railway service were not continued the operation of the Marblehead quarry, situated about ten miles along the line from Lardo, on Kootenay lake, would not be practicable. About $300,000 had been spent in the acquirement and development of this property, which would have an output of a car and a half of marble a day when conditions should again become such that orders would be received. There was now about 50,000 tons of marble on the bank ready for shipment. If operated at full capacity, the quarry would give employment to 100 men. The C.P.R. official representing the company at the hearing showed that no marble was shipped in 1914, and only six or eight cars in 1915, but the manager of the quarry replied that only development work had attention in the former year. The C. P. R. representative submitted figures for three years, as follows: Total cost of railway and train services, $100,387; total recipts, $47,407; loss to the company, $52,980. The Board reserved its decision.

Mr. Jules Labarthe, of San Francisco, California, engineer in charge of construction of the Bunker Hill & Sullivan Co.'s smeltery at Kellogg, Coeur d'Alene district of Idaho, when in Spokane, Washington, last month after a visit to the Consolidated M. & So. Co.'s smelting works at Trail, of which he was superintendent for several years prior to his removal to the United States three or four years ago, stated that he found the reduction works at Trail a great deal larger than when he was in charge, and still being enlarged. "They are making a success of their electrolytic zinc refining operations and are enlarging the capacity of the works by making a big addition. It is the first plant of the kind I have ever seen in operation, except an experimental plant of similar character at Anaconda, Montana," he said.

Metalliferous mining companies operating in British Columbia that have declared dividends payable in August are: Granby Consolidated M. S. and P. Co. $2 a share, total $299,970, August 1; Standard Silver-Lead Mining Co., 2½c. a share, total $50,000, August 10; Rambler-Cariboo Mines, 1c. a share, total $17,500, August 15.

La ROSE.

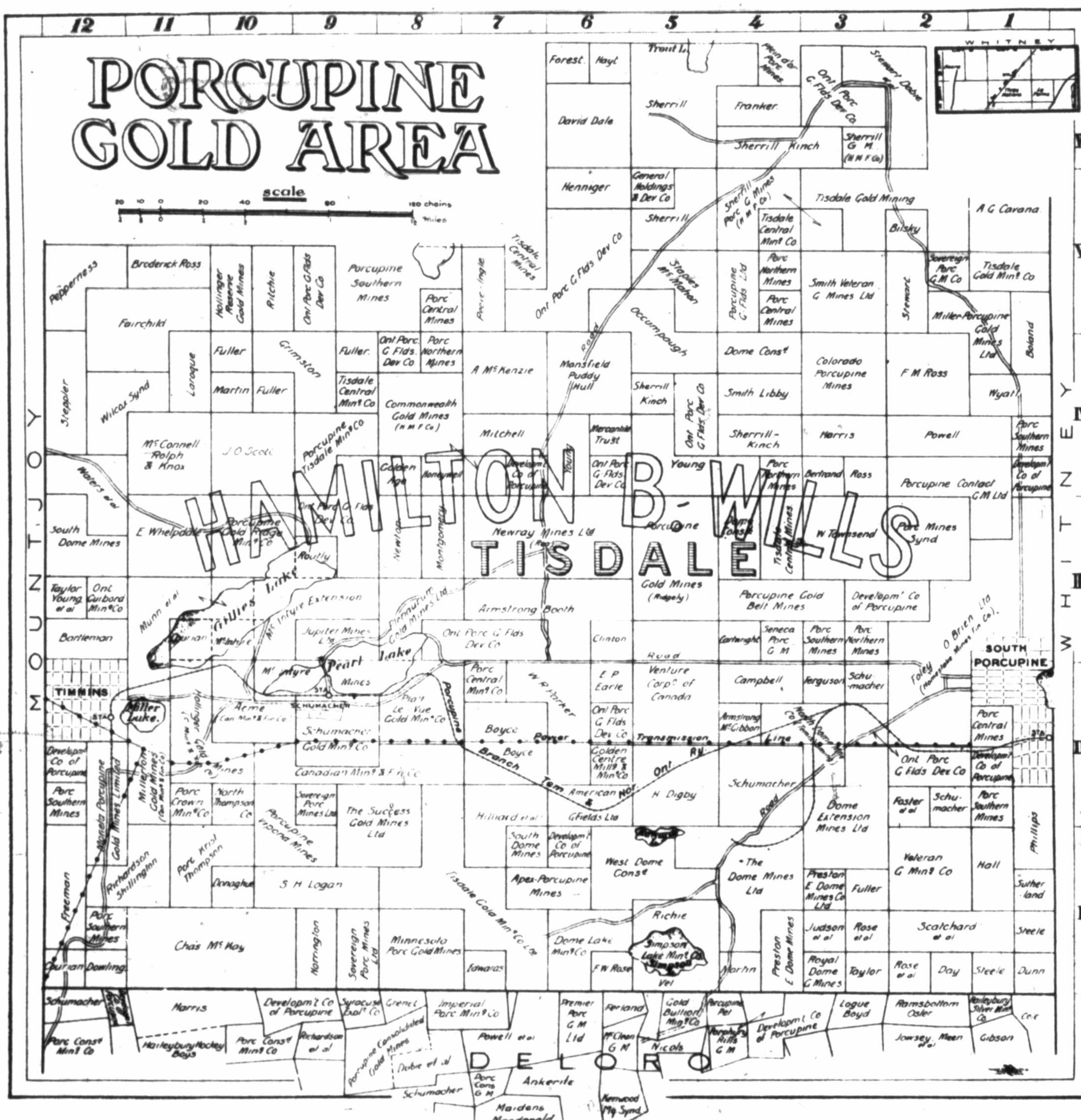
The shaft on the Maidens-McDonald property in the Porcupine district is now down approximately 100 feet, the work being done under La Rose management. The shaft will be continued to a depth of 110 ft. and a crosscut run to cut the vein at that level. One drill is now working on the Lawson property of the La Rose Consolidated, and in the original La Rose mine the most of the work is being done in the old stopes and workings.—Cobalt Nugget.

CROESUS.

The Croesus mines in Munro township will start as soon as possible on the erection of a new plant and buildings. It has not been decided yet whether or not a larger plant will be installed.—Northern Miner.

SILVER PRICES.

		New York, cents.	London, pence.
July	21	63⅜	30 3/16
"	22	63⅜	30 3/16
"	24	63¼	30⅛
"	27	63¾	30⅜
"	29	63½	30¼
"	31	64⅛	30 9/16
Aug.	1	64	30½
"	2	64	30½
"	3	64¾	30⅞
"	4	64⅞	30 15/16
"	7	65⅞	31 7/16
"	8	66¼	31⅝
"	9	66⅞	31 15/16
"	10	66¼	31⅝



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MARKETS

NEW YORK MARKETS.

August 10, 1916—Connellsville Coke—
Furnace, spot, $2.75 to $2.85.
Furnace, contract, $2.50.
Foundry, prompt, $3.25 to $3.50.
Foundry, contract, $3.25 to $3.50.
August 10 1916—Straits Tin, 38.30 cents.
Copper—
Prime Lake, nominal, 26.00 to 26.50 cents.
Electrolytic, nominal, 26.75 to 27.00 cents.
Casting, nominal, 24.00 to 24.25 cents.
Lead, Trust price, 6.00 cents.
Lead, outside, 5.97½ cents.
Spelter, prompt western shipments, 8.37½ to 8.47½ cents.
Antimony—
Chinese and Japanese, nominal, 10.50 cents.
American, nominal, 10.50 cents.
Aluminum—nominal—
No. 1 Virgin, 98-99 per cent., 58.00 to 60.00 cents.
Pure 98-00 per cent. remelt, 56.00 to 58.00 cents.
No. 12 alloy remelt, 45.00 to 47.00 cents.
Powdered aluminum, $1.00 to $1.15.
Metallic magnesium, 99 per cent. plus, $3.50 to $3.75.
Nickel, 45.00 to 50.00 cents.
Cadmium, nominal, $1.25 to $1.50.
Quicksilver, nominal, $75.00.
Platinum, nominal, $60.00.
Cobalt (metallic), $1.25.
Silver (official), 66¼ cents.
Metal Products.—Following base prices are all f.o.b. mill, but prices are purely nominal.
Sheet copper, hot rolled, 35.50 cents.
Sheet copper, cold rolled, 36.50 cents.
Copper wire, nominal, 31.00 cents.
Copper wire, nominal, October, 29.75.
High sheet brass, 38.00 to 39.00 cents.
Seamless brass tubing, 44.00 to 45.00 cents.
Seamless copper tubing, 44.50 to 45.50 cents.
Brazed brass tubing, 45.50 to 46.50 cents.
Brass wire, 38.00 to 39.00 cents.
Brass rods, 38.00 to 39.00 cents.
Sheet zinc, f.o.b. smelter, 15.00 cents.

TORONTO MARKETS.

Aug. 14—(Quotations from Canada Metal Co., Toronto)—
Spelter, 12 cents per lb.
Lead, 8 cents per lb.
Tin, 44 cents per lb.
Antimony, 16 cents per lb.
Copper, casting, 27 cents per lb.
Electrolytic, 28¼ cents per lb.
Ingot brass, yellow, 15 cents; red, 18 cents per lb.
Aug. 14—(Quotations from Elias Rogers Co., Toronto)—
Coal, anthracite, $8 per ton.
Coal, bituminous, $5.50 per ton.

STOCK QUOTATIONS.

(Courtesy of J. P. Bickell & Co., Toronto.)

As of close August 8th, 1916.

New York Curb.

	Bid.	Asked.
Atla. Cons.	20.00	28.00
Butte.	43.00	43.65
Can. Car	40.00	50.00
Curtiss Aeroplane	25.00	40.00
Can. Copper	1.38	1.50
Cambria Steel	81.00	85.00
Canada Cement	57.00	57.37½
Emma Copper	50.00	54.00
Howe Sound	4.50	4.75
International Petroleum	9.40	10.00
International Nickel (new)	44.25	44.75
Kennecott Copper	46.50	48.00
Maxim Munitions	4.50	4.75
Midvale Steel	61.00	61.25
Marconi.	3.38	3.50
Magma.	13.50	14.50
Mother Lode	30.00	31.00
Steel of Canada	52.00	55.00
Submarine Boat	32.75	33.50
Tonopah Extension	5.75	6.00

Porcupine Stocks.

	Bid.	Asked.
Apex.	.07⅛	.07¼
Dome Consolidated	.10	.15
Dome Extension	.34½	.35
Dome Lake	.42½	.43
Dome Mines	25.50	...
Eldorado.	...	.00⅜
Foley O'Brien	.50	...
Gold Reef	.01	.02
Hollinger.	28.25	29.00
Homestakes.	.60	.70
Jupiter.	.25½	.30
McIntyre.	1.38	1.39
Moneta.	.14½	.15½
Porcupine Crown	.63	.70
Porcupine Imperial	.03	.03⅛
Porcupine Tisdale	.01½	.02
Porcupine Vipond	.41	.41½
Preston East Dome.	.04½	.04¾
New Ray	.46	.48
Teck Hughes	.25½	.26
West Dome	.39½	.40

Cobalt Stocks.

	Bid.	Asked.
Adanac.	.22	...
Bailey.	.07½	.08
Beaver.	.37	.38
Buffalo.	.75	1.10
Chambers Ferland	.17	.20
Coniagas.	4.30	...
Crown Reserve	.40	.42
Foster.	...	.08
Gifford.	.04½	.05
Gould.	.00¾	.00½
Great Northern	.04	.05
Hargreaves.	.03¼	.03¾
Hudson Bay	55.00	...
Kerr Lake	4.35	4.62½
La Rose	.62	...
McKinley.	.59½	...
Nipissing.	6.85	7.10
Ophir.	.08	.08¾
Peterson Lake	.23¼	.23½
Right of Way	.04⅞	.05
Seneca Superior	.21	.25
Silver Leaf	.01⅞	.02
Temiskaming.	.58½	.59
Trethewey.	.21	.21½
York Ontario	.01½	.02
Wettlaufer.	.15	.16