

The Sudbury Mining District

by Frank G. Bedell

June, 1906

Submitted to the School of Engineering of the University of Kansas in partial fulfillment of the requirements for a course in Mining Engineering

Mining Thesis

Frank G. Bedell



THE
SUDBURY MINING DISTRICT.

A Dissertation Presented to the Faculty
of the
SCHOOL OF ENGINEERING
in the
UNIVERSITY OF KANSAS.

For the Completion of a Course in
MINING ENGINEERING.

by
Frank G. Bedell.

June 1906.

PREFACE.

In this paper will be given a brief history of the Sudbury Mining District and something of the geology and ore deposits of the same; also, a description of the mining and metallurgical methods used by the Canadian Copper Company in this district. Information on the various subjects treated was obtained partly from published literature by different authors, but principally from a personal visit during the summer of 1905 to the country and mines described.

BIBLIOGRAPHY.

- Report on the Nickel and Copper Deposits of
the Sudbury Mining District. A. E. Barlow.
Canadian Geological Survey.
- The Sudbury Nickel Deposits. A. P. Coleman.
Twelfth Annual Report of the Bureau of Mines of
Ontario.
- The Sudbury Nickel Region. F. Renshaw Bush.
Engineering and Mining Journal. Vol. 57, pp. 245-246
- Geological and Petrographical Studies of the
Sudbury Nickel District, Canada. T. L. Walker.
Quarterly Journal of the Geological Society (London)
Vol. LIII, pp 40 - 66. (1897)
- The Ore Deposits of Sudbury, Ontario. C. W. Dickson.
Transactions American Institute of Mining Engineers,
Vol. XXXIV, pp 3 - 65.
- Geological Relations and Distribution of Platinum
and Associated Metals. J. F. Kemp.
U. S. Geological Survey, Bulletin No. 193.
- The Ore Deposits of the United States and
Canada. pp 434 - 438. J. F. Kemp.

TABLE OF CONTENTS.

Historical.

Early History.

The Canadian Copper Company.

The International Nickel Company.

The Mond Nickel Company.

Conclusions.

Topography.

Geology.

Minerals of the District.

Mode of Occurrence of the Ore Bodies.

Origin of the Ore Deposits.

The Magnetic Properties of Pyrrhotite and their Uses.

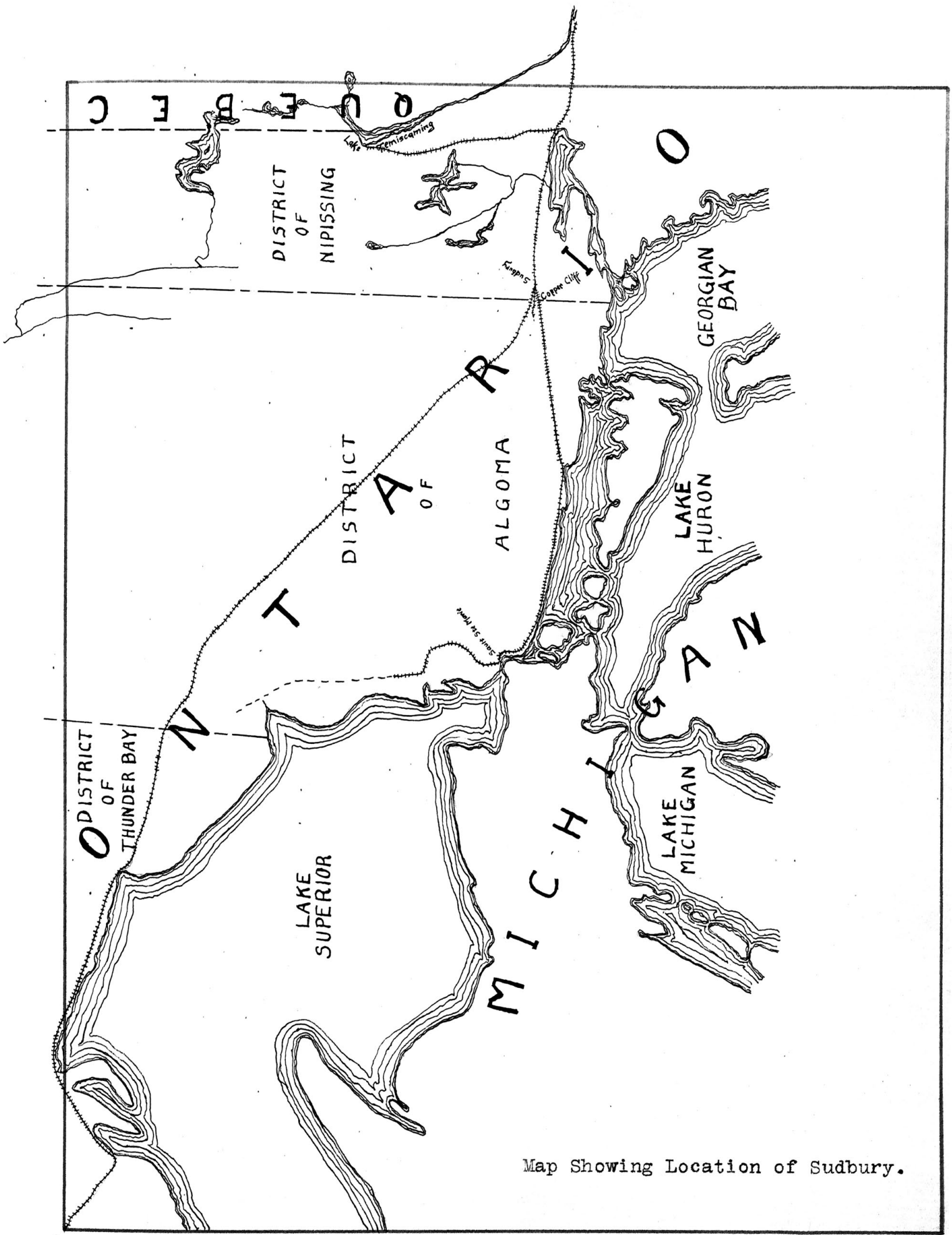
Mining Methods.

Roasting.

The New Smelter.

Table of Furnace Charges.

Analyses of Ore, Matte, Slag, etc.



Map Showing Location of Sudbury.

HISTORICAL.

The presence of large deposits of nickel and copper in the vicinity of Sudbury and close to the boundary between the districts of Algoma and Nipissing in northern Ontario, has, for many years, attracted world wide attention, in the first place on account of their immense and apparently inexhaustible character, but also because of the much more extended use of nickel, especially as an alloy with steel to improve the qualities of the latter.

Though nickel and copper were discovered in the Sudbury district in 1856 by Murry at what is now the Creighton mine, undoubtedly the most productive existing nickel mine, no importance was attached to this occurrence so long as the region was accessible only by canoes. The history of mining in the history dates from the construction of the Canadian Pacific Railroad in 1882, when the ore deposits, later called the Murry mine, was disclosed. In 1883 the ore bodies of what are now the Stobie and Copper Cliff mines were found. At first they were taken up for their copper contents, and it was only three or four years later, after a thousand tons of the Copper Cliff ore had been sent away for treatment, that its value as a nickel ore was established.

The history of mining in this region is largely that of the Canadian Copper Company, which was organized on January 5, 1886, with a subscribed and paid up capital of \$2,000,000.00, which was afterward increased to \$2,500,000.00 to operate the Copper Cliff, Stobie and Evans mines. During the first sixteen years this company drew almost all its ore from these three

important mines, the Copper Cliff, the Evans and the Stobie. In 1898 two new mines became producers, No. 1 southwest of Copper Cliff and No. 2 north of Copper Cliff, the former providing rich ore for a year, the latter producing average ore, but much larger in quantity, is still being worked.

In 1899 and the two following years mines No. 4 and 5, northwest of No. 2, provided some ore and in 1900 No. 3, often known as the Froot mine, began to supply considerable quantities of ore containing some intermixed rock. But with the exception of the deposit at No. 2 there was apparently no very large or continuous ore body encountered, for they were soon abandoned and are now completely dismantled. In August, 1901 the first ore was shipped from the Creighton mine to the roast yards at Copper Cliff. This is the greatest producing nickel mine in the world and from the very beginning of operations has produced large quantities of almost pure sulfids with little or no rocky admixtures. It is especially valuable as carrying a high percentage of nickel with a much smaller proportion of copper. The Creighton mine is at present the main source of supply for the Canadian Copper Company. According to Dr. Barlow this mine with its equipment allows for a production of 500 to 600 tons of ore per day, but during the summer of 1905 at the time of the writer's visit, Captain Tom Travers, who has charge of the mine, stated that the mine was then producing about 800 tons per day. It was being worked as an open pit and was down about 140 feet. The only other mine being worked is the No. 2 which is down about 400 feet and is working the fourth and fifth levels,

although very little work is being done at present on the fifth level.

The first blast furnace installed at the old or East smelter at Copper Cliff was blown in on December 24, 1888, this being augmented under the same roof by a second blast furnace, which was started on September 4, 1889. The activity in mining at Copper Cliff and the steady increase in the production of ore necessitated constant additions to the smelting equipment. We thus find that besides the enlargement of the east smelter where three new furnaces were installed in addition to the two already mentioned, an entirely new structure known as the west smelter was built in 1899. At first this building had room for only four furnaces, but this was quickly enlarged and the furnace capacity doubled. In the fall of 1900 the plant of the Ontario Smelting Works was installed by the Orford Copper Company, an organization closely related to the Canadian Copper Company, both of which in April, 1902, were included in the amalgamation of these and kindred corporations under the name of the International Nickel Company. These works were designed to further refine the low grade or blast furnace matter of the Canadian Copper Company.

In the summer of 1904 what is known as the New Smelter started operations. This is a thoroughly up-to-date plant of 1,000 tons capacity. The new smelter is the only one now in operation, the others having been partly destroyed by fire and were dismantled.

Perhaps the most important event in the development of

the nickel industry, either in this district or elsewhere, occurred in April, 1902, when after negotiations, covering a period of several months, the International Nickel Company was organized under the laws of the state of New Jersey, to consolidate and control the nickel production of the world. The following properties were included in the new organization: The Canadian Copper Company: the Orford Copper Company, with reduction works at Bayonne, New Jersey: the Anglo-American Iron Company; and the Vermillion Mining Company in Canada: the American Nickel Works in Camden, New Jersey; the Nickel Corporation, Limited, and the Societe Miniere Caledonienne, in New Caledonia. During 1902 and 1903 mining operations were considerably curtailed, except in the case of the Creighton mines where the production has been brisk ever since it was first opened.

In July 1905, the Canadian Copper Company, or more properly the International Nickel Company, began the erection of a new smelter at Copper Cliff, which when completed is to handle the copper-nickel arsenide ores from the new Lake Temiscaming district.

In 1899 Dr. Ludwig Mond, who worked out the Mond nickel carbonyl process for the separation of nickel, acquired the McConnell properties, since known as the Victoria mines. The mines are about twenty two miles west of Sudbury, while the smelter offices and official residences are close to the "Sault"

branch of the Canadian Pacific Railroad and a little over two miles south of the main openings. In October, 1900, the Mond Nickel Company, Limited of London, England, was incorporated with a capital of 600,000 for the purpose of acquiring all the above property plants, patents and smelters belonging to Dr. Ludwig Mond in the Sudbury district. A plant of the most modern type for roasting, smelting and bessemerizing the ore was erected at Victoria Mines under the direction of Hiram W. Hixon, formerly of the Anaconda Company, this equipment being the most complete and conveniently arranged which had up to that time been installed in the district. This company also uses ore from the North Star mine west of Sudbury on the Manitoulin and North Shore railroad and has used some ore from the Little Stobie mine north of Sudbury all of which is shipped to Victoria mines for treatment.

The bessemerised matte as quickly as produced by the smelting works at Victoria mines is shipped to Clydach, near Swansea, in Wales, where extensive works have been built for its treatment.

Although the above two companies are the only ones at present operating in the district many companies have entered the field, among which are; Henry H. Vivian & Co., the well known Welch smelting firm, The Dominion Mineral Company, the Algoma Nickel Company, the Drury Nickel Company, later re-organized under the name of the Trill Nickel Mining and Manufacturing Company, the Great Lakes Copper Company, the Lake

Superior Power Company, which has large works at Sault Ste. Marie and others.

The suspension of operations so often recorded in the history of the mining development of this district does not in all or even in a majority of cases imply a failure of the ore supply, but is oftener to be attributed to a waste of capital, owing to a lack of business judgment and the need of a technical knowledge of the difficulties to be encountered in both the mining and smelting departments.

Topography.

The topography of this region has been largely constructed by glacial action and presents a more or less disconnected netlike system of low well rounded ridges sometimes reaching a height of 100 to 200 feet above the low ground. The average elevation of the district as a whole varies from 800 feet to 1100 feet above the sea. The present topography has been the result of prolonged denudation and erosion, assisted to a considerable extent by subsequent glacial action which removed the softer decomposed material from the higher levels, to be deposited in the neighboring valleys in areas considerably removed to the southwest. The scouring action of the vast glacier is every where apparent in the smooth well rounded hills, while in many cases the exposed rock surfaces still preserve the glacial grooves and striae. The prevailing trend of the ridges is northeast, corresponding to the general stratification of the

region, and between them the surface can be defined in three divisions: First, tracts of irregular flat ground, hard and dry: Second, swampy areas and stream sources: Third, large and small lakes. The ground surface is largely covered with timber and brush where forest fires and the timber man's ax have not been too active in clearing it. The swamps are frequently almost impenetrable, owing to the thick matted brush and fallen trees. The region drains into Lake Huron on the south through the medium of three large rivers, the Spanish, Vermillion, and Wahnapiatae. The settlements, other than lumber and mining camps which are sparsely distributed over the region, are strung along the lines of the Canadian Pacific Railway and a mile or so in any direction takes one into a wilderness broken only by the bushman's trail and an occasional rough wagon road. The surface in its present aspect is not adapted to farming or stock raising. It is in the strictest sense a mining region.

Geology.

According to Dr. Barlow in his report on this district through the Canadian Geological Survey, the rocks of the Sudbury Mining District arranged in the probable order of their geological age may be stated as follows in ascending order.

I. Lower Huronian. No rocks of this age are at present known in the nickel bearing area, but this period is represented in part by the banded silicious magnetites and associated rocks

of the townships of Hutton and Wissner.

2. Upper Huronian. (A) Diorites, hornblende - porphyrites and green schiste: (B) Conglomerates, greywackes and quartzites: (C) Norite and diorite (Worthington mine belt and areas southeast of Evans mine and east of Sudbury.)

3. Laurentian Granite and diorite - gneiss near Wahnapitae station.

4. Upper Huronian (?). Tuffs, felspathic, sandstones and slates classified on previous geological maps as of Cambrian age.

5. Post Huronian. (A) Granites. (B) Nickel bearing eruptive of the main belt (quartz - hypersthene-gabbro or norite, diorite, with their peculiar differentian product, micropegmatite.) (C) Dykes of olivene diabase.

6. Pleistocene. Clay and Sands.

The geological history of the nickel mining area proper began in very ancient times and most of the rocks now exposed are regarded as representative of what is known as the Huronian period, being thus the oldest with which geologists are at present familiar. The detailed examination and study of these rocks have furnished abundant evidence of the almost unexampled volcanic activity then prevailing, caused largely, no doubt, by the instability of the earth's crust at this early period of its history. These rocks are essentially of pyroclastic origin, consisting mainly of tuffs of both acid and basic types, intimately associated with more or less altered basic eruptives, some of which still retain much of their original massive character.

Although by far the larger proportion have undergone such profound deformation and metamorphism, that it is exceedingly difficult, if not impossible, even with the assistance of the microscope, to make any very definite or accurate statement in regard to their original composition and structure. Some of these eruptives are, however, probably of laccolitic origin, and intruded along the planes of bedding of the enclosing clastic rocks, while many of the porphyrites and obscurely amygdaloidal forms, doubtless represent surface flows of lava which have been very much altered and decomposed.

With the establishment of conditions of more stable equilibrium came a time when the higher elevations were being subjected to the usual processes of degradation and erosion with the transportation of the material thus detached to be deposited at the lower levels, forming the conglomerates, felspathic sandstones, and quartzites, included in the above table as Upper Huronian. Even this period of comparative quiet was probably interrupted at intervals by a return of volcanic activity, and some of the breccia-like material, and certain of the interbedded greywackes may be the direct results of explosive action. Subsequent to the formation of these rocks, the huge batholiths of granite and diorite gneiss classified as Laurentian, and occurring in the vicinity of Wahnapiatae station, were intruded into the highest or quartzite member of the Upper Huronian. Later than these quartzites, and possibly also later than the Laurentian gneiss certain masses of norite and diorite were

intruded.

The age of the tuffs, felspathic, sandstones and slates hitherto classified provisionally as of Cambrian age, is still a matter of considerable doubt, and much more detailed work and critical examination of the area, characterized by the presence of these rocks, will be necessary before this can be satisfactorily settled.

The granites usually referred to as "younger" are decidedly so, in reference to the older diorites, porphyrites and green schists and a rock which may be called a breccia, formed by an exceedingly intricate intrusion of dykes and masses of granite material through these basic rocks, covers considerable areas throughout this district, while even the main mass of the granite batholith frequently contains embedded fragments and masses of all sizes and shapes of these older green stones.

The nickel bearing eruptive, which in its fresh condition is now referred to as a quartz-hypersthene-gabbro or norite, is decidedly later than, and intrusive through, the green schists and associated diorites. The relations between the so-called "younger" granite is much more complex. For the most part, the nickel bearing eruptive has cooled against the granite, as may be seen at the junction between these two rocks on the west side of the large pit known as No. 2 mine at Copper Cliff. Here the norite is distinctly finer in grain at the immediate point of contact, this rock growing visibly coarser farther away from the line of junction. On the other hand, in some

localities certain dykes or apophyses of the granite seem to penetrate the norite as may be noticed along the line of junction to the northwest of No. 2 mine at Copper Cliff, while the intrusive nature of the granite, and its apparently later age in relation to the norite is quite marked to the north of Clarabelle lake where the line of junction between the two rocks is well exposed for considerable distance. Besides, near the Creighton mine the granite has become decidedly more basic in the vicinity of the norite, and a certain zone or belt is formed by the mingling of the material of both rocks as a result of actual fusion. It has been suggested that the granite and norite may have been differentiates of the same magma, but a more reasonable explanation would seem to be that their periods of intrusion were so closely synchronous that they overlapped in their time of crystallization, and that the later secretions from the slower cooling granite magma forced or ate their way into the norite in certain places.

There are dikes of olivine-diabase which are distinctly later in age than the rest of the associated rocks. They cut the neighboring rocks as well as the ore bodies themselves. These dikes present every gradation between basalt and diabase.. The thin section of the fairly coarse rock shows a remarkably fresh olivine diabase, made up chiefly of plagioclase, augite and olivine.

According to the present state of our knowledge there are three main belts of norite with which workable deposits of

the various sulfides carrying nickel and copper occur. Until recently these were believed to be entirely distinct and separated, but later more detailed geological examinations are tending to prove that these are all portions of a geological unit, and all referable to one continuous mass. They have always been regarded as essentially the same in origin and mineralogical composition and approximately, at least, of the same geological age. Not much is known of any but the Southern, or Main Nickel Range. The most northerly of these bands known as the Northern Nickel Range extends west about twenty miles from Lake Wahnapitae at a distance of about twenty miles north of Sudbury. The Middle, or Levack Nickel Range extends from about the center of the township of Trill north and northeast through this township into Cascaden, and crossing under Windy Lake, goes on uninterruptedly through the northwest corner of Dowling to about the middle of the east side of Levack township.

By far the largest and most important band of norite is what is known as the Southern or Main Nickel Range. Its southwestern limit in all probability is in the southern part of Trill township extending southward into Drury and from here it has been traced continuously in a northeast direction for a distance of thirty five miles to about the center of Garson township. Most of the mines of the Canadian Copper Company at Copper Cliff are situated on a narrow dyke-like extension sent off in a southeasterly direction from the main belt.

Minerals of the District.

Pyrrhotite, Fe_8S_8

Chalcopyrite, $(\text{Fe Cu})\text{S}_2$

Pentlandite, $(\text{FeNi})\text{S}$

Lillerite, NiS

Pyrite and Marcasite, FeS_2

Magnetite, Fe_3O_4

Sperrylite, Pt As_2

Native Copper.

Galena.

Native Gold.

There has also been identified Niccolite, NiAs , Smaltite, CoAs_2 , Chalcocite, Cu_2S and other minerals which are unimportant.

The ore bodies are composed essentially of pyrrhotite and chalcopyrite with by far the greater percentage of pyrrhotite. The nickel occurs principally as pentlandite distributed throughout the ore bodies. The matrix of the pentlandite is almost always pyrrhotite. It was formerly supposed that the nickel occurred as replacing a part of the iron in the pyrrhotite, but it has been proven by Mr. C. W. Dickson that this is not the case and that pentlandite disseminated through the pyrrhotite is the real source of the nickel.

Aside from the nickel and copper minerals, the others are of small importance, except, perhaps, sperrylite which is furnishing an increasing amount of the world's supply of plat-

inum. Sperrylite is thought to be the source of the platinum which is always found in the bessemer matte of the smelters of the district.

In 1889 the announcement was made by Messrs. Wells and Penfield that they had identified the Arsenide of Platinum, (Pt. As₂) as a natural mineral. It had been collected by Mr. F. L. Sperry from the heavy concentrates of a gold ore taken from the Vermillion mine. This mine is about twenty miles west of Sudbury and is owned by the Canadian Copper Company. At this mine there is a quartz vein carrying gold which cuts across a belt of dioritic rock containing chalcopyrite and nickel bearing pyrrhotite. Professor Wells named the new mineral Sperrylite after its discoverer. It is the first and only natural compound of platinum with a non-metallic substance which has been found.

Sperrylite is a very rare mineral and until recently has been known from only two localities, this district in Ontario and North Carolina. A few years ago, however, investigations of the copper ores of the Rambler mine, Wyoming, by Professors Wells and Penfield, have shown minute crystals of sperrylite in the covellite which forms a considerable part of the oxidized zone of the mine. The platinum which has occasionally been found by assay in the other ores may have been present as a sperrylite.

Since cobalt so commonly occurs with nickel it is but natural that cobalt minerals should be expected in this region,

but as a matter of fact they are rare. The amount of cobalt obtained here is almost negligible in quantity.

Mode of Occurrence of the Ore Bodies.

Most geologists who have examined the ore bodies of this region agree that these deposits are not true fissure veins. In the mines there is no distinct foot, or hanging wall, but the ore grades off so that walls that are left often contain a considerable amount of ore, yet is too lean to work on.

The ore bodies are of irregular, oval or pod shaped outline and all agree in having their longer axis to correspond very closely with the direction of foliation of the enclosing rocks. Without exception, all of these immense bodies of sulfid material are situated at the immediate contact between the intrusive norite and the older rocks in such a way as to indicate in the clearest manner, their common origin.

The famous old Copper Cliff Mine is a veritable chimney of ore occurring in connection with an isolated stock of norite which comes in contact with feldspathic quartzites and green schists. This ore body averaged in width from 50 feet to 100 feet in the cross section through the shaft, while at right angles to this direction it varies from 30 feet to 210 feet, and has reached a depth of 1058 feet at the 14 level. This mine which furnished ore for so many years is not at present being worked, not because of exhaustion of the ore, but on account of the depth reached.

Rounded hills of gossan, indicating the presence of more

or less pure ore beneath, extend for miles along the line of junction, while by far the larger portion of the off sets and isolated masses, with which the ore bodies are associated, are also of a prevailing brownish color from the decomposition of the abundantly disseminated sulfids. This gossan has resulted, as usual, from the alteration of the pyrrhotite and chalcopyrite and the formation of hydrous oxide of iron which gives a prevailing brownish color to the upper portions of the deposits.

Origin of Ore Deposits.

In this paper I will merely touch on the origin of the Sudbury ores. This part of the subject has been studied by a number of very able men, among whom are the following:

Dr. Robert Bell and Dr. A. E. Barlow of the Canadian Geological Survey. Dr. T. L. Walker of the University of Toronto, Professor J. H. L. Vogt, of Christiania, Norway, Professor R. Beck of Freiberg, Professor J. F. Kemp and Professor C. W. Dickson of Columbia University, New York City, Mr. Phillip Argall of Denver and the late F. Posepny, the noted Bohemian authority.

There are two distinct theories for the origin of these deposits:

First, that of magmatic segregation in which the ore materials segregated at the margin of the molten norite.

Second: that of secondary action by which the ore material was deposited by the action of water along the line of fracture. In his paper presented to the University of Leipzig to obtain the degree of Doctor of Philosophy, T. L. Walker concluded that the sulfids have crystallized directly from the fused magma, just as have the usual components of an igneous rock, while Phillip Argall points out the faulted nature of the district and considers that a leaching out of the nickel and copper from the green stones in which they were

originally formed, and a concentration and precipitation along favorable zones, is a more reasonable explanation than magmatic differentiation.

The latest and by far the most complete report on the Sudbury district is that by Dr. A. E. Barlow through the Canadian Geological Survey. The writer of the article you are reading is not competent to give any original opinion regarding the origin of these ores, but is strongly inclined to favor Dr. Barlow, who says in his report: "More recent and detailed examination of the various ore bodies, has shown that while the first hypothesis of a segregation of these sulfids, directly from the magma, is in the main, the true explanation of their present position, other agencies which are usually grouped together under the name of secondary action, have contributed largely to bring about their unusual dimensions."

The Magnetic Properties of Pyrrhotite
and
Their Uses.

The mineral pyrrhotite has varying degrees of magnetism depending on the place from which it is obtained, specimens from different mines in the same district having different magnetic properties.

It has been thought the more nickeliferous portions of the pyrrhotite are less magnetic and that, by magnetic separation, one portion of the ore could be obtained which would be very magnetic, therefore low in nickel, and another portion which would not be magnetic and would contain nearly all the nickel values. Among those who have experimented along these lines are:

Thomas A. Edison, (1892)

Dr. S. H. Emmens, (1892)

David H. Browne, (1893)

The Wetherill Separating Co. (1900)

Mr. C. W. Dickson, (1901-1903)

Although much experimenting has been done along these lines, the results are disappointing and the general conclusion is that magnetic separation is not practical in the Sudbury region.

Considerable work has been done trying to locate ore

bodies in this region by means of the magnetic property of the pyrrhotite. The Mond Company, the Lake Superior Power Company, and Thomas A. Edison have had parties in the field, but no important deposits have been found by this means. The instruments used were of Swedish make.

Mining Methods.

The mining methods used in this district are very simple. A great deal of the mining has been done in open pits, but some of the mines have opened up under ground levels and stopes. The work being done in solid ground, very little timber is needed or used.

During the summer of 1905 the Copper Cliff Company was working only two mines, the Creighton and No. 2. The Creighton mine is the largest open pit in the district and has the dimensions (summer , 1905) of about 350 feet by 275 feet and 140 feet deep. It was planned to make a new shaft in the fall, sinking below the present level and breaking up through. I do not know whether or not it has been done. The ore is raised in skips through an inclined shaft. By far the greater amount of ore used by the Copper Cliff Company at present comes from this mine. The Creighton is the most productive nickel mine in the world at the present time.

The No. 2 mine at Copper Cliff was first opened up as an open cut, but is now down about 400 feet and is being worked on the 4th and 5th levels.

As the ore comes from the mine it is in large lumps with considerable fines. This ore is hoisted in skip cars to the top of a rock house where it is automatically dumped onto a large inclined grizzly sizing screen which separates the fines from the coarse ore. The coarse ore falls in front of large

Blake crushers, each of 400 tons daily capacity, into which it is fed and crushed to the requisite size for roasting. From the crusher it passes into slightly inclined horizontal revolving trommel screens from which it is discharged in three sizes, fines, ragging and coarse. The first two sizes escape through their respective holes in the trommel screen, while the last discharges through the lower and open end of the screen onto oscillating sorting tables. The motion of the tables causes the ore to move slowly across, while boys along the sides pick out the barren rock that is mixed with the ore. The ore then drops into its proper bin, from there to be removed to the roast yard.

Roasting.

From the ore bins at the mines the ore is taken to the roast yard. In the summer of 1905 the Copper Cliff Company was using two roast yards near Copper Cliff. No. 2 roast yard is about three fourths of a mile north of Copper Cliff and is about 150 feet by 7500 feet of carefully graded, prepared and drained ground.

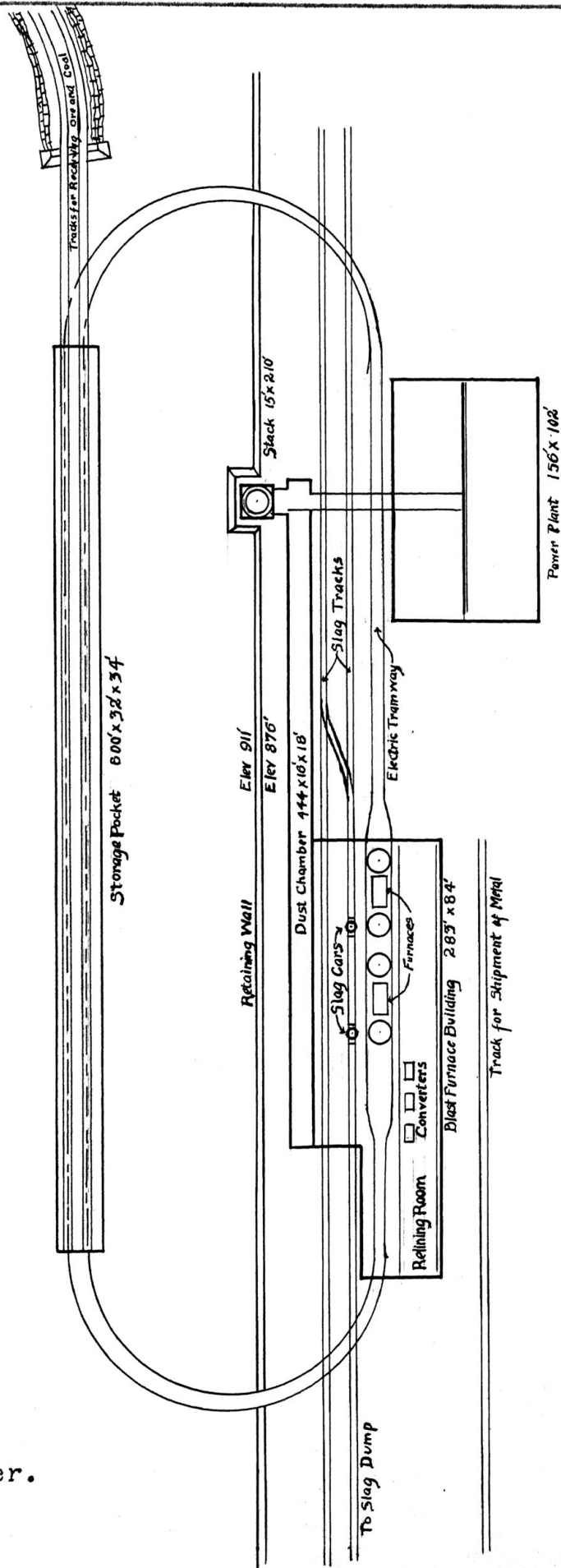
Here the plans of the roast heaps, rectangles varying from 30 X 60 feet to 60 X 125 feet, were laid out. When an excess of fines is in stock, the ground is first covered to a depth of several inches with the surplus fines, which after two or three heaps have been roasted on them, get roasted and caked together, and then are broken up and roasted as coarse

ore. Coarse ore is preferred in smelting. On top of these fines, if any have been used, or on the ground if no fines have been used, is laid a bed of dry cord wood from 9 to 18 inches deep. On the fuel bed coarse ore to about 65% of the total roast heap is piled. This is covered with raggin (nut sized ore) and finally by a complete covering of fines. Kindling holes are left open at intervals around the base.

The heap is lighted at all the kindling holes simultaneously and the long roasting operation commences. The openings are covered with fines as soon as the cord wood has been burned to a glowing charcoal. All carbonaceous fuel, even in large heaps and so well covered and protected from the air, is burned out in about sixty hours after lighting. A complete oxidizing roasting then begins and continues until the sulphur contents are so reduced and burned out that there is not sufficient left to promote combustion. The remaining portion, about 14 % , is enclosed and sealed up in the non-porous portions of ore, the semi-fused covering of which would have to be re-broken in order to expose new faces to the heat and liberate more sulphur. But it is not necessary to get rid of more sulphur, since the remainder is essential in the smelting of the ore in order to produce a clean slag.

A heap is carefully watched for a few days during the period of settling caused by the burning out of the fuel bed beneath. All vent holes caused by this disturbance are covered as soon as formed by throwing on fresh fine ore.

Plan of New Smelter.



This is to prevent too great generation of heat which would stop all roasting by fusing the heap into a matte. These precautions having been taken, the heap is left to itself for the next few months.

The roasting varies with the size of the heap: For a heap of 800 to 1000 tons, (small), about 35 or 40 days: For a heap of 2500 tons (common size), about four months: While a heap of 4000 tons will take seven months. The longer the period of roasting, the less matting which is preferable. A roast heap once fired up and fairly started to burn requires no further expense nor attention until the ore is cold enough to remove to the smelter.

The New Smelter.

On the upper edge of a cliff a system of bins has been constructed for storage purposes. The smelter building proper is situated parallel to these bins which is also the grade level of the charging floor connecting with the bins and also with the power house, making a circular track running on both sides of the furnaces and passing the coal chute in front of the power house. After roasting, the ore is loaded into dump cars and drawn to the top of the bins by locomotive. The track leading to the trestle is on an easy grade and is connected with the main line leading to the Canadian Pacific Railway.

All ore flux, coke, coal, etc., is handled on these tracks and dumped directly into the bins. Running on the

circular track beneath the bins into the smelter building and passed the power house is an electric locomotive drawing "Koppel" side sumping cars. The material is loaded into these cars and weighed on the end of the trestle. The furnace charge is dumped directly into the furnaces and the coal into pockets next the power house.

The charges to the furnace vary somewhat and in order to give some idea of how the charges run I give on page 39.

The blast furnace building contains two sectional rectangular water jacketed Holtjoff copper blast furnaces; three stands for Holthoff converters; one forty ton electric crane; the necessary matte settlers; clay mills; silica and clay storage bins, etc. Room is provided for expansion.

The furnaces are 50 X 204" at the tuyers. There are two tiers of jackets in this furnace with the lower jackets extending down to the crucible plate. This plate is supported by means of twelve jack screws which set on a masonry pier considerably above the ground level.

The lower jackets are 8 feet 6 inches high, there being one on each end and four on each side. The water spaces in these and in the upper jackets is 4 - 1/2 inches. The fire sheets of all the jackets are half an inch thick and the outside plates are three eights of an inch thick. The upper tier of jackets is 6 feet high and there are two jackets on

each side and one on each end. All of the jackets are securely stayed by means of stay bolts that bear against the fire sheet, but are not fastened to it. All of the upper jackets are hung from the mantel frame by means of adjustable rods. The lower jackets are hung from the second set of the binder beams by adjustable rods. The jackets are securely tied to each other with adjustable steel clamps. Each jacket is maintained in its proper position by four horizontal binder jack screws, which bear against the binder beams. The lower side jackets are straight and are inclined slightly to form the bosh of the furnace. The distance between the side jackets at the crucible plate is 3 feet 10 $-1/2$ inches, at the tuyere line 50 inches and at the upper end 5 feet 10 inches. All the upper jackets set plumb. There are two water supply pipes for each jacket, also two over flow pipes, and two blow-off pipes. Each jacket is fitted with two hand hole plates and covers.

The lower end jackets do not reach to the bottom and the space beneath is fitted with tap jackets made in halves. A steel water jacketed overflow spout or cast iron spout arranged for brick lining and fitted with a water jacketed nose tip is fitted to the tap jackets on each end of the furnace. There is one small cast iron tap jacket fitted with a spout in the center on each side of the furnace for draining the crucible. These tap jackets are fitted with supply and outlet pipes for the water.

The main supply pipe for the jackets is made of cast iron

and is 8 inches in diameter and is made in convenient sections and connected together by means of flanges. Each supply pipe for the jackets is fitted with a union for disconnecting and also a gate valve for regulating the amount of water. The discharge water from all the jackets is directed into two large overflow troughs, one on each side of the furnace.

The bustle pipe is 24 inches in diameter and extends around the entire furnace with a 36 inch diameter branch for connecting with the blast main. There are sixteen 6 inch tuyere pipes on each side of the furnace fitted with gate valves and connected by means of stuffing box connections to the bustle pipe and the tuyere elbows. About 40 ounce air pressure on the tuyeres is used in the furnaces.

The space between the upper end of the jackets and the feed floor is fitted with heavy sectional cast iron plates which are secured to the deck frame. The feed floor is 17- 1/2 feet above the ground.

The mantel frame consists of 15 inch I beams, three of them being placed side by side; it is supported by four 8 inch steel Z bar columns. The columns are tied together by means of binder beams, there being four on each side and end.

The stack is built of brick and that portion setting directly on the mantel frames is 19 feet high with the walls 20 inches thick. The upper part of the stack is 5 feet square and 14 feet high, and is fitted with a cast iron damper. The brick work of the stack and extension is securely tied by means of

rails, angles and binder rods.

There is a 30 inch by 60 inch inspection door on each end of the stack on a level with the charging floor. The door is made of cast iron and is arranged to slide vertically and is properly counterweighted. The charging doors run the full length of the furnace on each side; they are likewise made of cast iron and are arranged to slide vertically and are supplied with counter weights. The charging doors on the side are 2 feet 10 inches high. A cast iron collar 8 feet in diameter for connecting with the down take is built in the brick stack. "

The slag and matte run from the blast furnace into settlers which are 16 feet in diameter and 4 - 1/2 feet deep, lined with one row of fire brick end to end and another row of chrome brick placed end to end. The slag overflows into 30 ton Pollock cinder cars which are hauled to dump by standard gauge locomotives. The matte is tapped into 10 ton cast steel ladles and taken to the converter by a 40 ton Case Manufacturing Company's electric crane. The same crane removes the converter shells for relining.

The converters are 84 inches by 126 inches and are tilted by a train of gears and a worm driven by an electric motor. The blast used in the converters has an average pressure of about 9 pounds.

The lining of the converters is a very important operation and is done in one end of the building. The material is tamped into place by hand, and about the following mixture is

used:

- 1 - 1/2 shovels of fire clay.
- 1 - 1/2 shovels of local clay.
- 4 shovels of quartz.
- 4 shovels of old linings.

The converter matte is shipped to Constable Hook, New Jersey where it is refined by the Orford Copper Company, a branch of the International Nickel Company.

Composition of Ores, Matte, etc., obtained at Copper
Cliff in July, 1905.

	Cu. %	Ni. %	Fe %	S. %
Ore from Creighton Mine.	1.75	5.03		00.00
Ore from No. 2 mine	1.45	3.60		
Roast Ore.	1.70	5.69		15.60
Roast Ore	1.70	5.23		14.39
Roast Ore.	1.75	5.58		13.15
Roast Ore.	1.75	5.58		15.91
Margins.	1.65	5.79		18.44
Margins.	1.80	4.73		17.38
Margins.	1.90	5.33		17.10
Furnace Matte.	7.40	22.55		
Furnace Matte.	8.40	26.16		
Furnace Slag.	.20	.51		
Furnace Slag.	.20	.52		
Converter Matte.	20.78	60.15	0.68	18.11
Converter Matte.	20.66	59.95	0.81	18.34
Converter Matte.	20.35	59.45	1.33	18.75
Converter Matte.	20.12	59.79	0.91	17.88
Converter Slag.	1.90	6.80		
Converter Slag.	1.10	4.78		
Converter Slag.	1.30	5.13		
Rich Linings	3.10	10.87		
Rich Linings	3.40	11.37		
Rich Linings.	1.85	6.18		

	Cu. %	Ni. %	Fe. %	S. %
Scrap.	6.61	20.12		
Scrap.	6.81	21.23		
Scrap.	7.95	25.20		
Scrap.	5.22	17.53		
Flue Dust.	1.20	4.82		
Flue Dust.	1.10	3.05		
Flue Dust.	1.45	4.57		
Flue Dust.	1.35	4.32		
Flue Dust.	1.55	4.00		

Furnace Charges in Pounds.

Roast Ore	Margins.	Green Ore	Converter Slag	Scrap	Flue Dust	Rich Linings	Quartz	Coke
12000			2000	or 2000			2200	13%
9000	3000		2000	or 2000			2200	13
9000	3000		2000	or 2000			1500	13
9000			2000	or 2000	3000		1500	13
6000	3000		2000	or 2000	3000		1500	13
6000	6000		3000				600	13
12000			3000			3000	1600	13
12000				3000			1200	13
12000							1600	13
9000	3000	1000	3000				1600	13
9000		3000	3000				1400	13

Margins is the ore from the outside of the roast heap which has not been as thoroughly roasted as the interior of the roast heap, which is called roast ore. Rich linings is the part of the old linings of the converters which has become rich from the absorption of the matte. Scrap is material from leaks in the settlers, or forehearths, etc.

University of Kansas Libraries



3 3838 100532020