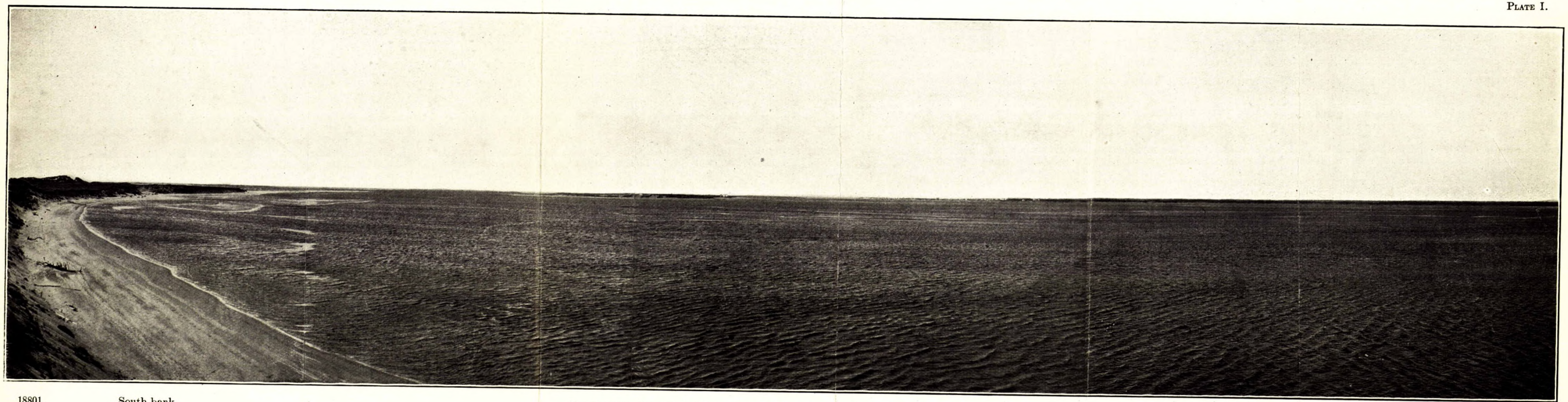
Frontispiece

PLATE I.



18801 South bank. Mouth of the Great Natashkwan river looking west towards the Gulf of St. Lawrence. North bank.

CANADA

DEPARTMENT OF MINES

MINES BRANCH

HON. ROBERT ROGERS, MINISTER; A. P. LOW, LL.D., DEPUTY MINISTER;
EUGENE HAANEL, PH.D., DIRECTOR.

THE MAGNETIC IRON SANDS

OF

NATASHKWAN,
COUNTY OF SAGUENAY
PROVINCE OF QUEBEC

BY

Geo. C. Mackenzie, B.Sc.

OTTAWA
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1912

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18801—1½

LETTER OF TRANSMITTAL.

DR. EUGENE HAANEL,
Director Mines Branch,
Department of Mines,
Ottawa.

SIR,—

I beg to submit, herewith, a report dealing with an investigation of the Natashkwan magnetic iron sands.

I have the honour to be, Sir,

Your obedient servant,

OTTAWA, May 23, 1912.

Geo. C. Mackenzie.

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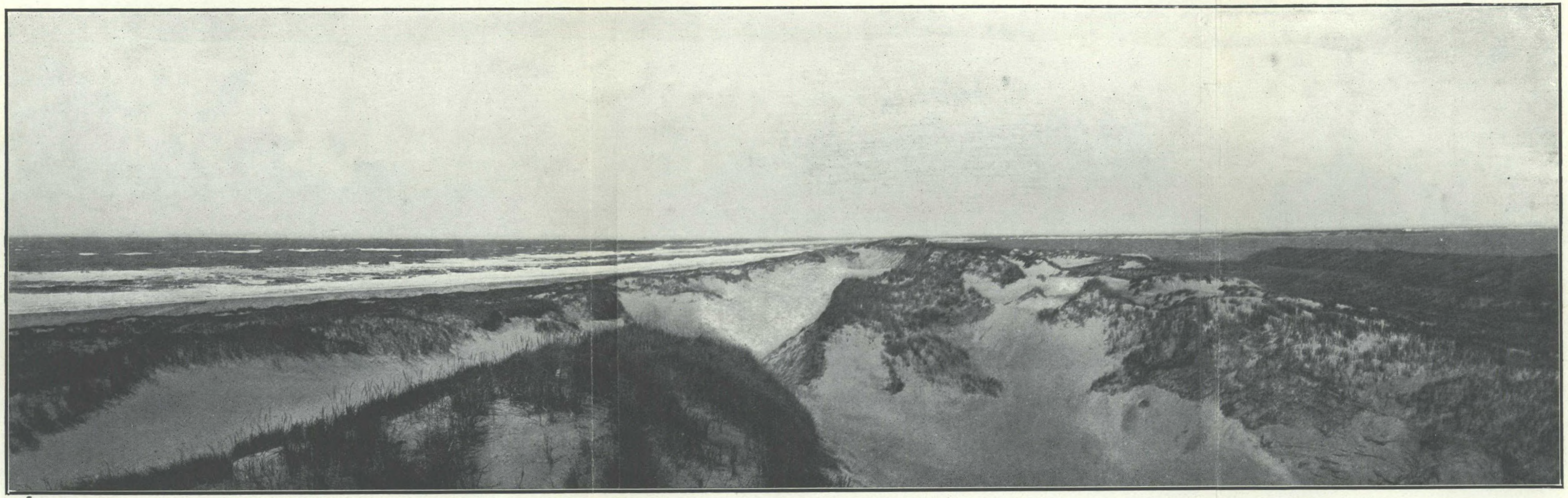

18801—p. 1. Gulf of St. Lawrence. Westerly end of dune area, looking west. Great Natashkwan river.

THE MAGNETIC IRON SANDS OF NATASHKWAN, COUNTY OF SAGUENAY, PROVINCE OF QUEBEC.

BY

Geo. C. Mackenzie, B.Sc.

INTRODUCTORY AND HISTORICAL.

The magnetic iron sands on the north shore of the lower St. Lawrence river and gulf have for many years presented an interesting problem as regards their profitable exploitation for the manufacture of iron and steel.

These sands are found in deposits of more or less size at various points along the shore; and while theories of disruption of ferruginous coast rocks, and submerged ferruginous rocky islands have been advanced as explanations of their origin, it is now generally recognized that they are only fluviatile deposits formed at the mouth of ancient, and modern coastal streams. This ferruginous material has in many cases been conveyed long distances by the rivers, from titaniferous ore bodies and anorthosite rocks situated inland.

No attempt will be made to discuss at length the geological origin and mineralogical composition of these sand deposits. For the purposes of this report it will be sufficient to state that the sands consist of a mixture of minerals; chiefly quartz, feldspar, garnet, olivine, magnetite, and ilmenite; the last two mentioned constituting respectively the iron and titanium minerals.

A list of the more important localities where magnetic sands are found, is as follows:—

Mouth of the	Portneuf	river,	county of Saguenay,	Quebec.
"	Bersimis	"	"	"
"	Moisie	"	"	"
"	Manitou	"	"	"
"	St. John	"	"	"
"	Mingan	"	"	"
"	Great Natashkwan		"	"
"	Kegashka river		"	"
"	Muskwaro river		"	"
"	Olomanoshibo		"	"

While black sand (magnetite and ilmenite) has been found in all of the above localities, the deposits differ greatly in point of size and richness and it is probable that not more than three or four are worthy of any attention.

Considering the manner in which the deposits were formed, it naturally follows that the valuable mineral (magnetite in small grains) is scattered throughout the sands in irregular quantities. On the beaches, natural concentration has been effected to some extent through the agencies of waves, tides, and winds. This has resulted in the formation of bands of black sand lying in staggered position, and alternating with bands of ordinary sand parallel to the shore line. These bands vary in thickness from a fraction of an inch up to a foot or more, and may be anywhere from 1 to 20 feet wide, and from 10 to 100 feet long.

It is evident, therefore, that the sands in their natural condition are quite unfit for the manufacture of iron, and that to render them commercially valuable requires concentration by some mechanical means. A number of attempts have been made in the past to this end, and although later experiments have demonstrated the practicability of producing a concentrate high in iron and low in titanium, capital has been notably hesitant in investment. This is due, no doubt, to a general disbelief in the extent of the deposits, and to the natural difficulties of transportation, working conditions, and short seasons.

As the sands consist of a mixture of practically free mineral particles, they present a rather easy problem in the separation of the magnetite and ilmenite from the other minerals by ordinary specific gravity methods of concentration. A glance at the following table will demonstate this without further comment.

TABLE I.[1]

Mineral.	Specific gravity.
Feldspar	2·4—2·6
Quartz	2·5—2·8
Olivine	3·2—3·3
Garnet	3·1—4·3
Ilmenite	4·5—5·0
Magnetite	4·9—5·2

There is, however, a serious objection to the specific gravity methods, in that the magnetite and ilmenite are thrown together, the difference in their specific gravities being insufficient to separate one from the other. This objection is founded on the fact that the value of the concentrated magnetite depends to a large extent on its freedom from ilmenite, the highly titaniferous mineral.

From the iron smelter's standpoint, any large percentage of titaniun in an iron ore is undesirable, because it forms an infusible compound in the furnace. It will not combine with the iron nor will it readily enter the slag, excepting under conditions of special fluxing materials, and abnormally high temperature. In this connexion, however, it should be stated that ores containing 12 per cent of titanium have been smelted successfully by mixing with other non-titaniferous ores, so that the mixture contained less than 2·5 per cent of titanic acid.[2]

To be of commercial value, any method of separation should, therefore, be capable of not only eliminating the ordinary gangue minerals but also the major portion of the ilmenite. In addition to fulfilling the above condition, the apparatus should be of simple construction, of large capacity, and capable of making the separation without any preliminary drying of the wet sands. These conditions are met more or less completely by the wet magnetic separators of the Gröndal type, and as the mineral ilmenite (in these sands) is not as strongly magnetic as the mineral

[1]Dana.
[2]Iron Age, Oct. 21, 1909.

magnetite, its removal is accomplished without great difficulty. It should be noted here that the permeability (magnetic conductivity) of ilmenite is not a constant. Samples from different localities will vary considerably in magnetic properties. This is due in large measure to the variable chemical composition of the mineral. Hence the separation of ilmenite from magnetite by magnetic separators is controlled by the factor of their relative permeabilities.

The working of such low grade material as these sands implies the necessity of saving as much of the free magnetite as possible. It is an easy matter to save practically all of the original magnetite, but by doing so much of the ilmenite will be concentrated with the magnetite. On the other hand, it is not difficult to produce a magnetite concentrate practically free from ilmenite, but only at the expense of considerable magnetite lost in the tailing. A commercial process should strike a balance between the two, saving a maximum of magnetite consistent with a maximum elimination of titanium.

The production of a rich iron concentrate low in titanium does not, however, solve the problem completely. The concentrate owing to its finely divided condition is not suitable for smelting. If charged into the blast furnace in this condition, the ascending furnace gases would carry a large portion out of the furnace, filling up gas mains and accumulating under boilers and in hot blast stoves. The portion that remained in the furnace would contribute its share of trouble by non-uniformity of descent with the coke and limestone giving rise to serious irregularities in smelting.

It is necessary, therefore, to agglomerate this fine material by some system of briquetting or nodulizing.

Briquetting experiments with the concentrated sand, conducted in Sweden for the Gröndal company, established the fact that the water worn rounded particles of magnetite would not interlock under the briquetting press. This resulted in a weak and more or less friable briquette. However, this trouble was corrected by subjecting the concentrate to a partial crushing, in ball mills, effecting a sharp, angular fracture of the particles. It was found, moreover, that crushing had the effect of breaking up certain middling particles (half magnetite, half ilmenite) which gave additional opportunity of eliminating titanium in a secondary concentration.

While a great deal of experimentation with the sands has been carried out in the past, there is record of only one serious attempt being made to concentrate and smelt the magnetite on a commercial basis. The locality selected for this enterprise was at Moisie, some 330 miles east of Quebec city, where the Moisie river entering the Gulf has deposited large volumes of iron sand.

The following notes on the Moisie furnaces have been compiled from some of the earlier reports of the Geological Survey, Canada, and the reports of the Superintendent of Mines, Quebec.[1]

In 1867 Mr. Wm. Molson, of Montreal, had certain tests made with the Moisie sands with the view of their commercial utilization. As a result of these tests, he established eight bloomery furnaces at Moisie under the name of The Moisie Iron Company, and for a time the industry flourished.

The crude sand was concentrated on shaking tables and by Dr. H. LaRues process of magnetic separation. The concentrated product was

[1]Geological Survey, Canada, Vol. IV, pages 14K and 40T, also Mines and Minerals of the Province of Quebec, 1889–90, by J. Obalski.

then smelted with charcoal in the bloomeries, the output being about 1 gross ton of iron per day per furnace. The fuel consumption was very high, being, it is said, 6,990 pounds of charcoal per ton of iron.

It is worthy of note that Mr. Molson did not depend altogether on the beach and dune deposits for his supply of crude sand, but employed a number of men with carts to remove the sand freshly deposited on the beaches by storms and gales. Titaniferous iron ore from the large deposits at Rapid river near Seven Islands was also used to mix with the concentrated sand, but just how much of this material and in what proportion it was used does not appear.

A portion of the blooms produced was shipped to Montreal and used for rolling into railway axles. The iron is said to have been of excellent quality equal to the best Swedish, and suitable for the manufacture of the finest steels. It is also stated that the iron contained no titanium.

The chief market for Moisie blooms was, however, in the United States, where they were shipped for a time, entering as pig iron under a duty of $7 a ton. From March 2, 1875, in consequence of representations and protests from United States iron-workers, the blooms were classed as bar iron and subjected to a duty of 1½ cents per pound. This excessive tariff had the effect of closing the United States market, and forced the Company to shut down its works, go into liquidation, and sell its property.

Since the close of the Moisie works, no further attempt has been made to exploit any of the St. Lawrence sand deposits on a similar scale of operation.

Several of the deposits at various points on the gulf have been examined within quite recent years by two different parties. Synopses of the reports made by these people have been placed at the disposal of the writer, who has thought it advisable to incorporate in this paper the essential points of interest contained therein.

In 1899 and 1900 examinations were undertaken for certain Canadian interests. Two reports were made which I have briefly summarized as follows:—

NATASHKWAN.

"The main deposit of iron sand is found in a bank along the shore of the gulf running in nearly easterly direction, commencing at the mouth of the Natashkwan river, continuing to English point (Mt. Joli) a distance of 3 miles.

The bank has a height of 8 to 25 feet above sea-level and is partially covered with wood. The surface of the bank is not a plain, there being several ridges or dunes from 4 to 15 feet high.

In this bank the sea sand is interstratified with layers of black sand. The pure black sand contains 50 per cent magnetite, that is about 35 per cent metallic iron. The thickness of the black sand layers is very variable, amounting from almost nothing to 15 feet.

Unfortunately, the thick layers of pure sand do not lie near the surface, but are covered with poorer iron sand, sometimes as much as 15 feet.

I have bored with an auger about 100 holes in the bank between English point and Natashkwan river; from every hole I have taken a sample which I tested for magnetite. In no one of these holes have I found the average higher than 20 per cent magnetite, and the usual richness of the sand was about 10 per cent.

The extension from the shore of 10 per cent magnetic sand appears to be about 500 feet.

At English point near the high bank is a low valley only 8 feet above the sea-level, 4,000 feet long and 60 feet wide.[1] In the richest part I found 5 feet of sand containing 40 per cent magnetite and 3 feet of sand containing 20 per cent magnetite. The leaner part does not contain more than 4 feet of 12 per cent magnetite."

"About 5 miles from Natashkwan river eastward is another deposit of iron sand. The bank here is 20 feet high, partly covered with wood, partly with peat. I found in the bank a layer 7 feet thick of pretty good iron sand which I could trace for a distance of 2,000 feet. This layer begins near the surface of the ground and dips slightly towards the sea.

As to the quantity—I have made an estimate of the iron sand and find that including the ore between the river and English point, the ore in the big layer east of English point, and also the ore on the beach[2], I have got nine million tons, obtained from sand containing 10 per cent magnetite and over.

Still it is possible that farther inland than I have been able to bore, there is iron sand in quantities worth working. Indeed the day before I left I was informed by fishermen who had been working on the telegraph line, that they had found black sand 8 miles inland from the shore.

As regards the harbour, Natashkwan river is not deep enough for a steamer, the depth not being more than 6 feet at low and 9 feet at high tide. Four miles west of the river is a good harbour for winds from every direction and with 5 fathoms of water near the shore.

Navigation is open from May until the middle of November."

MOISIE.

"This place is situated in Saguenay county about 150 miles west of Natashkwan. The iron sand is found both east and west of the river in the bank near the shore. The bank is very low being not more than 10 to 15 feet above the sea. On the east side the iron sand extends from the mouth of the river about $2\frac{1}{2}$ miles eastward. In the bank there are no large layers of pure black sand as were found at Natashkwan, the magnetite is mixed with red and white sand, and the thickness of this mixed sand varies from 6 inches to 12 feet.

Two and a half miles west of the Moisie river is another deposit of magnetic sand and the iron-bearing sand continues 3 miles westward.[3] The usual thickness varies from 2 to 4 feet, sometimes increasing to 6 feet. On the beach close to the bank there is always black sand wherever iron sand occurs in the bank. The depth of the alternate layers is from 2 to 6 feet.

The tests I have made from samples taken from the bore-holes show from 5 to 16 per cent magnetite. The richer layers of sand are very often so deep under the surface that if mixed with the overlying burden, the average percentage will not exceed 7 or 8 per cent magnetite.

The Moisie harbour is not one of the best, being open to southerly winds, but is deep enough for steamers of large tonnage.

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[1]The low valley referred to above lies west of and abutting Mt. Joli, the small hill overlooking English point.

[2](Author's note.)—It is not absolutely clear whether this means magnetic concentrate or original crude magnetic sand.

[3]The old bed of the Moisie river. (Author's note.)

If it will pay to work sand containing 8 per cent magnetite I think I have found over a million tons, and am of the opinion that indications are sufficient to warrant a more thorough exploration inland."

In 1904 an examination was made, in the interest of European capital, the report thereon being substantially as follows:—

"We arranged to visit Moisie, Mingan, St. John, Natashkwan, and Bersimis, all of which points are east of Quebec and upon the north shore of the river. Bersimis is some 200 miles, Mingan and St. John 430, Moisie 330, and Natashkwan the most easterly, approximately 530 miles east of Quebec.

We took supplies, tents, etc., and in addition 3 men as labourers.

The samples of magnetic bearing sands taken during the various examinations were subsequently assayed by means of a small magnetic separator, consisting of an ordinary horse-shoe magnet and cup. The results obtained gave, of course, the percentage of magnetic sand existing and disregarded the percentage of ilmenite (titanate of iron), present usually in almost equal proportion to the magnetite itself.

BERSIMIS AND MINGAN.

These places are quite insignificant and incapable of producing more than something like 3,000 to 5,000 tons of pure magnetite between them. The magnetite bearing sands are extremely poor, narrow in width and depth, and not of very considerable length, and although the tonnage of ore-bearing sand is considerable, the actual tonnage of magnetite is small and quite unworthy of further thought.

MOISIE.

This property gave disappointing results. It was found that, working from the percentages of magnetite occurring in nearly 30 samples, the total quantity of pure magnetite that could be separated from the beach sands which were considered worthy of treatment, only amounted approximately to 20,000 tons. Of this quantity about 10,000 tons exist on the east side of the Moisie river in sand richer on the average than that occurring on the west side. It follows, therefore, that the ore-bearing sands on the west side are poorer but greater in extent than those of the east, as the actual quantity of magnetite contained in the sands upon both sides is approximately the same.

Apart from the beaches proper, considerable areas of grassy dunes occur bearing on an average not over 5 per cent of magnetite. It would probably not pay to work sand containing only this percentage. When one considers it would be necessary to handle 20 tons of sand to obtain 1 ton of magnetite, the opinion would seem to me to be well founded, even if not based at present upon exact figures as to costs.

Beyond the dunes the ore bearing sands are still encountered, but are still poorer. Five-eighths of a mile of this district (wooded) was sampled at intervals upon a line projected inland at approximately right angles to the beach. The samples gave an average result of only 0·9 per cent of magnetite. This tract is, therefore, obviously useless.

This particular property narrows down, therefore, to the 20,000 tons of magnetite on the beaches, and to the 5 per cent dune area. It does not seem, in my opinion, to warrant further thought except as a possible auxiliary to Natashkwan.

NATASHKWAN.

As at Moisie, the sands at Natashkwan bear a striking resemblance in mode of occurrence. Strips of natural concentrates exist on each beach in a more or less continuous band a little above high water mark of neap tides. These natural concentrates vary considerably in depth from a few hundredths of an inch to a foot or more (in one case to as much as 4 feet). Below, the sands contain magnetite in more or less degree to an average depth of from 4 to 5 inches. At Natashkwan, however, the average richness of the sands is considerably greater than at Moisie, a result due to the greater quantity of natural concentrate as well as to the relative richer nature of the underlying sand. The results of the analyses gave approximately 12 per cent as the proportion of magnetite in the beach sands, and the tonnage of pure magnetite present in the total quantity of sand carrying this percentage is approximately 100,000 tons, or in other words, there is about 833,000 tons of 12 per cent sand.

Apart from this tonnage (which covers practically the entire ore-bearing sands on the beaches) there is a considerable grassy and wooded dune area carrying from 6 to 6½ per cent of magnetite. An approximate calculation showed that in all probability there exists some 400,000 tons of magnetite in these dune areas. This means that the dune areas which were sampled contain some 6,500,000 tons of sand carrying from 6 to 6½ per cent of magnetite.

The beach at Natashkwan is extremely exposed and is situated 6 miles from the harbour. It is separated from the harbour by the Natashkwan river which is about 1¼ miles wide at its mouth. The season is short, the sands are exposed to heavy erosion and readjustments during storms; fogs are of common occurrence.

Provided the difficulties in connexion with shipping can be overcome, and provided also it is found possible to come to terms with the owners, there would seem to me to be reason to think the ore could be sold in the form of concentrate or even briquettes, at a profit. It would, of course, be out of the question to consider making pig iron on the spot with such a small tonnage of ore as that existing in the beach in view."

Subsequent to the above examination and in connexion therewith, samples of the crude sand were sent to Sweden for experimental testing. Results were as follows:—

"Two samples of titaniferous iron sand.

1.—Sand poor in iron.

2.—Sand rich in iron.

SAMPLE 1.—POOR SAND:—

a.—Sizing of the average sample gave the following sizes:—

Size of aperture of sieve.	Percentage retained.
2 mm	0·50
1 "	3·30
½ "	38·00
¼ "	21·00
⅛ "	32·00
Less than ⅛ mm	4·60
	99·40

MAGNETIC SEPARATION.

On treatment the average sample gave:—
100 parts of raw sand:—
10·9 parts of concentrate No. 1.
89·1 parts of tailings No. 1.
The analysis gave the following results:—
Raw sand:—18·60 per cent iron.
4·02 per cent titanium.
Concentrates No. 1.....65·60 per cent iron.
2·60 per cent titanium.
0·001 per cent sulphur.
Tailings No. 1......12·70 iron.
Recovery of iron....38·70 per cent.

b.—The concentrates were crushed to a $\frac{1}{8}$ mm. size and concentrated with the following results:—
Out of 100 parts of concentrate No. 1:—
89·40 parts of concentrate No. 2.
10·60 parts of tailings No. 2.
The analysis gave the following results:—
Concentrate No. 2.........69·80 per cent iron.
1·70 per cent titanium.
0·004 per cent phosphorus.
Tailings No. 2............30·20 per cent iron.
Recovery of iron..........95·10 per cent.
Résumé:—100 parts of raw ore
gave:— .... 9·70 parts concentrate No. 2.
90·30 parts tailings 1 and 2.
Total recovery of iron.....36·70 per cent.

SAMPLE 2—RICH SAND.

a. Sizing of the average sample gave the following sizes:—

Size of aperture of sieve.	Percentage retained.
1 mm	0·1
$\frac{1}{2}$ "	0·6
$\frac{1}{4}$ "	3·2
$\frac{1}{8}$ "	81·8
Less than $\frac{1}{8}$ mm	13·9
	99·6

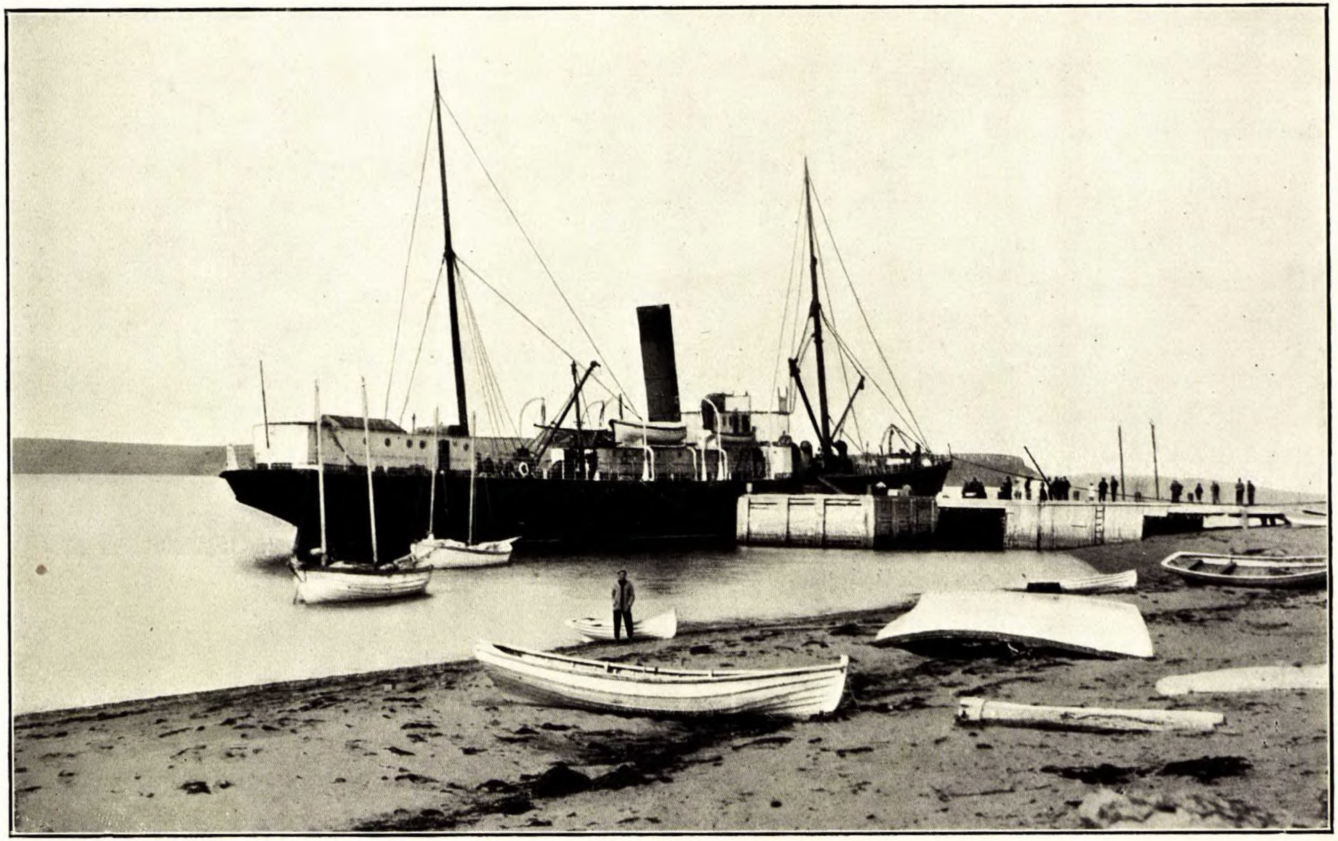
The average sample from one bag was treated by the magnetic separator and gave:—

Out of 100 parts of raw sand:— 42·2 parts concentrate No. 1.
57·8 parts tailings No. 1.
The analysis gave the following results:—
Raw sand: 54·80 per cent iron.
7·70 per cent titanium.
Concentrate No. 1:— 69·6 per cent iron.
1·4 per cent titanium.
0·003 per cent sulphur
Tailings No. 1: 43·9 per cent iron.
Recovery of iron:—53·60 per cent.

18801—p. 8.

Summer camp of Mountain Indians, mouth of Great Natashkwan river.

18801—p. 8. Canadian Government Indian Agent—Dr. Hare of Harrington—taking census of Indians, and administering vaccine.



S.S. Aranmore, Holliday Bros., Quebec, plying between Quebec, Harrington, and intermediate points.

Roman Catholic church, Natashkwan harbour.

b. "The concentrate No. 1 was crushed to $\frac{1}{6}$ mm. size and reconcentrated giving the following results:—

Out of 100 parts concentrates No. 1:—
96·60 parts concentrates No. 2.
3·4 parts tailings No. 2.

which analysed as follows:—

concentrates No. 2........70·5 per cent iron.
0·9 per cent titanium.
0·005 per cent phosphorus.
tailings No. 2.............44·00 per cent iron.
Recovery of iron:—97·80 per cent.
Résumé:—100 parts of raw sand gave:—
40·7 parts concentrate No. 2.
59·3 parts tailings 1 and 2.
Total recovery of iron:—52·4 per cent."

With regard to the briquetting tests with the above concentrate, the following extract from a private letter to the author will be of interest:—

"You will note that the titanium was reduced to a very satisfactory percentage when the iron sands were first crushed to $\frac{1}{6}$ of a mm. It was found, as you surmise, not easy to produce good briquettes with the natural concentrated sand on account of the water worn nature of the particles. By crushing, which can be done very cheaply in the Gröndal ball mills, this difficulty was overcome and beautiful briquettes produced. The crushing serves a dual purpose: 1st to eliminate the titanium in the concentration process; and 2nd for the production of a firm, coherent briquette."

For the past two years the Mines Branch has been collecting information with regard to these various sand deposits. Much of this information is fragmentary, indefinite, and contradictory, making it exceedingly difficult to form conclusions as to the relative value of the various occurrences. However, the evidence seemingly pointed to one outstanding fact, namely, that the sands of Natashkwan were on the whole more promising than any of the others. It was decided, therefore, to limit any primary investigation to the Natashkwan deposit, and if this place proved disappointing the other localities mentioned would in all probability be unworthy of attention.

In view of the fact that the ownership of some of the iron sand locations at Natashkwan has been transferred from the original patentees, an effort was made to secure from the Registrar of deeds and titles at Tadoussac, county of Saguenay, Quebec, a list of the present owners.

The Registrar was, however, unable to supply such a list as there was record of only one transfer, namely, Block A situated on the south bank of the river and north of the beach and dune lots, comprising some 4,000 acres sold May 1, 1907, to F. H. Markay, Esq., of Montreal.

The following list obtained from the Department of Colonization, Mines and Fisheries, Quebec, gives the names of the persons with their addresses who obtained the original concessions, just as they appear in the Letters Patent.

TABLE II.

List of the names, with their addresses, of the persons who obtained from the Crown, Mining Concessions in the townships of Natashkwan, Duval, Kegashka and Muskwaro, county of Saguenay, Quebec.

Henry Thomas	Montreal, Quebec.
A. Laflamme	"
Th. Labatt	"
Jean Langlois	Quebec, Quebec.
Abraham Joseph	"
Cirice Tetu	"
Pierre Garneau	"
Georges Duval	"
J. Guillaume Bossé	"
L. C. Fiset	"
Daniel Hoctor	Montreal, Quebec.
Elzéar Fiset	Quebec, Quebec.
J. H. R. Burrough	"
G. H. Larue	"
Robert Archer	"

As the above concessions were obtained many years ago, and as it is well known that transfers have been made without registration of the same, there will no doubt be some difficulty in establishing clear title to many of them.

"However the original deeds are registered in Quebec and they are the authoritative record of ownership, so long as they have not been superseded by registration at the county Registrar's office in Tadoussac. To take a concrete example: "A" obtains an original grant from the Crown of lot No. 1,000 at Natashkwan. He sells this lot to "B", neglecting to register the transfer at Tadoussac. Later on "B" wishes to sell to "C". "C" makes search and finds that the only registration is the original one at Quebec. He can then have registration of the transfer from "B" to "C" duly entered at Tadoussac and his title is clear without the intervention of "A" in any way. If in the meantime "A" had sold the same lot to "D" and "D" has had this transfer registered at Tadoussac before "C" got his, "D"s title has priority, and "B" can only have recourse against "A" without "D"'s title being affected. While the civil law of Quebec requires the registration of transfers, this requirement does not imply a compulsion to do so under penalty of invalidation. But the recording of such transfers will secure their validity against subsequent ones.[1]"

General Description of the Great Natashkwan River and its Magnetic Iron Sand Deposits.

The great Natashkwan river enters the Gulf of St. Lawrence on the north shore about opposite the east end of Anticosti island, approximately 530 miles northeast of the city of Quebec. The mouth of the river between low sandy points is a little over one mile wide, but is almost filled by a sandy island, with narrow channels on either side. At the entrance of each channel, sand bars have formed and are usually covered with surf. Both channels are suitable only for the entrance of small schooners, fishing boats, and similar craft.

[1] Theo. Denis, Supt. of Mines, Quebec.

The river inside and above the island is full of shifting sand bars, many of which are absolutely dry at low water, and is navigable for small boats only up to the first falls, 12 miles inland. On the north side, at the mouth of the river, there are a few scattered fishermen's dwellings, also a small post of The Hudson's Bay Company.

From the mouth of the river a sandy beach extends northeastwardly a distance of 4 miles and terminates at the mouth of the Little Natashkwan river—a very small stream that admits fishing craft only at high water. Natashkwan fishing village, situated on the south side of the Little Natashkwan river, has a population of probably three hundred, all of whom are French Canadian and all engaged in the fishing industry. The village contains a Roman Catholic church, a post-office, a school, and a station of the Canadian Government telegraph system.

Natashkwan[1] harbour is formed on the east and west sides by a number of rocky islands of Laurentian granite, off the entrance to the Little Natashkwan river. The north side is formed by the mainland and is also of granite. The entrance to the harbour is divided by "Central" reef of rocks with channels 180 yards wide on each side. The western channel has a depth of 3 fathoms, the eastern 5 fathoms, the latter being used entirely by large vessels. Anchorage space within the reefs has a diameter of about one-fourth of a mile each way, with a depth of from 3 to 5 fathoms, sand and mud bottom.

During the summer of 1911 a Government wharf was constructed on the east side of the harbour. This wharf is 30 feet wide, extends 400 feet at right angles to the shore, and has 14 feet of water at its outer end at low tide. On the east side of the entrance to the harbour is established a white fixed light with a range of 11 miles.

Southeast of the mouth of the Great Natashkwan river, a long sandy point or peninsula has formed between the river and the sea. On the river side it is heavily wooded to the water's edge up to within a mile of the mouth. The side facing the sea consists of a wide sandy beach that extends a distance of 14 miles eastward. Behind the beach and for a distance of 4 miles from the mouth of the river there occurs a considerable area of grassy dunes. The width of the dunes from the edge of a low sandy cliff overlooking the beach to a thick bush of jack-pine, spruce, and balsam does not average more than 500 feet.

Here it is that the black sands are found, occurring in more or less irregular patches and layers throughout the dunes and beaches. They persist for some 6 or 8 miles eastward along the coast, although apparently the richest ground lies between the mouth of the river and Mt. Joli, a small hill that forms the easterly terminus of the dune area.

Inside the river no black sand is found on the north bank, excepting a few valueless patches at the extreme mouth. On the south bank black sand is much more in evidence and may be seen in intermittent layers, comparatively low, and only small quantities of the black sand are seen alternating with ordinary sand in high sandy cliffs for a distance of 1½ miles in from the mouth. Beyond this distance the south bank is close to the water's edge.

The north bank for a distance of 6 or 8 miles is high and sandy and is fringed with a thick growth of jack-pine, spruce, balsam, poplar, and birch. Peat, in a more or less semi-humified condition and from 4 to 10 feet thick, overlies the sand in intermittent deposits. Here and

[1]St. Lawrence Pilot, Seventh edition, 1906.

there the bank is stained with yellow ochre, a ferruginous leaching from the overlying bogs. Several of the fishermen have used this ochre for painting their dwellings, and it was naturally concluded that the material would be found in some quantity. All that was seen, however, was a scanty and uneven coating on the sands and boulders at the foot of the cliffs. This coating is sometimes found half an inch thick, but would require at least half a day's labour for one man to collect enough of the softest and best to fill a gallon pail.

Four miles from the mouth a fine grey-coloured clay makes its appearance, lying underneath the sand and with a slight dip towards the mouth of the river. The clay continues on each bank for a distance of 5 miles, giving place to Laurentian granite. With the appearance of the granite the river turns north, flowing with a swifter current between rocky islands. There are three or four large islands heavily wooded with small timber. At the head of the last island the Government coast telegraph line crosses the river. A fourth of a mile above the last island is situated the first falls. These falls have a drop of 12 to 15 feet and are divided into two chutes by a small rocky island. At this point a United States fishing club has a large permanent camp on the south bank, and during the fishing season kill a great many salmon.

A short distance above the first falls are situated the second and third falls. These are more important than the first, as regards possibilities of power development, their heights being 18·38 and 45·0 feet respectively, with an average distance of 15 miles from the mouth of the river. The writer did not visit these falls, and is indebted for this information to Mr. A. O. Beauchemin, engineer for the Canadian Commission of Conservation.

Above the first falls, black sand is found on both banks wherever the contour of the shore has allowed it to accumulate. Test holes were bored 10 or 15 feet from the river's edge, half a mile above the falls, but no black sand was found within 12 feet from the surface, at which depth bed-rock was encountered. A sample taken at the water's edge contained 1·5 per cent of magnetic material.

Tide water never rises above the first falls; hence any black sand found above these falls must have come from ferruginous deposits higher up the river. This fact is so evident to even the most casual observer, that its statement seems unnecessary were it not required to controvert the theories of black sand origin from disruption of ferruginous coast rocks through the agency of waves and tides.

Test bore-holes 14 feet deep were sunk on the south bank of the river, 5 and 9 miles respectively from the mouth. These samples yielded only 1·5 per cent of magnetic material. It would seem, therefore, that the sand on the south bank, near the water's edge, contains the black sand in about the proportion in which it was originally brought from the interior. Concentration of the black sand does not take place to any extent, until the sands reach the sea and are thrown on the beaches by storms and tides.

The river, with its swift current and rocky bed, carries its load of sand with comparative ease to a point 2 miles below the first falls at the end of the islands. Here the current is slackened considerably by the stream widening to three-fourths of a mile or so, and from this point to the mouth the sand is deposited in heavy bars. These bars are being shifted constantly by the river current, the incoming tides and strong winds that whip the lighter and drier sands from the surface of the bars and carry it in clouds for long distances. Twice in every twenty-four hours the incoming tide presents a barrier to the river's current, causing the sand in suspension to deposit at a rapid rate. With the turn of the tide the river's current is accelerated, and a large volume of sand is swept towards the mouth. This cycle of movement constantly in operation carries the sand out of the river and over the bars at its mouth.

There are, then, four agencies contributing to the movement of the sand, one or more being constantly at work:—

(1) The river's normal current, always tending to carry sand slowly towards the mouth.

(2) The incoming tide, reversing the flow for 12 miles in from the mouth, causing the river to deposit its suspended load, and also carrying considerable quantities of sand up-river.

(3) Winds, either up or down stream, whipping the dry sand from the surface of the bars at low water.

(4). The outgoing tide plus the river's current causing the sands to rush towards and out of the river's mouth.

It should here be emphasized that the bed of the river for a distance of 8 or 10 miles in from the mouth consists entirely of sand. As regards its depth and black sand content, the writer is unable to make definite statement, because the boring tools at his command were not suitable for testing wet ground.

Thin irregular bands of black sand are being continually formed along the edges of the bars, and then destroyed by the alternate tidal flow. It is probable that the major portion of the ferruginous sand is discharged into the sea, but it is quite possible that large quantities have settled through the lighter sand and accumulated towards the bottom of the river bed.

The sands with their quota of magnetic material, having been carried out of the river, are then slowly moved eastward and driven up on the beaches by the tides and prevailing southwesterly gales. It is here that nature's efforts towards concentration of the black sand are most marked. Wave action throws the sand on the beaches and the constant wash of the water carries the lighter particles ahead of the heavier black sand. This leaves the latter lying in thin bands and layers parallel to the shore, successive waves adding fresh material and continually sorting the lighter from the heavier minerals. Each successive tide carries the sand a little farther up the beach depositing newer material behind it; hence a layer of black sand formed to-day at the edge of the water will in a short time be found some yards inland.

The rate at which the points on both sides of the river's mouth are growing is illustrated by the accompanying photographs. The flat low-lying portions have been deposited within ten years. This new ground on the south bank was measured and found to be 2,300 feet, hence it has grown at the rate of 230 feet yearly. It is, of course, necessary to state that the points are growing faster than the beaches proper as they are in a more favourable position to receive the bulk of the sand.

After the sand has been thrown on the beaches by waves and tides, the wind plays an important part in its distribution and further concentration. As the top layers of sand become dry, the lighter particles are blown away from and ahead of the heavier black sand. The black sand is also moved by the wind, but at a much slower rate. In consequence of this wind action, the sands are continually working inland forming dunes and ridges in long undulating rolls, parallel to the shore. Inasmuch as the lighter particles are blown ahead of the black sand, the dunes would supposedly be relatively leaner in magnetic material with their distance from the sea. This supposition has not been proved absolutely, but attention is called to the fact that a series of drill holes on the river side of the peninsula did not show an average content of magnetic material as high as a coresponding series nearer the sea.

While no positive evidence was established regarding the exact condition of black sand distribution in vertical and horizontal directions, it will be of interest to discuss and form a possible theory of its deposition across the peninsula.

It is evident that the peninsula has grown and is still growing in width from south to north. Hence it follows that, provided the river sands have always contained magnetic material, the layers of black sand were deposited on the beach of the newly formed and narrow peninsula just as they are to-day. As the peninsula widened, the layers of black sand were covered by later and additional material, the dry surface sands being gradually shifted by the prevailing southwest winds and accumulated in dunes towards the river bank. The wind moved the layers of black sand also towards the river and would in all probability widen and thin out these bands. The dunes as they became covered with a thick growth of rank grass were protected against excessive erosion by wind and rain storm, yet porous enough to allow the quick escape of surface water by percolation through the underlying sand.

A mile and a half from the west end of the peninsula a thick growth of forest extends from the river bank to within a few hundred feet of the sea and extends easterly for 4 or 5 miles. This area under forest was no doubt during its formation identical in general structure with the treeless dunes farther west, but as the forest growth increased it prevented the wind-driven sands from advancing much beyond its southern limit. The forestation also prevented the rapid escape of surface waters, which, held in check, formed numerous small streams that very gradually levelled the original rolling dunes.

In the gradual process of erosion and levelling of the dunes under forest, the original banded black sand structure would be destroyed and the ferruginous material scattered in all directions, a large proportion finding its way back to the river and sea. This process is going on at the present time and many of these small streams contain appreciable quantities of black sand along their banks and beds. Heavy rains and spring freshets of melting snow would no doubt penetrate some distance below the surface before finding the level of the river and sea. This would result in effecting a gradual settlement of the heavy ferruginous particles, concentrating this material in depth. The accompanying ideal sections across the peninsula illustrate this theoretical condition as above outlined.

The bands or layers of natural concentrate vary considerably in thickness from a fraction of an inch up to a foot or more. Their length and breadth are also extremely variable, the former being anywhere from 10 to 50 feet, the latter from 1 to 10 feet. Hence there is no continuity of individual layers; they lie rather in scattered and staggered position throughout the dunes with a gentle dip towards the sea.

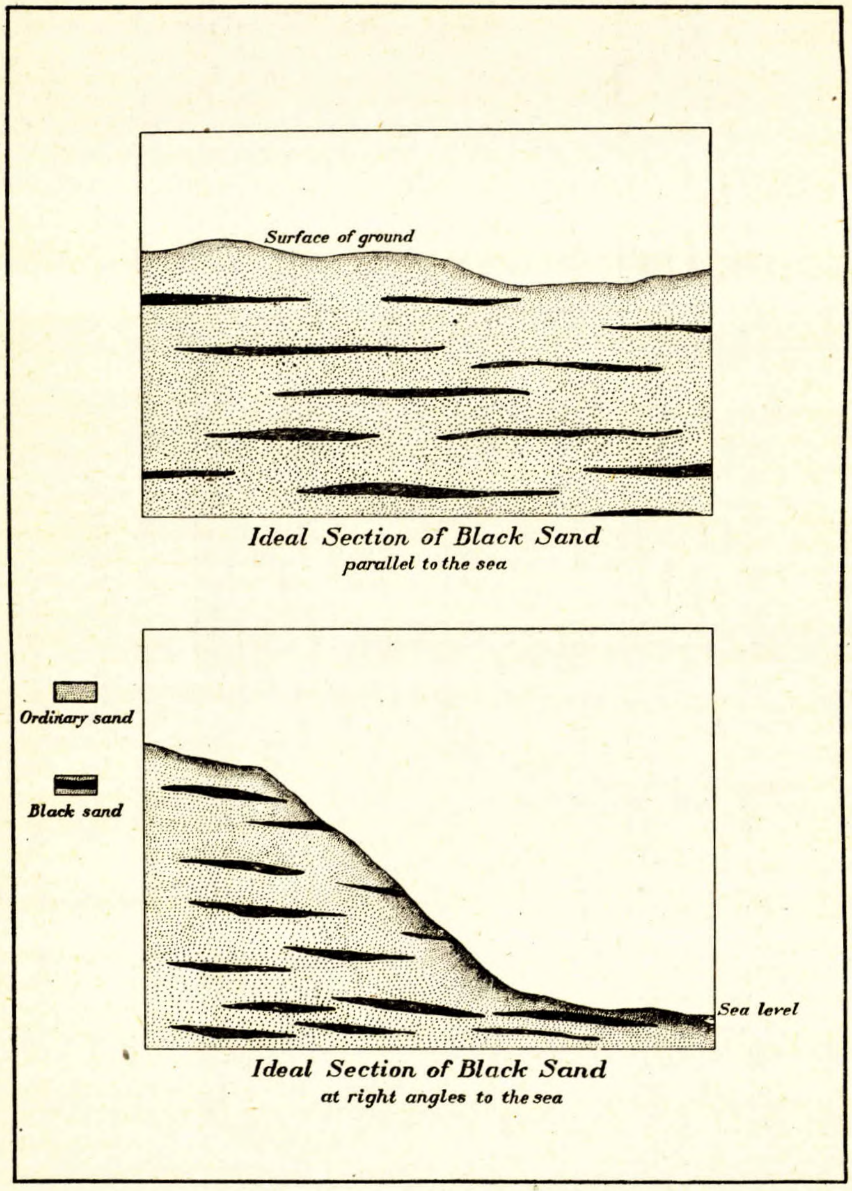
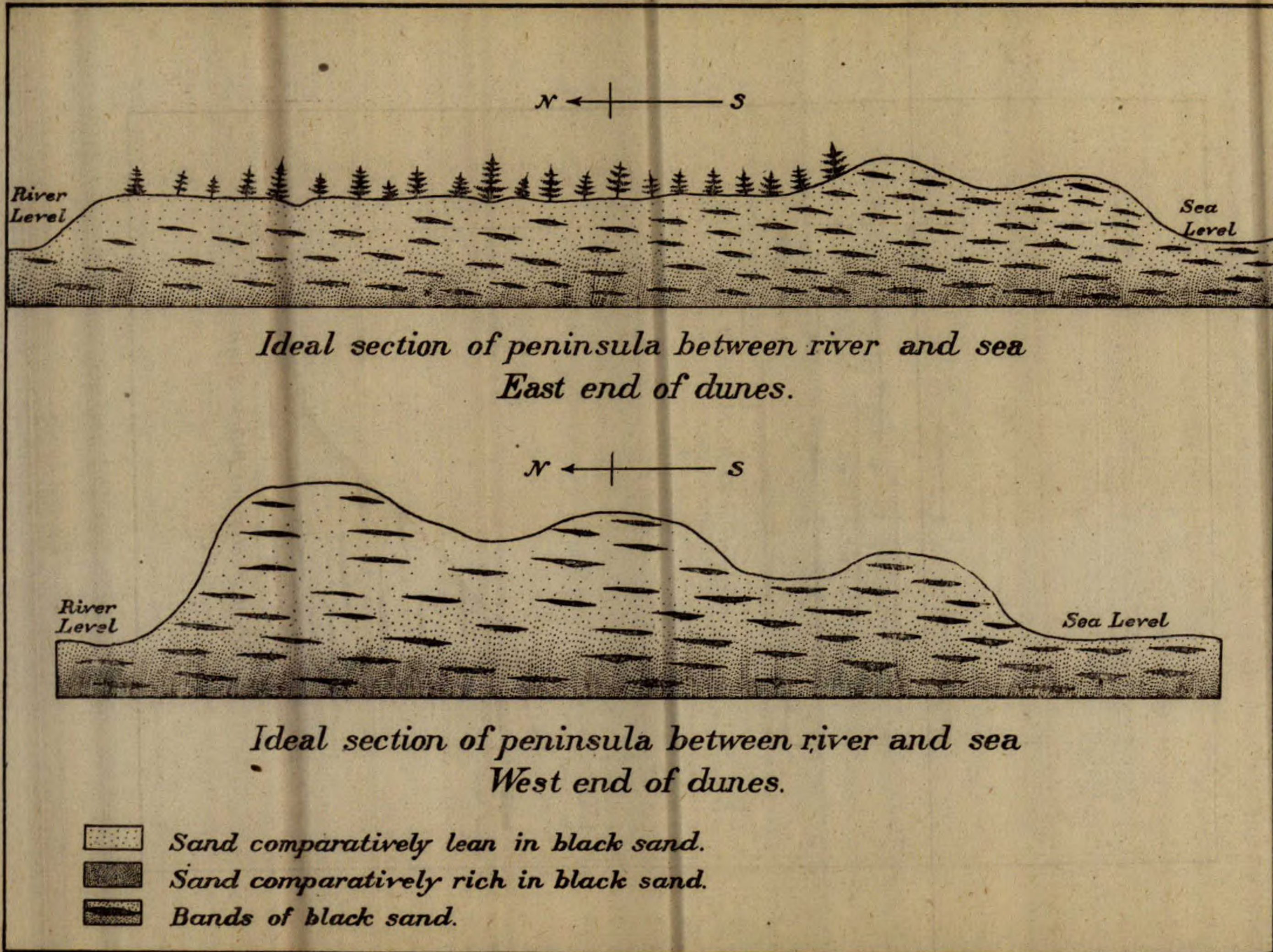

Surface of ground
Ideal Section of Black Sand
parallel to the sea
Ordinary sand
Black sand
Sea level
Ideal Section of Black Sand
at right angles to the sea

Fig. 1.

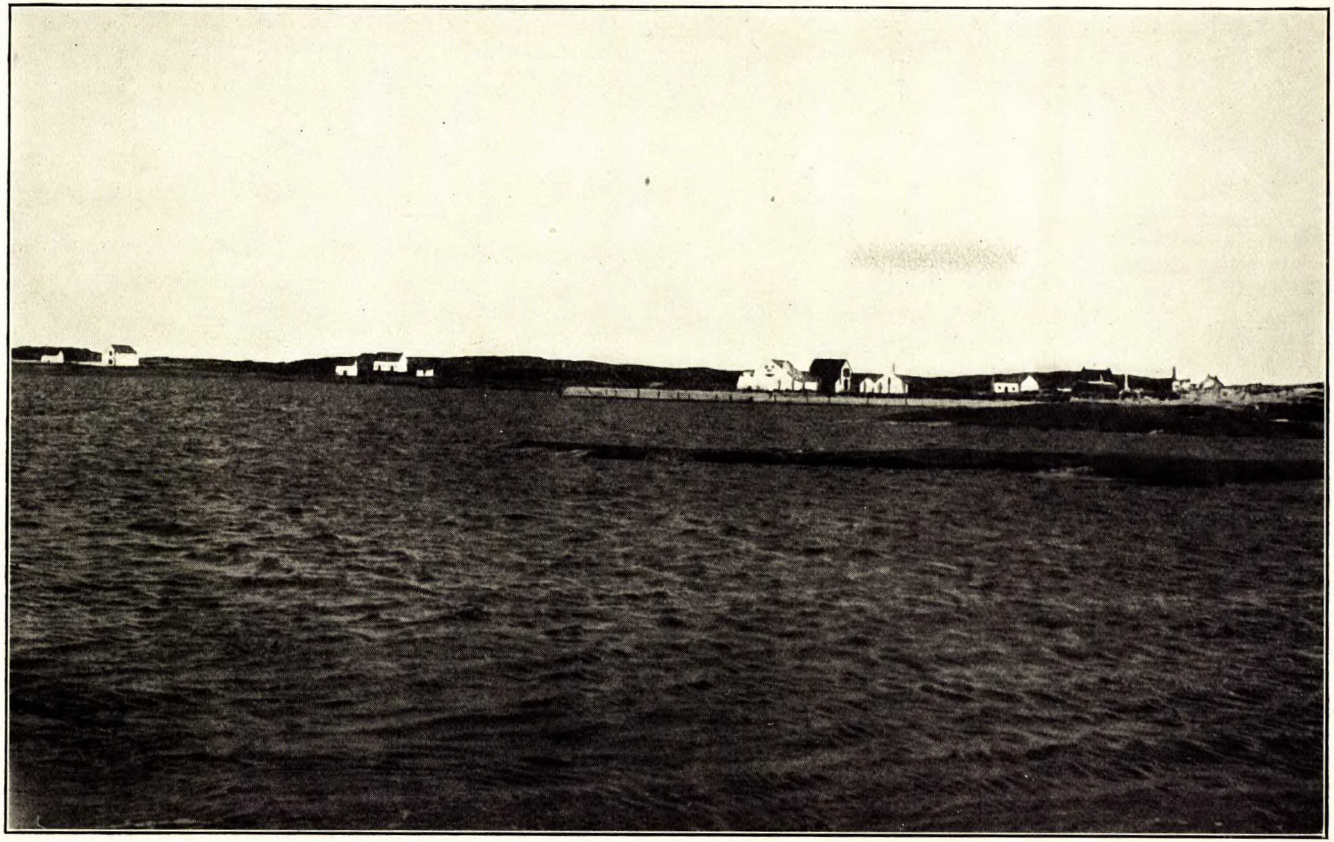


Ideal section of peninsula between river and sea
East end of dunes.

Ideal section of peninsula between river and sea
West end of dunes.

Sand comparatively lean in black sand.
Sand comparatively rich in black sand.
Bands of black sand.

FIG. 2.



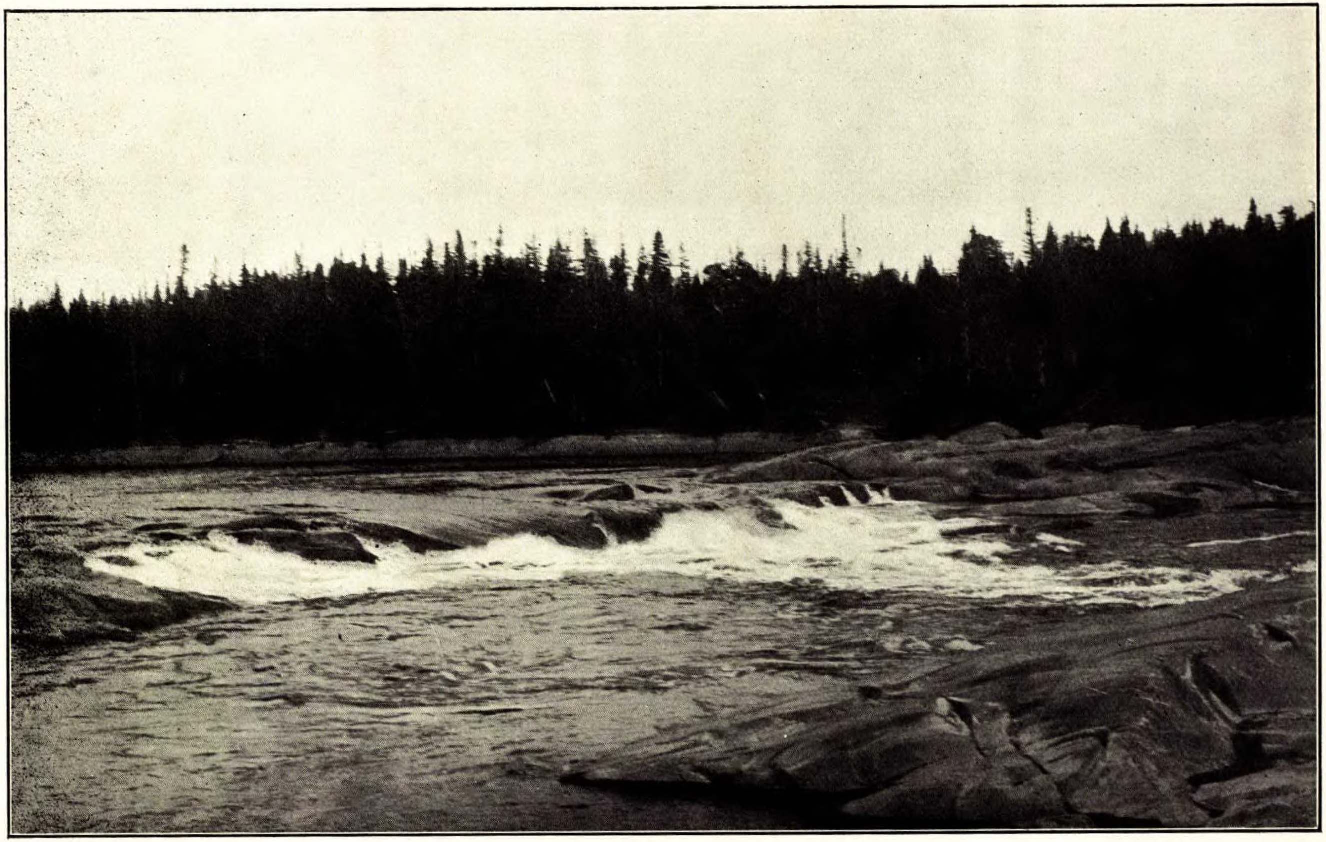
18801—p. 16.

Entrance to Natashkwan harbour.

18801—p. 16.

Fisherman's family and dwelling, Natashkwan harbour.

18801—p. 16. Government dock under construction, Natashkwan harbour.



18801—p. 16.

First falls, Great Natashkwan river.

It is, therefore, evident that any given cross section at right angles to the sea may cut a maximum or minimum number of black sand bands and, therefore, contain magnetic material much above or below the average content. This renders an accurate sampling and estimation of tonnage very difficult.

It was originally intended to survey two areas each 50 chains wide parallel to the sea and 100 chains deep, subdivide each area into blocks two chains square, and then sample by boring holes at the corners of each block. However, a reconnaissance showed that while bore-holes of fair average depth could be sunk in the grassy dunes, holes in the lower and swampy bush area could not be put down more than 7 feet below the surface on account of the watery condition of the ground. As these shallow holes did not penetrate much below plant soil, the samples therefrom contained very little black sand. It was, therefore, considered unfair to make any calculations of black sand tonnage underlying the bush area from such shallow test holes.

The only alternative was to block out and sample the grassy dune area lying between the bush and the edge of the bank overlooking the beaches. This was accomplished by running a base line through the centre of the dune area parallel to the sea and making offsets right and left to the beach and bush every 250 feet.

Three bore-holes were put down on each offset, one at each end and one at the point of intersection of the offset with the base line. The holes were sunk with an ordinary 7″ sand auger attached to drill rods of ¾″ iron pipe. The rods were cut in 3½ and 7 ft. lengths, the method of drilling being as follows.

A shallow cut was first made through the grass sod with a round nosed shovel, and the auger started with 3½ ft. length of pipe attached. A "tee" pipe joint screwed to the upper end of the rod received a short wooden handle, allowing the driller to rotate the auger. After the 3½ ft. length of pipe was "down" the drill was withdrawn and a 7 ft. length substituted. In this manner, using alternate lengths of pipe as required, the holes were drilled to the water level.

The sand cores were "pulled" in about 8″ to 12″ sections, each 3½ feet of core being piled in a cone by itself near the mouth of the hole. When the hole was finished the core piles each representing 3½ feet of depth were sampled, the accumulated sample being bagged and tagged with the survey number of the hole and its depth. No difficulty was experienced in drilling to the water level. If care is taken to keep the hole vertical, the sides will not cave although it requires some practice to draw 10 inches of core from a depth of 20 feet without knocking the core off the auger. When the water level is reached this type of drill is obviously at its limit. The loose watery sand will not stand, rendering further progress impossible.

In the dune area 158 holes were drilled, their depth varying from 6 to 22 feet, with 16·3 feet of an average. A second series of holes, 13 in number, was drilled across the peninsula from sea to river, but as these holes were in swampy ground, their depth did not average over 5 feet. A third series drilled in a high ridge of bush land near and parallel to the river bank, were sunk to an average depth of 17 feet. Core samples from these holes were found to contain more black sand than the cores from holes across the peninsula, but not as much as from those obtained in the dune area.

Including the three samples taken some distance up the river, the total number of samples secured was 189, weighing together a little more than 8 net tons. These samples were shipped to Ottawa for subsequent analyses and magnetic separation tests.

Sampling and Magnetic Separation Tests at Ottawa.[1]

As previously mentioned, all samples, constituting some 8 tons of sand, were shipped to Ottawa for re-sampling, assay, and magnetic separation tests. This work was carried out at the Ore Dressing and Metallurgical Laboratory of the Mines Branch in Ottawa.

Each bag of sand was first dried to bone dryness and then cut down by means of a Jones sampler, to a small sample of 100 grammes for subsequent magnetic separation tests by hand. The sand from each bag was then weighed in a measured box to obtain its weight per cubic foot, after which it was re-bagged to await the main test with the Gröndal magnetic separators.

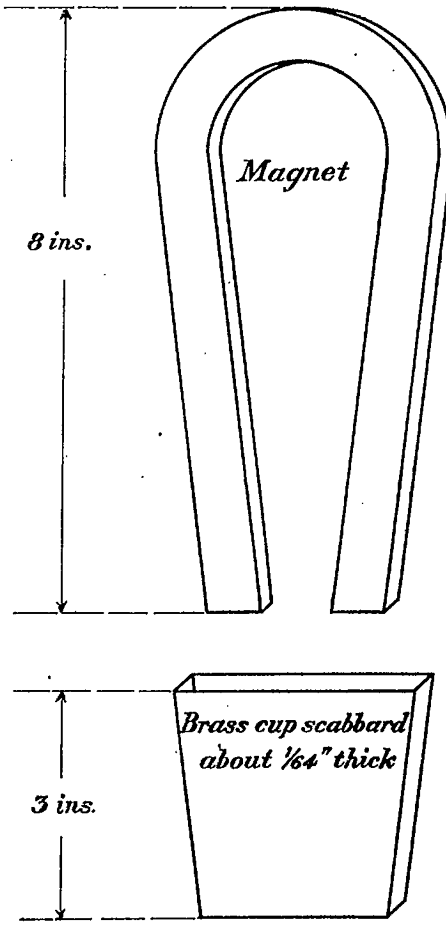
Throughout this work all samples were taken by means of the Jones sampler, which, it was expected, would give more reliable samples than the ordinary method of coning and quartering. The latter method would have yielded rather indifferent results, because the black sand has a strong tendency to settle towards the bottom of the cone.

The 100 gramme samples, each representing original bags of sand, were then examined for percentage of magnetic concentrate by means of the permanent horse-shoe magnet and brass cup scabbard (shown in the accompanying illustration). These tests were made under water, the method being as follows:—

The sample contained in a 6″ evaporating dish was covered with water, care being taken to submerge all particles of dust. The magnet inside its scabbard was then moved about through the wet sand, picking up a small load of the magnetic material The load of magnetic concentrate was then transferred to a second dish, and released by withdrawing the magnet from its scabbard. This operation was repeated until the sand was practically free of all magnetic material. The first concentrate thus obtained was then reconcentrated in a similar manner three, and more often four, times, until it appeared clean and free from gangue minerals.

The figures representing the weights per cubic foot of dry sand, percentage of concentrate, and depth for all bore-holes, are tabulated below. These figures were used in tonnage calculations, but are given here, as they belong more properly under the heading of sampling and separation.

[1]All chemical analyses made in The Mines Branch Laboratory by H. A. Leverin, Ch.E.



Magnet and cup scabbard for making magnetic separation tests by hand.

FIG. 3.

TABLE III.

Bore-hole Records.

PERCENTAGE OF MAGNETIC CONCENTRATE, AND WEIGHTS PER CUBIC FOOT OF THE DRY CRUDE SAND.

Location.	Bore-hole.	Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
Dune area, south side of peninsula, facing sea.	Number.	Feet.	Per cent.	Pounds.
	1	21	3·5	99·5
	2	19	2·0	98·5
	3	18	7	99·5
	4	20	4·5	101·5
	5	14	1·5	97·5
	6	18	5·5	106
	7	16	4·5	99·5
	8	21	5·0	104·5
	9	18	12·0	114·0
	10	16	2·5	99·5
	11	19	3·0	98·5
	12	21	9·0	106
	13	13	2·5	103·5
	14	17	4·0	100·5
	15	21	6·0	100·5
	16	13	2·0	95·5
	17	14	20·5	126·0
	18	20	7·5	105·5
	19	13	2·0	99·0
	20	17	9·0	105·5
	21	18	6·0	99·5
	22	10	4·0	100·5
	23	16	8·0	109
	24	18	7·5	100·5
	25	11	4·5	105·5
	26	15	8·5	103·5
	27	20	2·5	97·5
	28	11	5·5	101·5
	29	15	9·0	106·5
	30	15	18·5	105·5
	31	12	2·5	107·5
	32	14	14·5	121·5
	33	17	6·5	107·0
	34	12	3·0	108·0
	35	17	22·0	131·5
	36	18	10·5	106
	37	13	6·0	107·5
	38	17	16·5	125·5
	39	20	10·0	116·5
	40	15	3·0	101·0
	41	16	13·5	119·0
	42	17	8·5	110·0
	43	15	7·5	109·0
	44	16	16·5	119·5
	45	18	3·5	108·5
	46	13	10·5	112·5
	47	15	23·0	123·5
	48	22	3·0	95·5
	49	13	11·0	114·5
	50	18	7·0	107·0
	51	21	5·0	102·5
	52	14	17·5	120·0
	53	15	24·0	128·0
	54	19	7·5	106·0
	55	15	14·0	116·0
	56	20	10·5	106·5
	57	13	5·0	101·5
	58	21	2·0	101·5

TABLE III.—*Continued.*

Location.	Bore-hole.	Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
Dune area, south side of peninsula, facing sea.	Number.	Feet.	Per cent.	Pounds.
	59	20	9·5	115·5
	60	18	7·0	107·5
	61	20	15·0	118
	62	21	16·5	115·5
	63	13	15·5	115·0
	64	19	12·5	123·5
	65	20	7·5	113·5
	66	21	3·5	98
	67	16	12·0	112·5
	68	20	5·0	106·5
	69	20	5·5	99·5
	70	16	13·5	124·5
	71	18	10·5	107·5
	72	18	11·5	105·5
	73	15	9·0	104·0
	74	19	2·0	98·5
	75	18	16·0	113·5
	76	14	8·0	103·5
	77	20	6·5	110·5
	78	19	8·0	95·5
	79	11	11·5	106·0
	80	20	13·0	109·0
	81	19	10·5	107·0
	82	10	9·5	118·5
	83	19	13·0	108·5
	84	18	10·0	105
	85	11	1·5	95·5
	86	19	10·0	109·5
	87	19	6·5	107
	88	9	10·0	107
	89	19	14·0	104
	90	17	7·5	106·5
	91	11	10·5	110·5
	92	18	6·5	106·5
	93	7	9·0	104·5
	94	12	11·5	117·5
	95	16	7·5	112·5
	96	17	12	110·5
	97	19	11·5	110·5
	98	15	7·0	95·5
	99	6	9·0	107·0
	100	14	19·5	126·5
	101	22	6·0	101·0
	102	21	2·0	99·0
	103	20	4·0	100·5
	104	19	7·0	104·5
	105	21	9·5	105·0
	106	22	11·0	97·5
	107	16	7·0	108·0
	108	21	7·0	104·5
	109	19	13·5	100·5
	110	19	2·5	96·0
	111	22	17·0	117·5
	112	19	2·5	105·5
	113	16	11·5	116·0
	114	20	15·5	124·0
	115	16	6·0	107·0
	116	9	16·0	123·5
	117	17	9·5	112·0
	118	14	21·0	135·5
	119	12	6·0	107·5
	120	18	8·5	105·5
	121	16	16·0	118
	122	10	13·5	123

TABLE III.—*Continued.*

Location.	Bore-hole.	Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
Dune area, south side of peninsula, facing sea.	Number.	Feet.	Per cent.	Pounds.
	123	18	7·5	103·5
	124	16	29·0	127·5
	125	16	9·0	115·0
	126	19	7·5	104·0
	127	16	0·5	95·5
	128	14	15·0	115·5
	129	16	5·5	103·5
	130	10	4·0	102·0
	131	16	8·5	109·5
	132	18	3·5	106·0
	133	15	8·0	106·5
	134	17	17·5	123·5
	135	17	5·5	108·5
	136	16	28·5	139·5
	137	14	14·0	115·0
	138	17	6·0	113·5
	139	15	6·5	110·5
	140	16	6·5	106
	141	14	8·0	116
	142	19	9·5	116·5
	143	12	9·5	111·0
	144	19	7·5	103·5
	145	22	15·5	116·5
	146	9	3·0	102·5
	147	10	3·5	100·5
	148	14	5·5	106
	149	22	6·5	99·5
	150	18	7·5	108·5
	151	11	4·5	100·5
	152	16	23·0	126·5
	153	13	6·5	110·5
	154	16	11·5	114·5
	155	5	12·0	110·0
	156	14	10·0	114·0
	157	10	3·5	100·5
	158	14	18·0	119·5

Arithmetical averages of the above figures are as follows:—

Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
Feet.	Per cent.	Pounds.
16·3	9·45	109·75

TABLE III.—*Continued.*

Location.	Bore-hole.	Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
	Number.	Feet.	Per cent.	Pounds.
Wooded area, across peninsula from sea to river.	159	7	3·0	102
	160	6	0·5	98·5
	161	4	0·5	96·0
	162	5	0·5	91·5
	163	4	Trace	104·5
	164	5	0·5	91·5
	165	5	0·5	87·5
	166	4	Trace	91·5
	167	6	0·5	92·0
	168	5	0·5	81·0
	169	6	0·5	92·5
	170	5	0·5	92·5
	171	6	0·5	105·5

Arithmetical averages of the above figures are as follows:—

Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
Feet.	Per cent.	Pounds.
5·2	0·61	94·3

TABLE III.—*Continued.*

Location.	Bore-hole.	Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
	Number.	Feet.	Per cent.	Pounds.
Wooded area, north side of peninsula, facing river.	172	16	9·5	108·5
	173	18	2·0	85·5
	174	22	5·5	101·0
	175	19	15·5	110·5
	176	21	3·5	97·5
	177	18	3·5	98·5
	178	18	1·5	97·5
	179	20	2·5	96·0
	180	21	5·0	102·5
	181	13	2·0	94·5
	182	21	7·0	104·0
	183	19	3·0	97·5
	184	21	1·5	95·0
	185	14	0·5	93·5
	186	4	1·0	88·0

TABLE III—*Continued.*

Arithmetical averages of the above figures are as follows:—

Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
Feet.	Per cent.	Pounds.
17·6	4·2	98

Location.	Bore-hole.	Depth of hole.	Concentrate.	Weight per cubic foot of dry crude sand.
	Number.	Feet.	Per cent.	Pounds.
Above first falls, Great Natashkwan river	187	Scoop sample.	1·5	95·5
South bank of Great Natashkwan river, below first falls	188	14	1·5	93·5
South bank of Great Natashkwan river, below first falls	189	13	1·5	92·5

It will be noted that the weight per cubic foot of the dry sand does not vary according to the percentage of magnetic concentrate. This is explained by the fact that the heavy minerals other than magnetite, i.e., ilmenite and garnet, are not present in any fixed proportion to the magnetite. A sample low in magnetic concentrate may have a relatively high weight per cubic foot, owing to a preponderance of ilmenite and garnet.

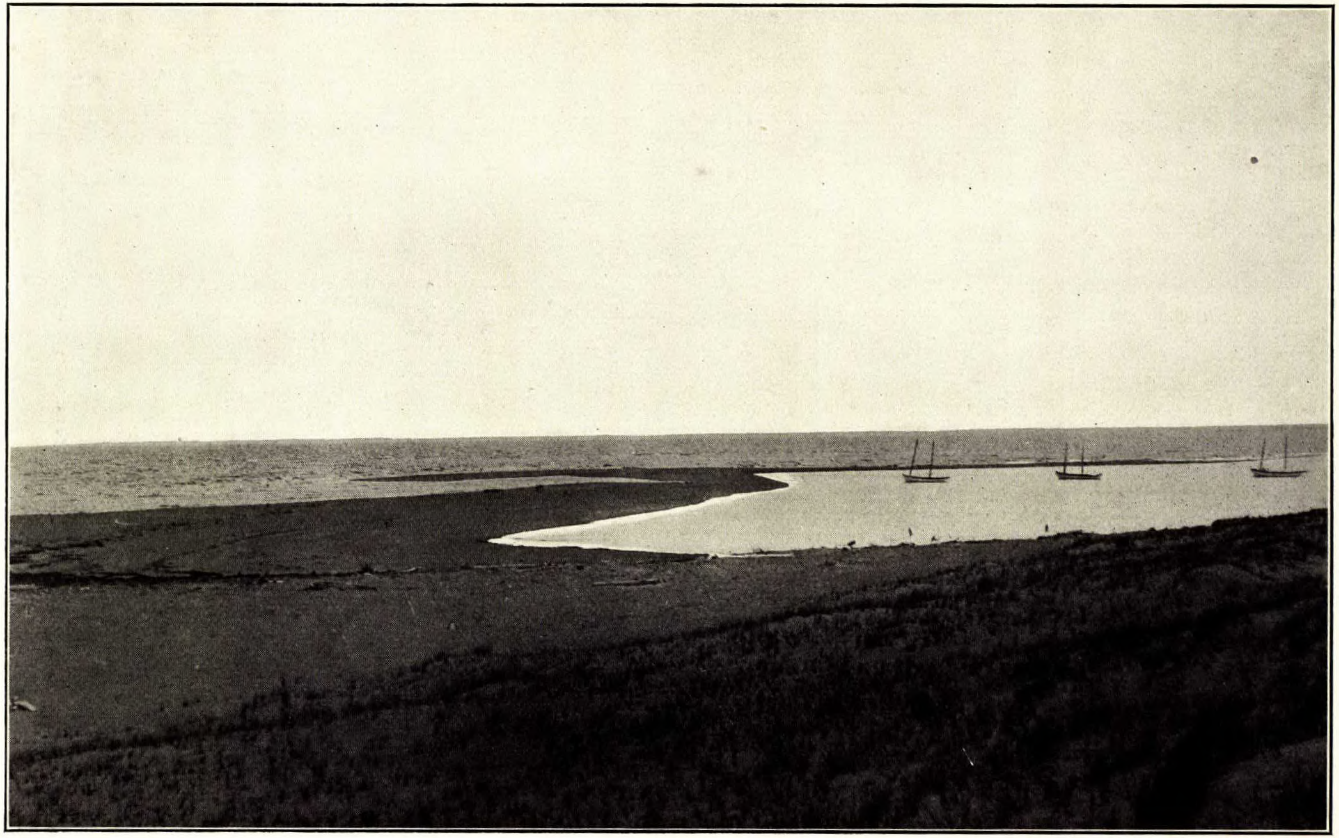
All concentrates and tailings of samples from the dune area were collected, and added concentrate to concentrate, tailing to tailing, as the tests proceeded. These accumulated heads and tails were then sampled and assayed, with the following results:—

	Concentrate.	Tailing.
Fe	68·10	8·30
TiO_2	2·5	3·17
SiO_2	1·00	
P	0·023	
S	Trace.	

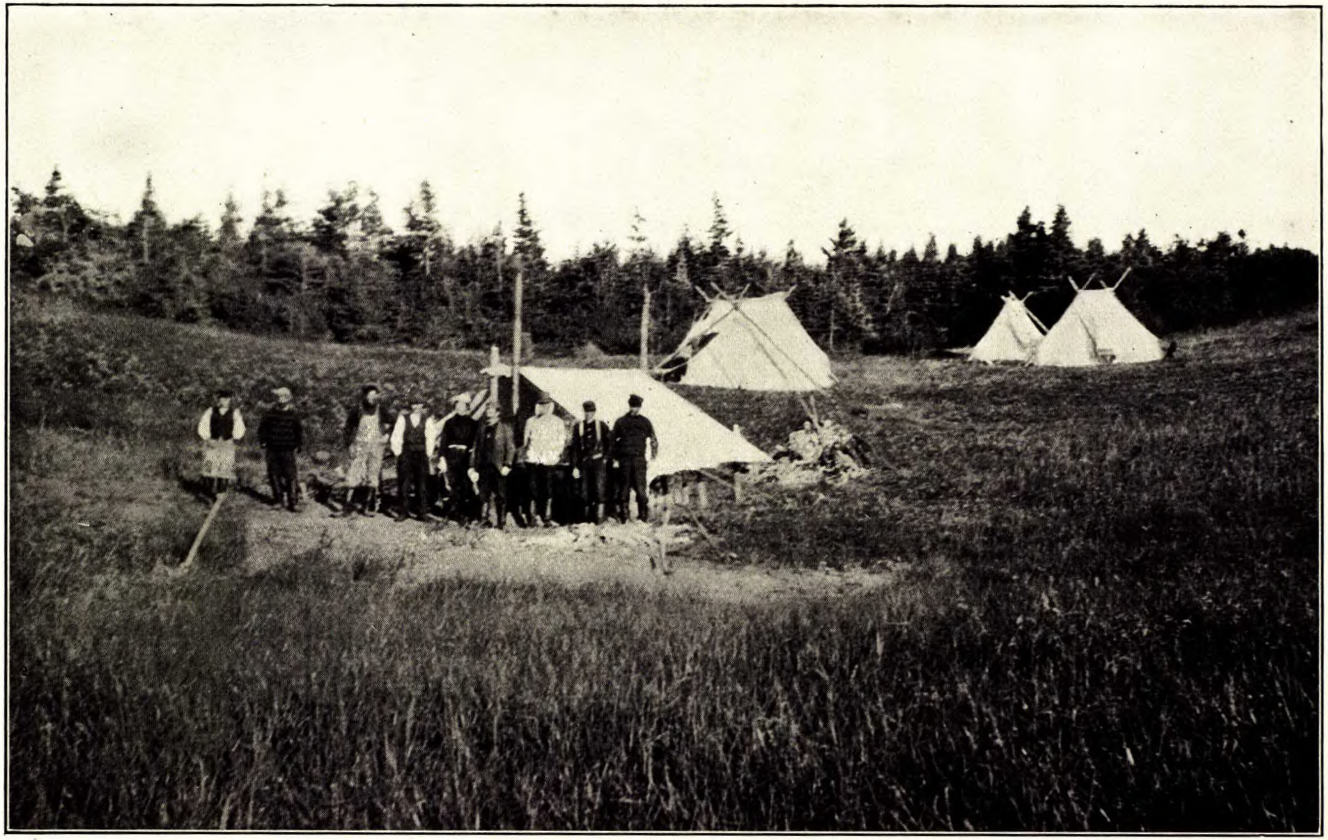
After the above hand tests were completed, the bags of sand from bore-holes in the dune area (158 in number) were sampled collectively, preparatory to magnetic separation by the Gröndal machines. A cubic foot of this general sample was found to weigh 108 pounds. This is a close check on 107·5 pounds per cubic foot, as deduced from subsequent tonnage calculations.

While the general sample was being taken, all the bags were brought to equal weight. This was necessitated by the fact that the hand tests had been made on samples of equal weight.

18801—p. 24. Mouth of Great Natashkwan river, south bank. The flat, low lying sands have accumulated in ten years.



18801—p. 24. Mouth of Great Natashkwan river, north bank. The flat, low lying sands have accumulated in ten years.



18801—p. 24.

Main camp, south bank, Great Natashkwan river.

18801—p. 24.

Sand dunes broken by wind, west end of dune area.

After sampling, the sands were fed through a 10 mesh screen, to remove chips, grass, etc., and thence direct to the Gröndal separators. These machines are mounted in tandem, the first separator acting as a rougher, the second as a finisher. They consist of (1) horizontally rotating brass drums, containing a system, (2) of electro magnets of alternate polarity. The pulp is fed into weir boxes (3) that admit water jets at (4) and discharge sand at (5) and slime at (6). The magnetic particles are drawn out of the water against the drum and are discharged under water spray (7) at the end of the magnetic field. The power required to excite the magnets and rotate the drums is about 1·5 H.P. for each machine.

With the first pass, of the crude sand, much difficulty was experienced in making the machines release their load of concentrate under the water sprays. The spray was quite unable to discharge the load, which had to be scraped off periodically; otherwise it would accumulate and stop the drums from rotating. On the second pass, of the first concentrate, which had been ground in the pebble mill, this difficulty was not encountered; the drums released their load under the water spray as fast as it accumulated. The probable explanation of this phenomenon is that the original black sand possessed a residual polarity that rendered the particles more strongly magnetic than ordinary magnetite. This residual polarity was destroyed in the pebble mill grinding of the first concentrate, and secondary concentration was made without further difficulty. The Gröndal Company were advised of this trouble, and they replied that they were aware of the difficulty in concentrating black sand. They have devised a special machine for this class of work very similar to their standard separator, but having a take-off belt of rubber that surrounds the drum and a small pulley placed in front of and slightly higher than the drum. The take-off belt serves to carry the concentrate out of the magnetic field. A description and cut of this machine will be found under the heading of "Proposed Method of Working."

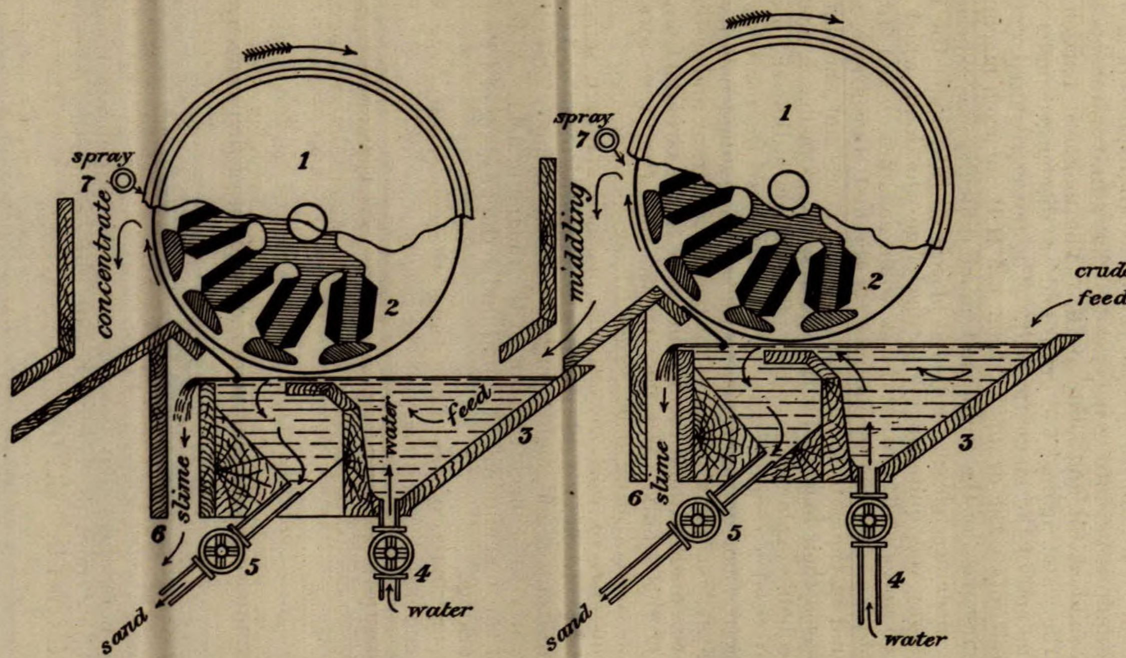
After the first pass, of the crude sand, the concentrate was dried, weighed, and sampled. A summary of the results is as follows:—

Crude sand fed to separators	10,930	pounds.
Concentrate recovered	1,087	"
Lost as tailing	9,843	"

$$\frac{10930}{1087} = 10 \cdot 05 \text{ units of crude sand required per unit of first concentrate.}$$

or, $\frac{100}{10 \cdot 05} = 9 \cdot 95$ per cent of concentrate recovered.

It may be noted here that the percentage of concentrate recovered from the machines compares very well with the arithmetical average of concentrate recovered by hand tests.



№5 GRONDAL SEPARATOR

Fig. 4.

TABLE IV.

Analyses of Crude Sand, First Concentrate, and First Tailing.

—	Fe.[1]	TiO_2.	Insoluble Res.	P.	S.
Crude sand	14·7	4·43	76·00	0·006	0·006
First concentrate	67·20	3·51	7·45	0·043	0·012
First tailing	8·30	4·70	....	....	....

[1] Soluble iron only.

Calculation of iron saved from the above analyses:—

$$\frac{67\cdot2-8\cdot3}{14\cdot7-8\cdot3} = 9\cdot2 \text{ units of crude required per unit of first concentrate.}$$

$$\frac{67\cdot2\times100}{14\cdot7\times9\cdot2} = 49\cdot68 \text{ per cent of the iron in crude sand saved in concentrate.}$$

Calculation of saving, from actual weights and assays:—

$$\frac{(10930\times14\cdot7\ -\ 9843\times8\cdot3)\ 100}{1087\ \times\ 67\cdot2\times9843\times8\cdot3} = 50\cdot38 \text{ per cent of iron saved.}$$

The percentage of recovery calculated from weights and assays checks fairly well with the percentage of recovery calculated from assay alone. Hence it may be assumed that the work has been throughout reasonably accurate.

A screen test of the crude sand was made in order to show the distribution of the iron and titanium according to the size of the mineral particles. This test is given in the following table, the screens used being the standards adopted by the Institute of Mining and Metallurgy. These screens were used in all subsequent screen analyses. But it should be stated that the 80 mesh screen was found to be unreliable; hence figures for material of this size are not accurate. The inaccuracy of the 80 mesh screen has also caused an error in the figures for 90 mesh material.

All screening analyses were made dry.

TABLE V.

Screen Test of Crude Sand.

SHOWING DISTRIBUTION OF IRON AND TITANIC ACID.

Screen.	Weight in grammes.	Per cent of total weight.	Cumulative per cent of total weight.	Iron, per cent	Distribution of iron; per cent of total.	Cumulative per cent of total iron.	Titanic acid, per cent	Distribution of titanic acid; per cent of total.	Cumulative per cent of total titanic acid.
+16	0·9								
+20 – 16	1·0	0·825	....	1·8	0·10	....	1·00	0·20	....
+30 – 20	8·0								
+40 – 30	64·2	5·350	6·175	2·3	0·80	0·90	1·05	1·29	1·49
+50 – 40	169·5	14·125	20·300	2·6	2·50	3·40	1·20	3·88	5·37
+60 – 50	255·5	21·293	41·593	3·7	5·36	8·76	1·75	8·52	13·89
+70 – 60	323·4	26·950	68·543	6·7	12·30	21·06	2·44	15·05	28·94
+80 – 70	23·5	1·957	70·500	11·8	1·57	22·63	4·61	2·06	31·00
+90 – 80	117·8	9·816	80·316	20·7	13·83	36·46	7·55	16·95	47·95
+100 –90	55·8	4·600	84·916	34·4	10·77	47·23	9·80	10·30	58·25
+120 –100	69·5	5·792	90·708	45·2	17·80	65·03	6·70	8·88	67·13
+150 –120	85·5	7·125	97·833	55·1	26·70	91·73	15·18	24·75	91·88
+200 –150	24·5	2·042	99·875	58·1	8·07	99·80	9·86	4·61	96·49
–200	1·5	0·125	....	23·1	0·20	....	10·25	3·51	....
Totals..	1,200·00	....	100·00	....	....	100·00	....	....	100·00

Note: the 0·825 per cent figure is bracketed to cover +16, +20 – 16 and +30 – 20.

From this screen test it is at once apparent that the grains or particles of magnetite and ilmenite are smaller than the particles of the gangue minerals. By screening out everything larger than 60 mesh 41·5 per cent of the sand is eliminated. This coarse material contains only 8·7 per cent of the total iron and 13·89 per cent of the total titanic acid, leaving 58·4 per cent of fine sand, containing 91·2 per cent of the total iron and 86·11 per cent of the total titanic acid.

The above figures would suggest the use of wet screening appliances (Callow screens, for instance) to eliminate the coarse sand prior to magnetic separation, with an expectant higher total recovery of iron. With this idea in view the following small scale experiments were made.

Three samples of the crude sand were taken; the first screened through 50 mesh, the second through 60 mesh, and the third through 70 mesh. The oversize and undersize from each screen were then examined for magnetic concentrate by means of the hand magnet, and the products of separation analysed for iron. The following tables contain the results:—

TABLE VI.

Test No. 1, 50 mesh screen.

—	Weight, grammes.	Per cent o total weight.	Concentrate, grammes.	Concentrate, per cent of total weight.	Iron in concentrate, per cent.	Tailing, grammes.	Tailing per cent of total weight.	Iron in tails, per cent	Recovery of iron in concentrate, per cent.
+50	174	21·5	0·8	0·098	52·9	173·2	21·34	3·70	....
−50	638	78·5	76·0	9·35	69·10	562·0	69·21	10·50	44·3
Total.	812	100·0	76·8	9·448	....	735·2	90·55	....	....

Test No. 2, 60 mesh screen.

—	Weight, grammes.	Per cent of total weight.	Concentrate, grammes.	Concentrate, per cent of total weight.	Iron in concentrate, per cent.	Tailing, grammes.	Tailing per cent of total weight.	Iron in tails, per cent	Recovery of iron in concentrate, per cent.
+60	323	42·3	1·0	0·13	51·50	322	42·14	2·10	....
−60	441	57·7	70·7	9·25	69·50	370·3	48·47	14·20	45·0
Total.	764	100·0	71·7	9·38	....	692·3	90·61	....	....

Test No. 3, 70 mesh screen.

—	Weight, grammes.	Per cent of total weight.	Con-centrate, grammes.	Con-centrate, per cent of total weight.	Iron in con-centrate, per cent.	Tailing, grammes.	Tailing per cent of total weight.	Iron in tails, per cent	Recovery of iron in con-centrate, per cent.
+70	575	68·4	5·5	0·65	60·00	569·5	67·79	3·50	....
−70	265	31·6	73·0	8·69	69·40	192·0	22·86	23·60	42·4
Total.	840	100·0	78·5	9·34	....	761·5	....	....	....

These three small tests indicate that, whereas a preliminary wet screening of the crude sand would cut out a large portion of the coarse particles and thus throw less work on the separators, there would be no increase in iron saved.

The capacity of the magnetic separators would without doubt be increased, but would in turn be dependent on the capacity of the screens. A very large number of screens would be required to handle any appreciable tonnage (5,000 to 8,000 tons daily), and it is extremely doubtful if such an installation would pay for itself in any way.

Grinding and Reconcentration of the First Concentrate.

The first pass of the crude sand, while elevating the percentage of iron from 14·7 to 67·2, had not depressed titanic acid much more than one per cent. It was, therefore, necessary to grind the first product to effect disintegration of middling particles (part magnetite, part ilmenite) and then reconcentrate.

In similar tests made on Natashkwan sand some years ago by the Swedish Gröndal Company, it was found that all attempts to briquette the first concentrate by the Gröndal system failed. This was due to the water-worn, rounded particles failing to interlock and hold together. By grinding, the particles were given a more angular form and briquetting was then accomplished without further difficulty.

Hence, in order to briquette, by the Gröndal system (either briquetting or nodulizing is necessary to effect a commercial product), the first concentrate must be crushed. Now crushing has the effect of liberating a considerable portion of gangue, siliceous and titaniferous, that is held in middling particles, and advantage is taken of this opportunity to eliminate as much gangue as possible by reconcentration. The reconcentration costs but a few cents a ton, which cost is more than counterbalanced by the additional value given to the finished product.

Attention may here be directed to a point already referred to on a previous page. It is not a difficult matter to save all the iron, if elimination of titanic is not required. Nor is it difficult to make an iron concentrate practically free from titanic acid, if the loss of iron entering the tailing is disregarded. However, the production of a low titanic acid iron concentrate consistent with a maximum recovery of the original iron is not attained without the introduction of comminution.

Re-grinding of the first concentrate was accomplished in a 4′–6″ Hardinge mill, charged with 1,292 pounds of flint pebbles. From the pebble mill the pulp was discharged to the separators. There was no difficulty experienced with the load of concentrate hanging to the drums. Residual polarity had evidently been destroyed in the pebble mill.

Results of this secondary concentration are as follows:—

First concentrate fed to separators...... 1,064 pounds.
Second concentrate recovered.......... 890 pounds.
Lost as second tailing.................. 174 pounds.

$\frac{1064}{890}=1\cdot19$ units of first concentrate required per unit of second concentrate.

or $\frac{100}{1\cdot19}=84\cdot03$ per cent of first concentrate recovered as second concentrate.

Recapitulation for First and Second Concentration.

10·05 units of crude sand required per unit of first concentrate.

1·19 units of first concentrate required per unit of second concentrate.

$\therefore 10\cdot05\times1\cdot19=11\cdot96$ units of crude sand required per unit of second concentrate.

or crude sand yields $\frac{100}{11\cdot96}=8\cdot36$ per cent of second concentrate.

TABLE VII.

Analyses of First Concentrate, Second Concentrate, and Second Tailing.

——	Fe.	TiO_2.	Insoluble Residue.	S.	P.
First concentrate	67·20	3·51	7·46	0·016	0·043
Second concentrate	69·8	2·37	2·74	0·006	0·015
Second tailing	43·5	11·62	....	....	....

Calculation of iron saved, from the above analyses:—

$\frac{69\cdot8-43\cdot5}{67\cdot2-43\cdot5}=1\cdot11$ units of first concentrate required per unit of second concentrate.

$\frac{69\cdot8\times100}{67\cdot2\times1\cdot11}=93\cdot57$ per cent of iron in the first concentrate saved in second concentrate.

Calculation of iron saved, from analyses and actual weights:—

$\frac{(67\cdot2\times1064-43\cdot5\times174)100}{69\cdot8\times890-43\cdot5\times174}=91\cdot73$ per cent of iron in the first concenttrate saved in the second concentrate.

Recapitulation for iron saved by first and second concentration.

Calculation from analyses alone:—
Iron saved, first separation = 49·68 per cent.
Iron saved, second separation = 93·57 per cent.
Total per cent of original iron saved in second concentrate =

$$\frac{49 \cdot 68 \times 93 \cdot 57}{100} = 46 \cdot 48$$

Calculation from weights and analyses:—
Iron saved, first separation = 50·38 per cent.
Iron saved, second separation = 91·73 per cent.
Total per cent of original iron saved in second concentrate =

$$\frac{50 \cdot 38 \times 91 \cdot 73}{100} = 46 \cdot 21.$$

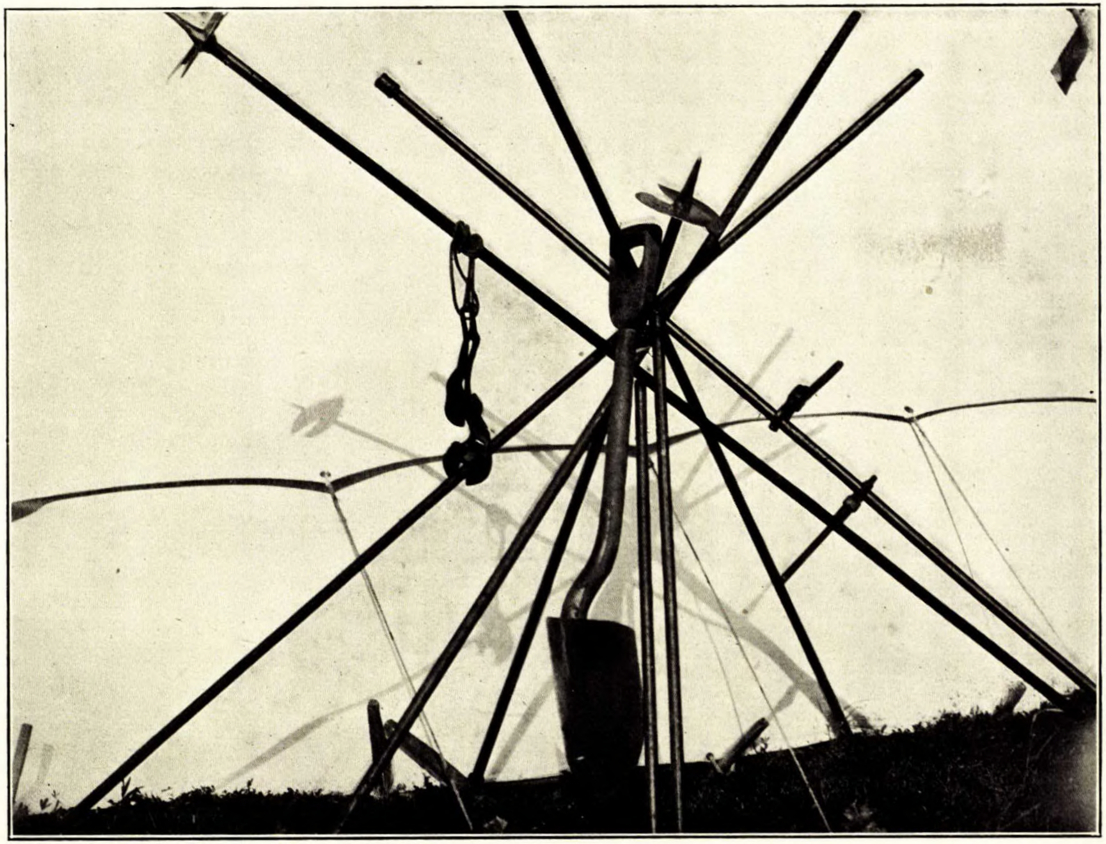
A screen analysis of the second concentrate, illustrating the distribution of iron and titanic acid, is as follows:—

TABLE VIII.

Screen Test of Second Concentrate.

SHOWING DISTRIBUTION OF IRON AND TITANIC ACID.

Screen.	Weight in grammes.	Per cent of total weight.	Cumulative per cent of total weight.	Iron, per cent.	Distribution of iron; per cent of total.	Cumulative per cent of total iron.	Titanic acid, per cent.	Distribution of titanic acid; per cent of total.	Cumulative per cent of total titanic acid.
+ 60 – 50	1·5	0·3030							
+ 70 – 60	1·2	0·2424	0·8282	56·1	0·67	....	4·00	1·513	....
+ 80 – 70	1·4	0·2828	....						
+ 90 – 80	7·3	1·4747	2·3029	64·6	1·37	2·04	4·17	2·807	4·320
+100 – 90	8·2	1·6565	3·9594	66·6	1·58	3·62	3·64	2·752	7·072
+120 –100	26·2	5·2929	9·2523	68·6	5·22	8·84	3·50	8·456	15·528
+150 –120	63·0	12·7272	21·9795	69·4	12·69	21·53	2·28	13·246	28·774
+200 –150	92·2	18·6262	40·6057	68·9	18·45	39·98	2·00	17·004	45·778
–200	294·0	59·3939	....	70·3	60·01	....	2·00	54·222	....
Totals...	495·0	....	99·9996	....	....	99·99	....	....	100



18801—p. 32. Sampling the dunes. Boring tools.

18801—p. 32. Sampling the dunes. Starting a hole.

18801—p. 32. Sampling the dunes. Lifting a sand core.

18801—p. 32. Sampling the dunes. Lifting 25 feet of drill rods.

It will be noted that grinding and re-separation of the first concentrate have had the effect of elevating the percentage of iron over $2\frac{1}{2}$ points, and depressing titanic acid from 3·51 to 2·37 per cent. The screen analysis of the second concentrate shows that the major portion of the titaniferous mineral is in particles finer than 200 mesh, and as such, is difficult of removal without wasting an undue proportion of iron. On the other hand, the particles of the titaniferous mineral coarser than 150 mesh contain 28·77 per cent of the total titanic acid, hence a re-crush and third separation should effect a considerable reduction of titanium.

The second concentrate was accordingly re-crushed in the pebble mill and re-separated with the results noted below:—

Weight of second concentrate fed to pebble mill.....872 pounds
Weight of third concentrate recovered..........795 pounds.
Loss, tailing, samples, slime, etc.................... 77 pounds.

$\frac{872}{795}=1\cdot096$ units of second concentrate required per unit of third concentrate.

$\frac{100}{1\cdot096}=91\cdot24$ per cent of the second concentrate recovered.

Recapitulation for first, second, and third concentration:—
10·05 units of crude sand required per unit of first concentrate.
1·19 units of first concentrate required per unit of second concentrate.
1·096 units of second concentrate required per unit of third concentrate.
$\therefore 10\cdot05\times1\cdot19\times1\cdot096=12\cdot9$ units of crude sand required per unit of third concentrate

or the crude sand yields $\frac{100}{12\cdot9}=7\cdot05$ per cent of third concentrate.

TABLE IX.

Analyses of Second Concentrate, Third Concentrate, and Third Tailing.

——	Fe.	TiO_2.	SiO_2.	S.	P.
Second concentrate........................	69·8	2·37	0·93	0·006	0·015
Third concentrate........................	70·40	1·70	0·70	Trace.	0·018
Third tailing........................	43·50	13·67	....	....	....

Calculation of iron saved, from the above analyses:—

$\frac{70\cdot4-43\cdot5}{69\cdot8-43\cdot5}=1\cdot022$ units of second concentrate per unit of third concentrate,

and $\frac{70\cdot4\times100}{69\cdot8\times1\cdot022}=97\cdot28$ per cent of iron in the second concentrate saved in the third concentrate.

Calculation of iron saved, from analyses and actual weights:—

$\frac{(69\cdot8\times872-43\cdot5\times77)\ 100}{70\cdot4\times795+43\cdot5\times77}=96\cdot96$ per cent of iron in the second concentrate saved in the third concentrate.

Recapitulation for iron saved, by first, second, and third concentration:—

Calculation from analyses alone:—

Iron saved, first concentration $=49\cdot68$ per cent.
" second " $=93\cdot57$ "
" third " $=97\cdot28$ "

Total per cent of original iron saved in third concentrate $=$

$$\frac{49\cdot68\times93\cdot57\times97\cdot28}{100\times100}=45\cdot21.$$

Calculation from analyses and weights:—

Iron saved, first concentration $=50\cdot38$ per cent.
" second " $=91\cdot73$ "
" third " $=96\cdot96$ "

Total per cent of original iron saved in third concentrate $=$

$$\frac{50\cdot38\times91\cdot73\times96\cdot96}{100\times100}=44\cdot80 \text{ per cent.}$$

Summary.

It has been shown that the crude sand containing 14·7 per cent of iron and 4·43 per cent of titanic acid may be concentrated to a product containing 70·4 per cent of iron and 1·7 per cent of titanic acid. This is accomplished, however, with a recovery of approximately 45 per cent only of the original iron; and means a concentration ratio of practically 13 units of crude to one of product.

A little more than 97 per cent of the titanic acid has been eliminated, and there is no doubt that almost complete depression of this element would be secured by allowing more iron to enter the tailing.

The final concentrate was obtained after three separations, and two intermediate crushings. This does not mean that a commercial application of the process would require these steps. The testing work was elaborated and detailed for the special purpose of noting the distribution of the iron and titaniferous minerals under variable conditions of size of particles.

While there are no authoritative data to offer, it is suggested that had keener advantage been taken of the residual polarity in the crude sand the first concentrate might have contained less titanic acid. The residual polarity of the sand renders it extremely susceptible to the tractive force of the magnets, and it is probable that this natural magnetism is possessed to a much higher degree by the magnetite than by the ilmenite.

With due appreciation of the foregoing, the separators could be so adjusted that only the most magnetic particles would be drawn into the concentrate, allowing more of the weakly magnetic ilmenite to escape with the tailing. This does not, of course, take any account of the middling particles, half magnetite and half ilmenite, that would, if sufficiently magnetic, report in the concentrate; and it would be impossible to make any adjustment that would render a complete saving or a complete elimination of these particles.

It follows then that the first concentrate should be made with the view of eliminating the major portion of free ilmenite particles, by suitable adjustment of the separators, at the same time avoiding any approach to a condition where ilmenite particles enter the tailing at the expense of a heavy loss of iron in middling particles.

Tonnage Calculations.

As has already been explained, the dune area comprising 169 acres was surveyed and divided into small blocks. These blocks were laid out with north and south lines at approximately right angles to the sea-shore; the distances east and west between block centres being generally 250 feet.

Each block is represented by six bore-holes, three on each side, as shown in the accompanying sketch. The distance between bore-holes in line at right angles to the sea-shore varied with the topography of the ground and the width of ground between the bush and the edge of the dunes overlooking the beaches. Hence these blocks may be considered as rectangular prismoids, and their volume calculated by application of the prismoidal formula. This formula is as follows:—

If A_1 = area of one of two parallel sides,
A_2 = area of the other of the two parallel sides,
M = the area of the section taken midway between the two parallel sides,
h = distance between the parallel sides,
V = volume of the prismoid.

$$\text{Then } V = \frac{h}{6}(A_1 + 4M + A_2)$$

Complete calculations for one of the blocks, number 22, are given below, as it was thought advisable to draw attention to the methods used in arriving at the tonnage of magnetic concentrate in the area under consideration. To render the explanation of the calculation more clear, the block has been subdivided into sections I, II, and III.

It will be noted that sections II and III are each represented by four bore-holes, whereas section I is represented by two holes only. The reason for this is that the two northerly bore-holes were at the edge of the bush, any attempts to bore holes of appreciable depth farther north being prevented by the watery condition of the ground.

It may be contended that subsection I should not be included in the calculation at all, but a little reflection will show that this would be unfair.

It would be absurd to assume that the black sand was suddenly cut off at the northerly boundary of subsection II. It had been found to continue inland from the sea for a distance of 638 feet on the west and 485 feet on the east side of the block. Hence it is a reasonable supposition that the ground farther north will contain some black sand. Just exactly how much ground beyond the bore-holes should be included in the estimate is difficult to say, but it is suggested that a distance equal to half of the width of section II would be considered safe. As regards the black sand content of the included area, it could not be assumed that it contained 10·8 per cent (the percentage found in section II), because the two bore-holes on its southern boundary show but 7·5 and 5 per cent respectively. Therefore a geometric mean is taken of these figures as a representative for section I. All blocks were estimated on the above reasoning; the following is a sample of the calculations:—

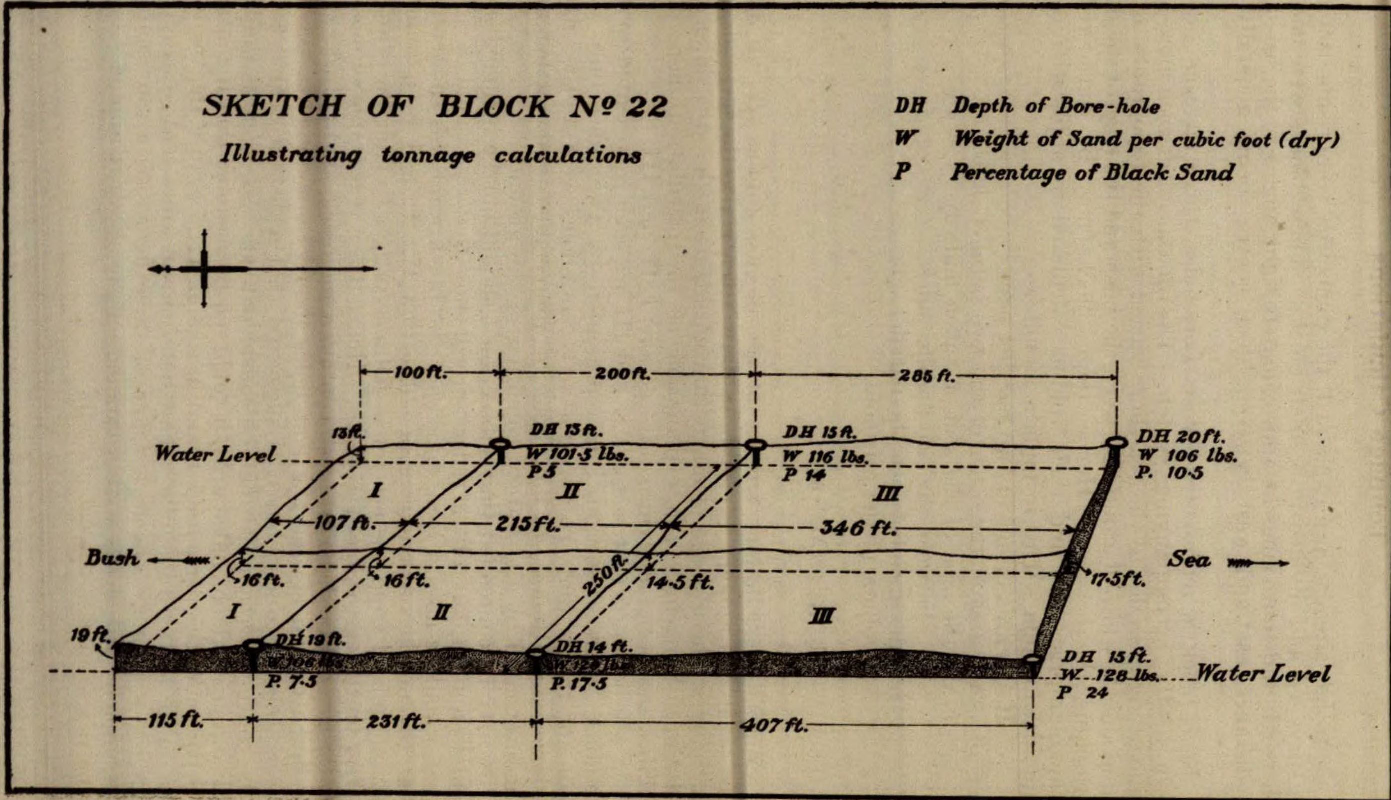

SKETCH OF BLOCK Nº 22
Illustrating tonnage calculations
DH Depth of Bore-hole
W Weight of Sand per cubic foot (dry)
P Percentage of Black Sand
100 ft.
200 ft.
285 ft.
13 ft.
DH 13 ft.
W 101·5 lbs.
P 5
DH 15 ft.
W 116 lbs.
P 14
DH 20 ft.
W 106 lbs.
P. 10·5
Water Level
I
II
III
107 ft.
215 ft.
346 ft.
Bush
Sea
16 ft.
16 ft.
250 ft.
14·5 ft.
17·5 ft.
I
II
III
19 ft.
DH 19 ft.
P. 7·5
DH 14 ft.
P. 17·5
DH 15 ft.
W 128 lbs.
P 24
Water Level
115 ft.
231 ft.
407 ft.

FIG. 5.

Tonnage Calculation, Block No. 22.

Section I.

Volume in cubic feet:—

A_1 = 100 feet × 13 feet = 1,300 square feet.
4M = 107 " × 16 " × 4 = 6,848 "
A_2 = 115 " × 19 " = 2,185 "
h = 250 "

$$\text{Volume} = \frac{250 \text{ ft.}}{6}(1,300 + 6,848 + 2,185) = 430,541 \text{ cubic feet.}$$

The average percentage of magnetic concentrate is found by the well-known foot percentage method, as follows:—

	Depth of bore-hole. Feet		Per cent. Magnetic concentrate.		
	13	×	5	=	65
	19	×	7·5	=	142·5
Totals........	32				207·5

$$\frac{207 \cdot 5}{32} = 6 \cdot 5 \text{ per cent magnetic concentrate.}$$

The average weight per cubic foot of dry sand is found in similar manner.

	Depth of bore hole. Feet.		Weight in lbs. per cubic foot dry sand.		
	13	×	101·5 lbs.	=	1,319·5
	19	×	106 "	=	2,014
Totals........	32				3,333·5

$$\frac{3333 \cdot 5}{32} = 104 \cdot 1 \text{ lbs. weight of dry sand per cubic foot.}$$

$$\text{Gross tons of dry sand in Section I} = \frac{430,541 \times 104 \cdot 1}{2,240} = 20,008 \cdot 6.$$

$$\text{Gross tons of magnetic concentrate in Section I} = \frac{20,008 \cdot 6 \times 6 \cdot 5}{100} = 1300 \cdot 56$$

Section II.

Volume in cubic feet.

A_1 = 14 feet × 200 feet = 2,800 square feet.
4M = 15·25 " × 215 " × 4 = 13,115 square feet.
A_2 = 16·5 " × 231 " × = 3,811 square feet.
h = 250 ".

$$\text{Volume} = \frac{250}{h} \text{ ft.} (2,800 + 13,115 + 3,811) = 821,916 \text{ cubic feet.}$$

Average percentage of magnetic concentrate:—

Depth of bore-hole. Feet.		Per cent. Magnetic concentrate.		
13	×	5	=	65
15	×	14	=	210
19	×	7·5	=	142·5
14	×	17·5	=	245·0
Totals...... 61				662·5

$$\frac{662 \cdot 5}{61} = 10 \cdot 8 \text{ per cent of magnetic concentrate.}$$

Average weight per cubic foot of dry sand:—

Depth of bore-hole. Feet.		Weight in lbs. per cubic foot dry sand.		
13	×	101·5	=	1,319·5
15	×	116	=	1,740
19	×	106	=	2,014
14	×	120	=	1,680
Totals...... 61				6,753·5

$$\frac{6,753 \cdot 5}{61} = 110 \cdot 7 \text{ lbs. weight of dry sand per cubic foot.}$$

Gross tons of dry sand in Section II $= \frac{821,916 \times 110 \cdot 7}{2,240} = 40,618 \cdot 8.$

Gross tons of magnetic concentrate in Section II $= \frac{40,618 \cdot 8 \times 10 \cdot 8}{100}$

$= 4,386 \cdot 83.$

SECTION III.

Volume in cubic feet:—

$A_1 = 17 \cdot 5 \times 285 = 4,987.$

$4M = 16 \times 346 \times 4 = 22,144.$

$A_2 = 14 \cdot 5 \times 407 = 5,901.$

$h = 250$ feet.

$V = \frac{250}{6}$ ft. $(4,987 + 22,144 + 5,901) = 1,376,333$ cubic feet.

Average percentage of magnetic concentrate:—

Depth of bore-hole. Feet.		Per cent. Magnetic concentrates.		
15	×	14·0	=	210
20	×	10·5	=	210
14	×	17·5	=	245
15	×	24·0	=	360
Totals...... 64				1,025

$$\frac{1,025}{64} = 16 \cdot 0 \text{ per cent of magnetic concentrate.}$$

Average weight per cubic foot of dry sand:—

	Depth of bore-hole. Feet.		Weight in lbs. per cubic foot dry sand.		
	15	×	116	=	1,740
	20	×	106·5	=	2,130
	14	×	120	=	1,680
	15	×	128	=	1,920
Totals......	64				7,470

$\frac{7,470}{64}$ = 116·7 lbs. = average weight of dry sand per cubic foot.

Gross tons of dry sand in Section III = $\frac{1,376,333 \times 116 \cdot 7}{2,240} = 71,704 \cdot 5$

Gross tons of magnetic concentrate in Section III = $\frac{71,704 \cdot 5 \times 16 \cdot 0}{100}$
= 11,472·72.

Recapitulation for total block:—

——	Volume in cubic feet.	Crude sand.	Magnetic concentrate.
		Gross tons.	Gross tons.
Section I........................	430,541	20,008·6	1,300·56
" II........................	821,916	40,618·8	4,386·83
" III........................	1,376,333	71,704·5	11,472·72
Totals..................	2,628,790	132,331·9	17,160·11

$\frac{132,331 \cdot 9}{17,160 \cdot 11}$ = 7·71 units of crude sand per unit of magnetic concentrate.

$\frac{100}{7 \cdot 71}$ = 12·97, average percentage of magnetic concentrate.

Similar calculations were made for each and every block from 1 to 55, inclusive. These blocks are indicated on the accompanying map by figures as follows: B.1, B.2 . . . . B.55. The tonnages of crude sand and magnetic concentrate for each block are entered in the following table for comparison with the map showing location of bore-holes.

TABLE X.

Tonnage and Percentages of Crude Sand and Magnetic Concentrates in Blocks 1 to 55, Inclusive.

Block No.	Volume in cubic feet.	Weight in pounds. — Crude sand.	Gross tons. — Crude sand.	Gross tons. — Magnetic concentrate.	Magnetic concentrate. — Per cent.	Ratio crude sand to magnetic concentrate.
1.......	2,509,325	262,143,640	117,028·4	8,786·17	7·51	13·32
2.......	2,685,937	279,077,433	124,588·1	10,919·4	8·76	11·41
3.......	3,283,812	333,495,168	148,881·77	9,720·24	6·52	15·32
4.......	3,470,707	344,893,126	153,970·15	6,523·92	4·21	23·75
5.......	3,457,333	347,772,500	155,211·98	6,490·99	4·18	23·91
6.......	3,275,541	339,962,119	151,768·7	8,502·16	5·6	17·85
7.......	4,540,354	472,184,622	209,973·27	13,525·77	6·44	15·52
8.......	4,333,394	440,732,169	196,755·42	9,430·12	4·79	20·87
9.......	3,846,763	398,130,590	177,736·86	11,017·26	6·2	16·13
10.......	3,701,207	382,777,188	170,882·68	11,487·28	6·72	14·88
11.......	3,362,749	343,160,493	153,196·6	9,134·8	5·96	16·77
12.......	2,765,207	286,446,247	127,877·8	8,172·0	6·39	15·65
13.......	2,710,791	281,203,730	125,537·2	10,603·93	8·45	11·84
14.......	3,107,499	337,958,300	150,874·2	13,463·32	8·92	11·21
15.......	3,129,374	360,510,242	160,942·0	14,707·71	9·14	10·94
16.......	3,272,624	379,020,551	169,205·8	18,580·97	11·0	9·10
17.......	3,506,228	394,708,482	176,009·1	16,142·93	9·17	10·9
18.......	3,476,750	382,991,287	170,978·23	13,807·82	8·08	12·39
19.......	3,301,978	361,834,948	161,533·5	15,372·22	9·51	10·51
20.......	2,966,666	318,023,707	141,975·1	12,402·22	8·73	11·45
21.......	2,827,416	315,990,529	141,066·6	15,934·37	11·21	8·92
22.......	2,628,790	296,423,480	132,331·9	17,160·11	12·97	7·71
23.......	2,081,000	193,907,740	100,082·7	7,622·43	7·69	13·13
24.......	2,766,374	310,548,090	138,637·8	16,997·30	12·25	8·16
25.......	2,318,832	260,055,054	116,095·9	13,428·42	11·57	8·64
26.......	2,753,781	297,984,661	133,028·8	10,342·98	7·77	12·86
27.......	3,084,249	336,189,413	150,084·5	14,210·08	9·46	10·57
28.......	2,293,737	252,102,294	112,545·5	13,007·74	11·56	8·65
29.......	1,791,041	186,591,976	83,298·8	7,620·42	9·15	10·93
30.......	1,454,500	152,234,500	67,961·8	6,460·85	9·50	10·52
31.......	1,103,208	119,419,889	53,312·5	5,898·98	11·06	9·04
32.......	1,219,666	130,046,570	58,054·3	4,636·32	8·00	12·50
33.......	1,145,541	120,588,271	53,834·0	3,939·68	7·33	13·64
34.......	974,907	104,630,307	46,709·9	4,340·85	9·29	10·76
35.......	898,790	99,681,606	44,500·9	4,474·68	10·06	9·94
36.......	1,134,687	124,485,394	54,573·7	5,697·39	10·46	9·56
37.......	507,300	57,063,890	25,474·9	3,318·96	13·04	7·67

Totals for blocks west of La Petite river, Nos. 1 to 37 inclusive:—

Volume in cubic feet.	Weight in pounds. — Crude sand.	Gross tons. — Crude sand.	Gross tons. — Magnetic concentrate.
97,688,058	10,404,970,206	4,656,521·36	383,882·79

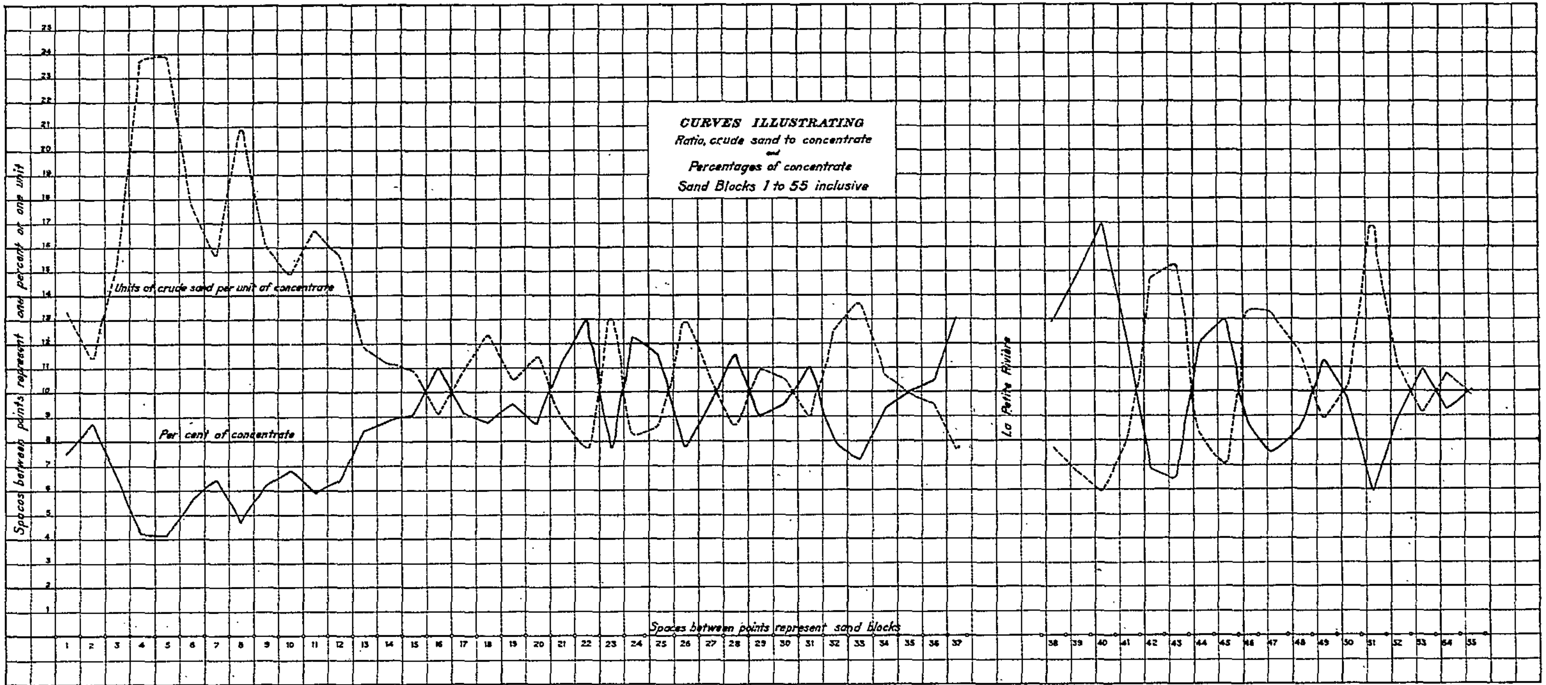

CURVES ILLUSTRATING
Ratio, crude sand to concentrate
and
Percentages of concentrate
Sand Blocks 1 to 55 inclusive
Units of crude sand per unit of concentrate
Per cent of concentrate
Spaces between points represent one percent or one unit
Spaces between points represent sand blocks
La Petite Rivière

Fig. 7

18801—p. 40. Bringing in the samples.

18801—p. 40. Black sand alternating with layers of ordinary sand. View taken immediately west of La Petite rivière.

West end of grassy dunes. Looking east.

TABLE X.—*Continued.*

Average weight of dry sand per cubic foot = 106·51 pounds.
Average ratio of crude sand to magnetic concentrate = 12·13: 1.
Average percentage of magnetic concentrate = 8·24.
Volume in cubic yards = 3,618,076·2.
Gross tons of dry crude sand per cubic yard = 1·287.
Gross tons of dry magnetic concentrate per cubic yard = 0·106.

Block No.	Volume in cubic feet.	Weight in pounds. — Crude sand.	Gross tons. — Crude sand.	Gross tons. — Magnetic concentrate.	Magnetic concentrate. — Per cent.	Ratio crude sand to magnetic concentrate.
38.......	882,666	105,452,744	47,077·1	6,107·32	12·97	7·71
39.......	1,130,040	135,903,742	60,671·2	8,978·0	14·8	6·76
40.......	1,193,457	140,667,585	63,797·9	10,809·78	16·94	5·96
41.......	1,339,250	150,933,586	67,381·0	8,353·3	12·31	8·066
42.......	1,293,415	137,025,673	61,172·5	4,171·8	6·82	14·66
43.......	1,250,165	132,017,457	58,936·3	3,859·15	6·55	15·27
44.......	1,424,666	164,776,626	73,561·0	8,856·48	12·06	8·29
45.......	1,399,707	174,135,926	77,739·2	10,657·81	13·07	7·3
46.......	1,213,933	154,666,118	69,047·3	6,088·97	8·82	11·34
47.......	1,819,700	204,805,550	91,431·0	6,897·15	7·55	13·25
48.......	1,395,000	157,149,100	70,155·8	6,004·15	8·56	11·68
49.......	1,339,000	149,124,200	66,573·3	7,521·87	11·3	8·85
50.......	1,103,541	121,026,059	54,029·5	5,241·45	9·7	10·31
51.......	1,181,500	120,910,000	53,977·6	3,205·08	5·94	16·84
52.......	1,226,375	129,572,987	57,845·1	5,194·05	8·98	11·13
53.......	1,121,445	125,310,404	55,942·1	5,794·2	10·94	9·14
54.......	1,058,854	118,705,329	52,993·5	4,911·77	9·27	10·79
55.......	924,333	101,682,564	45,393·9	4,577·35	10·08	9·92

Totals for blocks east of La Petite river, Nos. 38 to 55 inclusive:—

Volume in cubic feet.	Weight in pounds. — Crude sand.	Gross tons. — Crude sand.	Gross tons. — Magnetic concentrate.
22,297,047	2,523,865,650	1,127,725·30	117,228·78

Average weight of dry sand per cubic foot = 113·19 pounds.
Average ratio of crude sand to magnetic concentrate = 9·61:1.
Average percentage of magnetic concentrate = 10·40.
Volume in cubic yards = 825,816·5.
Gross tons of dry crude sand per cubic yard = 1·365.
Gross tons of dry magnetic concentrate per cubic yard = 0·141.

Grand totals for blocks 1 to 55, inclusive:—

Volume in cubic feet.	Weight in pounds. — Crude sand.	Gross tons. — Crude sand.	Gross tons. — Magnetic concentrate.
119,985,105	12,928,835,856	5,784,246·66	501,111·57

Total average weight of dry sand per cubic foot = 107·5 lbs.
Total average ratio of crude sand to magnetic concentrate = 11·54 : 1.
Total average percentage of magnetic concentrate = 8·66
Total volume in cubic yards = 4,443,892·7.
Gross tons of dry sand per cubic yard = 1·301.
Gross tons of dry magnetic concentrate per cubic yard = 0·112.

There is no intention to convey the impression that the above methods of survey and sampling afford true and exact data for purposes of tonnage calculation. They will, at best, give an approximation only, but it is thought that the tonnage deduced is correct to within an error of 10 per cent.

It should be kept in mind that the dune area which was systematically sampled covered only 169 acres, and that the average depth of boreholes was 16·3 feet. Within this area, and to the average depth as stated, there was found 5,784,246 tons of crude sand, containing 501,111 gross tons of magnetic concentrate, or 8·66 per cent.

The wooded country lying north of the dune area is probably from 15 to 20 times the size of the latter, and although the present investigation failed to prove the existence of black sand in any quantity in this area to an average depth of 5·2 feet—for reasons already stated—it would be unwise to assume that black sand did not exist in workable quantities some distance below the surface.

It would be unwise also to assume that 501,111 tons of black sand is an approximation of the *total* amount of black sand in the dune area. It is altogether likely that had the drills admitted of taking samples to a depth of 30 feet, the above tonnage figures would have been considerably larger. As regards the probability of the sand deposit averaging a depth of 30 feet, there is in the writer's opinion no doubt that this depth at least would be found over the major portion of the whole peninusla.

The making of a complete and reliable examination of the whole deposit would entail at least three or four months' work. The bush and dune areas should be surveyed into blocks of not less than 500 feet on a side, sample drill holes being sunk at the corners of every block. As regards the sampling by drill holes it is desirable that a type of drill be used that would admit of taking samples at least 40 feet below the surface. This drill should be of comparatively light weight to facilitate transport, and capable of being worked by hand power.

The Empire drill manufactured by the New York Engineering Company for purposes of placer gold exploration would seem to meet requirements. The writer has had no experience in the use of this drill, but as it has found a wide and useful application in the sampling of gold placer ground, it is believed that its vigorous use at Natashkwan would result in a thorough proving of the ground.

It should be noted that whereas the above calculations have shown that 11·54 is the ratio of concentration for a concentrate containing 68·1 per cent of iron and 2·5 per cent of titanic acid, the tests by magnetic separation indicate that 12·9 or practically 13 units of crude will be required per ton of concentrate containing 70·4 per cent of iron and 1·7 per cen of titanic acid. Hence the total tonnage of crude sand found in the dune area will yield $\frac{5,784,246 \cdot 66}{13}$ = 444,942 gross tons of the latter concentrate.

Summary of Conclusions.

The Natashkwan sands are, on the whole, one of the most promising of any similar deposit on the Gulf of St. Lawrence.

The treeless dune area at Natashkwan contains at least 500,000 tons of magnetic iron concentrate that will average 67 per cent in iron.

It is quite possible that the total volume of ore-bearing sand under dune and forest may contain much more than 500,000 tons, but the proof of its existence will require at least three months of systematic test drilling. The test drill should be capable of securing true samples of watery sand to a depth of at least 40 feet.

The average ratio of crude sand to magnetic concentrate in the dune area was found to be 10·05 to 1 for a 67 per cent iron concentrate, and 13 to 1 for a 70 per cent iron concentrate.

From crude sand containing 14·7 per cent of iron and 4·43 per cent of titanic acid, a concentrate may be made containing 70·4 per cent of iron and 1·7 per cent of titanic acid.

About 45 per cent of the original iron will be saved in the production of the above concentrate.

The presence of 1·7 per cent of titanic acid in the concentrate should not affect its value as an iron ore.

The weight of the dry crude sand in the dune area was found to be 1·301 gross tons per cubic yard.

The weight of dry magnetic concentrate (68 per cent iron) was found to be 0·112 gross tons per cubic yard of crude sand.

Proposed Method of Working.

Providing that magnetite has been proved to exist in such quantity as would encourage a capital outlay for plant and machinery, the question then arises as to the type of machinery best adapted to effect its economical recovery and the problem of its transportation to the markets.

It is out of the question to attempt the production of a rich iron concentrate low in titanium by ordinary specific gravity methods of separation. Magnetic separators are alone suitable for this work.

While there are a number of magnetic separators on the market, some of them proved and many of them not proved, and by this is meant proved in actual commercial operation, there are certain conditions which the machines must fulfil. (1) The sand must be concentrated wet; the cost of drying is not admissible, hence the machines should be capable of treating the sand in its natural condition. (2) The working season is short and the output must in consequence be large; this, coupled with the fact that the ratio of concentration (13 : 1) is somewhat high, demands a separator of large capacity. (3) The machines must be of rugged and simple construction to enable them to withstand a heavy working duty without much repair.

In so far as the experience of the writer extends, there is no magnetic separator on the market that will meet the conditions of capacity, simplicity, and efficient work better than the Gröndal machines. These separators are not adapted to the concentration of weakly magnetic minerals, but where the mineral magnetite requires separation in low grade and especially in finely crystalline ores the machine is very efficient in every respect.

On a previous page is given a short description of the No. 5 Gröndal separator, and it is explained that this particular type did not allow a proper and continuous discharge of the concentrate, because of the residual polarity in the crude sand. To overcome this difficulty the Gröndal Company have devised their No. 5–D type machine. This separator is exactly the same in general construction detail as the type No. 5, with the exception that it carries a take-off belt that surrounds the drum and a small roller pulley placed in front of the drum. The take-off belt carries the concentrate out of the magnetic field as fast as it is made, and a spray of water against the under side of the belt washes the magnetic product into a discharge apron. The type 5–D, as shown in the accompanying illustration, has a working face of 33 inches, and on material such as the Natashkwan sand has a capacity of 300 tons per 24 hours. The machines are mounted in tandem, two machines constituting one unit. The first separator makes a rough concentration eliminating the major portion of the gangue and discharges its product to the second for re-separation.

On account of the short season (6 to 7 months), in which the deposit may be worked, it would be necessary to install a plant of large capacity. It will be assumed, therefore, that the production of 500 tons of concentrate is made daily. To produce this tonnage means the excavation and concentration of $500 \times 13 = 6{,}750$ tons of crude sand per 24 hours, which it is proposed may be accomplished in the following manner.

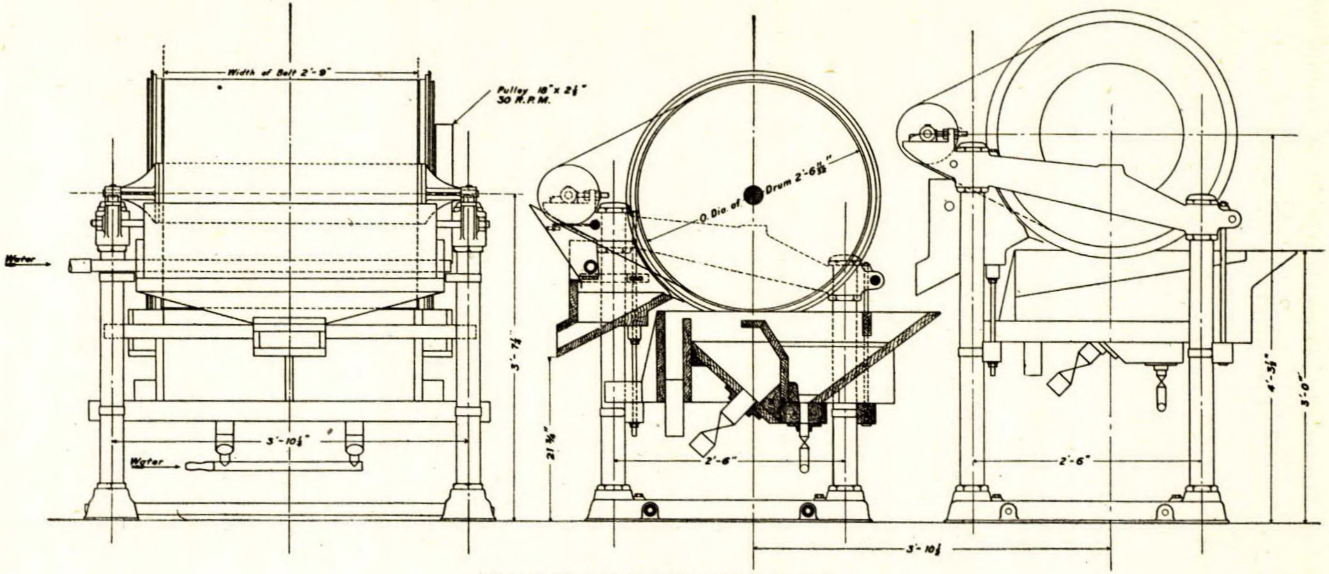
Two large dredges of the bucket line type employed in California and elsewhere for gold dredging would be used to excavate the crude sand. These dredges, 100 feet long, 40 feet wide, and 8 feet deep, would each carry 14 units of the Gröndal type 5–D separators. Each dredge would have a capacity of 2,500 cubic yards of sand per 24 hours, and would be capable of operating to a depth of 32 feet below the water level.

The dredges would attack the sands from the inside of the river fully protected from the weather, and would work south and east through the deposit, leaving a strip of ground between them and the sea to act as break-water.

The first or preliminary concentrate from the dredges would then require transport to a retreatment plant for grinding, secondary concentration, and briquetting. The retreatment plant must obviously be located in immediate proximity to the shipping pockets or docks, and as the only harbour in the vicinity is that at Little Natashkwan the preliminary concentrate must be conveyed to this point.

Because of the sand bars at the mouth of the Great Natashkwan, and the uncertain weather conditions, it would be found very difficult to establish water transportation between the dredges and the Little Natashkwan with any degree of reliability. It is proposed, therefore, to convey the first concentrate to the harbour by means of an aerial rope tram, which would have its loading terminal on the south bank of the Great Natashkwan. It may be suggested that the rope tram should, after crossing the river, make direct connexion with the dredges, and this would no doubt be feasible if the dredges were always stationary, but as they are constantly moving an auxiliary fixed loading station must be provided.

It will be assumed, therefore, that the loading terminal will be situated on the south bank of the river and the location of this terminal and tramway so arranged as to take advantage of the island at the river's mouth for purposes of crossing the latter. The rope way would be carried thence from the north bank of the river to the retreatment plant at the harbour at Little Natashkwan. The tramway would require an angle station, at which point it would be divided, the buckets being transferred from one section to the other without dumping. The capacity of the system would be 25 tons per hour and would require for its operation about 75 horse-power.



GRONDAL MAGNETIC SEPARATOR
TYPE 5-D
AMERICAN GRONDAL CO.
50 CHURCH STREET
NEW YORK

FIG. 6.

At the unloading terminal of the tramway the retreatment plant would be established. This would contain the pebble mills and separators for reconcentration, as well as the briquetting plant and shipping docks.

A description of the operation of the completed system from the dredges to the briquetting furnaces would be briefly as follows.

The crude sand excavated by the dredges is delivered to a long, cylindrical trommel by means of which gravel and coarse stone are prevented from getting into the separators. The fine material is distributed from the trommel to 14 units of the type 5–D separators, which deliver the first concentrate to scows on each side of the dredges. These scows are built with false bottoms to facilitate drainage of the concentrate. The non-magnetic tailing with the coarse stone is delivered by a tailing stacker, or other suitable means, a sufficient distance behind the dredge.

As the concentrate scows are filled, they would be transferred by tug boat to the loading terminal of the tramway, a sufficient number of scows being employed, so that "empties" may be substituted for "fulls" at the dredges without loss of time. At the loading terminal the concentrate would be transferred by means of a grab bucket to a storage pocket, from which the tramway buckets would in turn be filled.

On its arrival at the retreatment plant, the concentrate would be either discharged into storage tanks or direct to the agitators in the separating plant. A supplementary trolly gear, with grab bucket, would be supplied at this point to transfer concentrate from the storage tanks to the agitators, should the tramway be stopped or supplying an insufficient amount of concentrate to the agitators. The storage tanks would be installed for the purpose of equalizing the feed to the separator plant, as it is probable that the tramway load would fluctuate accordingly as the dredges were working rich or lean sand.

In the agitators the concentrate is mixed with its proper proportion of water and from thence fed to the pebble mills for grinding. From the pebble mills the finely ground pulp passes to separators of the Gröndal No. 5 type, which in turn deliver final concentrate to the dewaterizers and tailing to waste. The dewaterizers (Dorr type) discharge the concentrate, containing about 8 per cent of water, to a storage sump, from which it would be taken by a grab bucket and transferred to a feeding platform, over the presses in the briquetting plant. From the briquetting presses the briquettes pass to three 10 ft. Gröndal briquetting kilns, fired by producer gas. The kilns would each have an approximate capacity of 200 tons per 24 hours, The briquettes, as they issue from the kilns, would be loaded direct on a vessel, or stored for subsequent shipment.

The cost estimate given hereunder, also plans of dredges and retreatment plant, have been submitted by the American Gröndal Company, 50 Church Street, New York, and, providing that the Natashkwan deposit can be proved to contain at least 1,000,000 tons of magnetite, the figures representing net profit are believed to be conservative.

In view of the fact that the plant and equipment is proposed for a part of the country that is some distance from labour and supply centres, it is difficult to arrive at costs of installation within any degree of accuracy. It will be noted, therefore, that a liberal allowance has been made to cover this item.

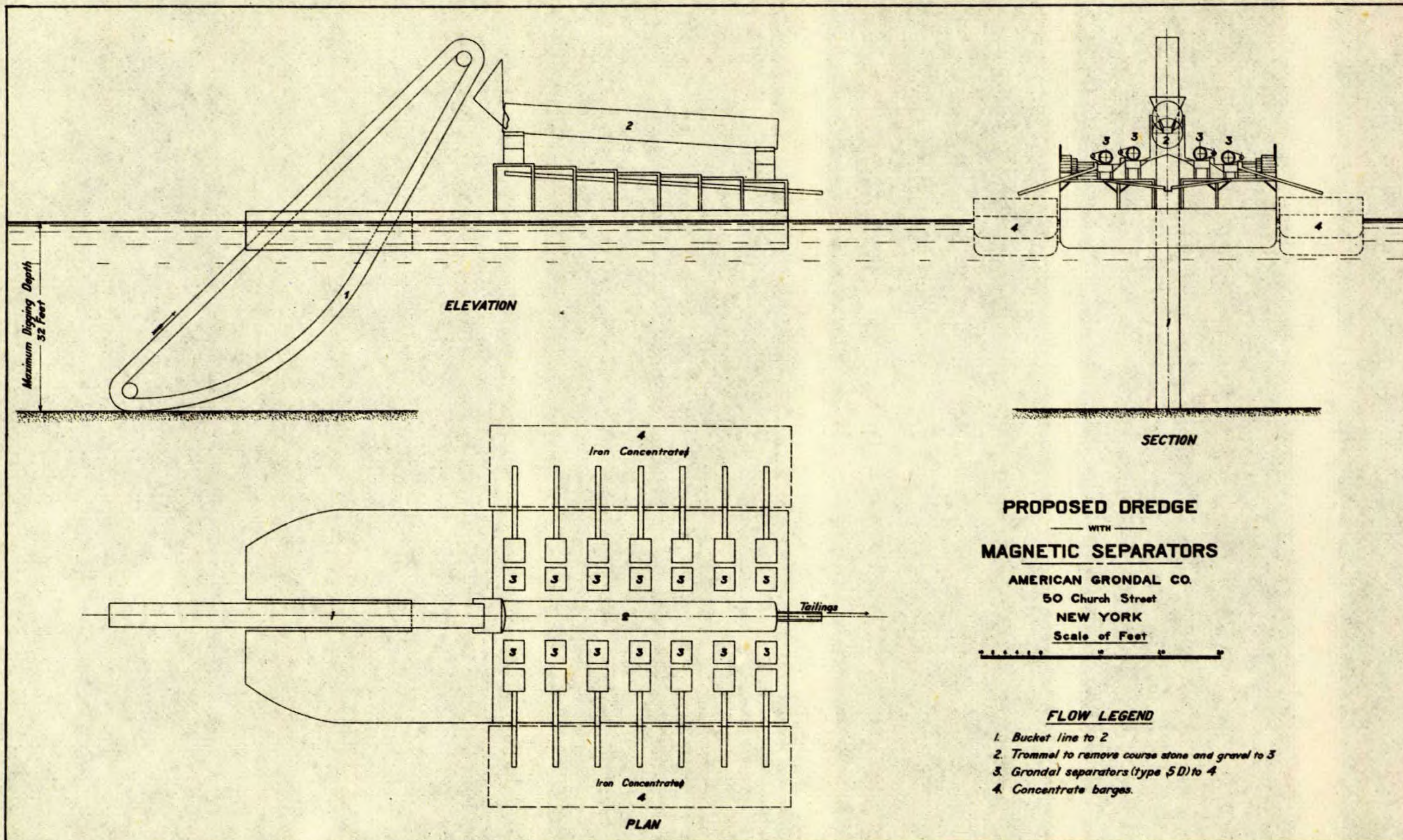

ELEVATION
Maximum Digging Depth 32 Feet
SECTION
PLAN
Iron Concentrates
Iron Concentrates
Tailings
PROPOSED DREDGE
WITH
MAGNETIC SEPARATORS
AMERICAN GRONDAL CO.
50 Church Street
NEW YORK
Scale of Feet
FLOW LEGEND
1. Bucket line to 2
2. Trommel to remove course stone and gravel to 3
3. Grondal separators (type 5 D) to 4
4. Concentrate barges.

Fig. 8

Cost Estimate of Total Plant Required.

Quantity.		Price.	Total.
		$	$
	Dredges.		
2	Dredges with electric motors for operation	120,000	
28	Units, type No. 5—D magnetic separators, at $1,400 each	39,200	
6	Scows and one tug boat	22,000	
7	Miles electric transmission line, including 5 pontoons	7,000	
			188,200
	Tramway.		
1	Loading plant	20,000	
5½	Miles aerial rope tram, including erection	60,000	
			80,000
	Retreatment Plant.		
	Concrete work—		
300	Cubic yards, at $7	2,100	
	Machinery—		
3	Mechanical agitators	900	
6	Six foot, conical pebble mills	16,500	
6	Units, type No. 5, wide magnetic separators, at $1,400	8,400	
4	Wide Dorr dewaterizers	2,600	
2	Screw conveyers	80	
	Power transmissions	2,000	
	Water conduits and piping	420	
	Electric wiring, for light and separators	400	
	Pumps	500	
			33,900
	Briquetting Plant: Three Kilns, 10 × 170 feet.		
	Concrete work	3,000	
	Brick work	8,600	
	Steel work	2,000	
	Cast iron work	480	
105	Briquette cars, at $200	21,000	
4	Transfer cars	600	
3	Charging machines	2,100	
4	Fans	620	
6	Briquetting presses at $4,000	24,000	
	Mechanical haulage	1,500	
	Electric transmissions	900	
	Electric motors	2,200	
			67,000
	Gas Producer Plant.		
4	Producers	....	20,000
	Power Plant.		
	Electric generating station, with boilers, engines, and generators for 850 H. P., at $100 per H. P.	....	85,000
	Shipping Dock.		
	Dock equipped with machinery for loading briquettes and unloading coal	....	50,000

SUMMARY.

Dredges, with separators, scows, tug-boat, etc	$188,200
Aerial tramway, with loading plant	80,000
Retreatment plant	33,900
Briquetting plant	67,000
Gas producer plant	20,000
Power plant	85,000
Shipping dock	50,000
Buildings with cranes	39,100
Installation machinery	10,000
Engineering, freight, duty, etc	50,000
	$623,200

OPERATING EXPENSES.

It is assumed that the dredges and the plant can be operated for 200 days in the year, with a production of 100,000 tons of briquettes.

It is also assumed that the deposit has been proved to contain 1,000,000 tons of concentrate, which at the above rate of working means a life of 10 years.

It is, therefore, obvious that buildings and machinery should be designed for only this length of time.

A plant producing 100,000 tons of briquettes annually will require considerable working capital, as money will be tied up in concentrates and briquettes as well as in current accounts. It is proposed that $50,000 will be required for this purpose.

The total capital required will, therefore, be:—

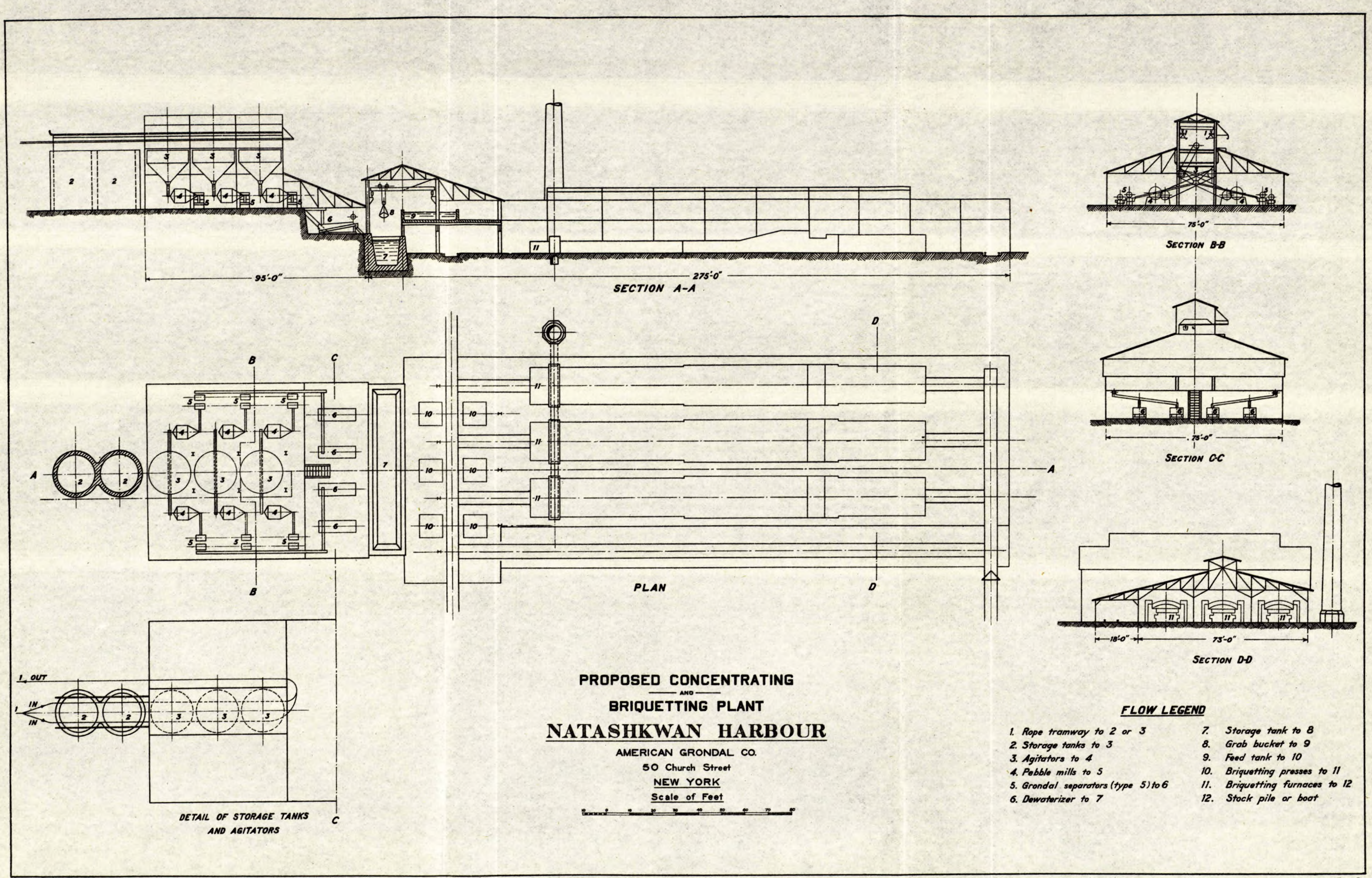
Capital invested in plant	$623,200
Working capital	50,000
Total capital required	$673,200

LABOUR EXPENSES FOR 200 DAYS.

Clearing land ahead of dredges, 20 men at $2	$8,000
Dredges, 40 men at $2.50	20,000
Tug and scows, 6 men at $2.50	3,000
Unloading plant for scows, 4 men at $2.50	2,000
Retreatment plant, 8 men at $2.50	4,000
Producer and briquetting plants, 24 men at $2.50	12,000
Power plant, 10 men at $3	6,000
Incidental labour	5,000
Total labour during campaign	$60,000

COAL REQUIREMENTS FOR 200 DAYS.

Briquetting plant, 7,000 tons at $4	$28,000
Coal for 850 H.P., 6,000 tons	24,000
Coal for tug boat, 650 tons	2,600
Total	$54,600



PROPOSED CONCENTRATING
AND
BRIQUETTING PLANT

NATASHKWAN HARBOUR

AMERICAN GRONDAL CO.
50 Church Street
NEW YORK

Scale of Feet

FLOW LEGEND

1. Rope tramway to 2 or 3
2. Storage tanks to 3
3. Agitators to 4
4. Pebble mills to 5
5. Grondal separators (type 5) to 6
6. Dewaterizer to 7
7. Storage tank to 8
8. Grab bucket to 9
9. Feed tank to 10
10. Briquetting presses to 11
11. Briquetting furnaces to 12
12. Stock pile or boat

Fig. 9

TOTAL OPERATING EXPENSES FOR ONE YEAR.

Labour	$ 60,000
Coal	54,600
Expenses during idle period, 165 days at $50	8,250
Maintenance (repair and supply)	10,000
Amortization of $673,200, in ten years at 7 per cent interest and 4 per cent amortization annually	103,194
General office expenses, including superintendence, insurance and taxes	25,000
[1] Royalty to owners, at 8 cents per ton, on 100,000 tons	8,000
Total	$269,044

The cost of briquettes at Natashkwan harbour will be, therefore, $2.70 per ton, on an output of 100,000 tons yearly.

PROBABLE REVENUE.

Assuming that the selling price of iron ores on the Atlantic sea-board will average 7·5 cents per unit for the next ten years, the average value of briquettes containing 67 per cent of iron will be, during this period, $5.02, delivered at, say, Philadelphia, Pa.

Selling price at Philadelphia		$5.02	per ton.
Cost at Natashkwan	$2.69		
Freight to Philadelphia	$1.50		
Total cost		$4.19	"
Profit		$0.83	"

Total yearly profit on 100,000 tons at $0.83 = $83,000, which is equivalent to 12·3 per cent return on the total investment of $673,200.

[1] An 8 cent per ton royalty on the concentrate corresponds to an $80,000 valuation per million tons of concentrate. This is thought to be a fair valuation in consideration of the nature of the deposit and the capital required to work it.

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MINES BRANCH

HON. ROBERT ROGERS, MINISTER; A. P. LOW, LL.D., DEPUTY MINISTER;
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PUBLISHED BY THE

MINES BRANCH

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    Vol. II—Boiler and Gas Producer Tests.
    Vol III—
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111. Diamond Drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with Introductory by A. W. G. Wilson, Ph.D.

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Appendix II
Boiler Tests and Diagrams, by R. J. Durley.
Vol. V—
Appendix III
Producer Tests and Diagrams, by R. J. Durley.
Vol. VI—
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MAPS.

6. Magnetometric Survey, Vertical Intensity: Calabogie Mine, Bagot township, Renfrew county, Ontario—by E. Nyström, 1904.

13. Magnetometric Survey of the Belmont Iron Mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, 1905.

14. Magnetometric Survey of the Wilbur mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, 1905.

15. Magnetometric Survey, Vertical Intensity: Iron Ore Deposits at Austin brook, Bathurst township, Gloucester county, N.B.—by E. Lindeman, 1906.

33. Magnetometric Survey, Vertical Intensity: Lot 1, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909.

34. Magnetometric Survey, Vertical Intensity: Lots 2 and 3, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909.

35. Magnetometric Survey, Vertical Intensity: Lots 10, 11, and 12, Concession IX, and Lots 11 and 12, Concession VIII, Mayo township, Hastings county, Ontario—by Howells Frechette, 1909.

36. Survey of Mer Bleue Peat Bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nyström, and A. Anrep.

37. Survey of Alfred Peat Bog, Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nyström, and A. Anrep.

38. Survey of Welland Peat Bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nyström, and A. Anrep.

39. Survey of Newington Peat Bog, Osnabrook, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nyström, and A. Anrep.

40. Survey of Perth Peat Bog, Drummond township, Lanark county, Ontario—by Erik Nyström, and A. Anrep.

41. Survey of Victoria Road Peat Bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nyström and A. Anrep.

48. Magnetometric Map of Iron Crown claim at Klaanch river, Vancouver island, B.C.—by Einar Lindeman.

49. Magnetometric Map of Western Steel Iron claim, at Sechart, Vancouver island, B.C.—by Einar Lindeman.

50. Vancouver island, B.C.—by Einar Lindeman.

51. Iron Mines, Texada island, B.C.—by E. H. Shepherd, C.E.

52. Sketch Map of Bog Iron Ore Deposits, West Arm, Quatsino sound, Vancouver island, B.C.—by L. Frank.

53. Iron Ore Occurrences, Ottawa and Pontiac counties, Quebec, 1908—by J. White, and Fritz Cirkel.

54. Iron Ore Occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel.

57. The Productive Chrome Iron Ore District of Quebec—by Fritz Cirkel.

60. Magnetometric Survey of the Bristol mine, Pontiac county, Quebec—by Einar Lindeman.

61. Topographical Map of Bristol mine, Pontiac county, Quebec—by Einar Lindeman.

64. Index Map of Nova Scotia: Gypsum—by W. F. Jennison, M.E.

65. Index Map of New Brunswick: Gypsum—by W. F. Jennison.

66. Map of Magdalen islands: Gypsum—by W. F. Jennison.

70. Magnetometric Survey of Northwest Arm Iron Range, Lake Timagami, Nipissing district, Ontario—by Einar Lindeman.

72. Brunner Peat Bog, Ontario—by A. Anrep.

73. Komoka Peat Bog, Ontario—by A. Anrep.

74. Brockville Peat Bog, Ontario—by A. Anrep.

75. Rondeau Peat Bog, Ontario—by A. Anrep.

76. Alfred Peat Bog, Ontario—by A. Anrep.

77. Alfred Peat Bog, Ontario: Main Ditch profile—by A. Anrep.

78. Map of Asbestos Region, Province of Quebec, 1910—by Fritz Cirkel.

86. Map showing general distribution of Serpentine in the Eastern Townships—by Fritz Cirkel.

94. Map showing Cobalt, Gouganda, Shiningtree, and Porcupine districts—by L. H. Cole, B.Sc.

95. General Map of Canada showing Coal Fields. (Accompanying report No. 83—by Dr. J. B. Porter).

96. General Map of Coal Fields of Nova Scotia and New Brunswick. (Accompanying Report No. 83—by Dr. J. B. Porter).

97. General Map showing Coal Fields in Alberta, Saskatchewan, and Manitoba. (Accompanying Report No. 83—by Dr. J. B. Porter).

98. General Map of Coal Fields in British Columbia. (Accompanying Report No. 83—by Dr. J. B. Porter).

99. General Map of Coal Field in Yukon Territory. (Accompanying Report No. 83—by Dr. J. B. Porter).

106. Austin Brook Iron Bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman.

107. Magnetometric Survey, Vertical Intensity: Austin Brook Iron Bearing District—by E. Lindeman.

108. Index Map showing Iron Bearing Area at Austin brook—by E. Lindeman.

109. Sections of Diamond Drill Holes in Iron Ore Deposits at Austin brook—by E. Lindeman.

112. Sketch plan showing Geology of Point Mamainse, Ont.—by Prof. A. C. Lane.

119-137. Mica: Township maps, Ontario and Quebec—by Hugh S. de Schmid.

138. Mica: Showing Location of Principal Mines and Occurrences in the Quebec Mica Area—by Hugh S. de Schmid.

139. Mica: Showing Location of Principal Mines and Occurrences in the Ontario Mica Area—by Hugh S. de Schmid.

140. Mica: Showing Distribution of the Principal Mica Occurrences in the Dominion of Canada—by Hugh S. de Schmid.

141. Torbrook Iron Bearing District, Annapolis county, N.S.—by Howells Fréchette, M.Sc.

146. Distribution of Iron Ore Sands of the Iron Ore Deposits on the North Shore of the River and Gulf of St. Lawrence, Canada—by Geo. C. Mackenzie.

147. Magnetic Iron Sand Deposits in Relation to Natashkwan harbour and Great Natashkwan river, Que. (Index Map)—by Geo. C. Mackenzie.

148. Natashkwan Magnetic Iron Sand Deposits, Saguenay county, Que.—by Geo. C. Mackenzie.

166. Magnetometric Map of No. 3 mine, Lot 7, Concessions V and VI, McKim township. Sudbury district, Ont.—by E. Lindeman.

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113. Holland Peat Bog, Ontario—by A. Anrep.

152. Map Showing the Location of Peat Bogs investigated in Ontario—by A. Anrep.

153. Map Showing the Location of Peat Bogs investigated in Manitoba—by A. Anrep.

157. Lac du Bonnet Peat Bog, Ontario—by A. Anrep.

158. Transmission Peat Bog, Manitoba—by A. Anrep.

159. Corduroy Peat Bog, Manitoba—by A. Anrep.

160. Boggy Creek Peat Bog, Manitoba—by A. Anrep.

161. Rice Lake Peat Bog, Manitoba—by A. Anrep.

162. Mud Lake Peat Bog, Manitoba—by A. Anrep.

163. Litter Peat Bog, Manitoba—by A. Anrep.

164. Julius Peat Litter Bog, Manitoba—by A. Anrep.

165. Fort Francis Peat Bog, Ontario—by A. Anrep.

168. Map showing Pyrites Mines and Prospects in Eastern Canada, and Their Relation to the United States' Market—by A. W. G. Wilson.

171. Geological Map of Sudbury Nickel region, Ont.—by Prof. A. P. Coleman.

172. " " Victoria mine—by Prof. A. P. Coleman.

173. " " Crean Hill mine—by Prof. A. P. Coleman.

174. " " Creighton mine—by Prof. A. P. Coleman.

175. " " showing Contact of Norite and Laurentian in vicinity of Creighton mine—by Prof. A. P. Coleman.

176. " " of Copper Cliff offset—by Prof. A. P. Coleman.

177. " " No. 3 mine—by Prof. A. P. Coleman.

178. " " showing vicinity of Stobie and No. 3 mines—by Prof. A. P. Coleman.

185. Blairton Iron mine, Lot 8, Con. I, Belmont township, Peterborough county, Ont.—by Einar Lindeman.

186. Belmont Iron mine, Lot 19, Con. I, Belmont township, Peterborough county, Ont.—by Einar Lindeman.

187. St. Charles mine, Lot 19, Con. XI, Tudor township, Hastings county, Ont.—by Einar Lindeman.

188. Baker mine, Lot 18, Con. XVIII, Tudor township, Peterborough county, Ont.—by Einar Lindeman.

189. Ridge Iron Ore deposits, Lots 17 and 18, Con. III, and Lots 16 and 17, Con. II, Wollaston township, Hastings county, Ont.—by Einar Lindeman.

190. Coehill and Jenkin's Iron Ore deposits: Lots 15, 16, 17, and 18, Con. VIII, Wollaston township, Hastings county, Ont.—by Einar Lindeman.

191. Iron Ore deposits at Bessemer, Lot 1, Con. VII, Lots 2, 3, 4, and 5, Con. VI, Mayo township, Hastings county, Ont.—by Einar Lindeman.

192. Rankin, Childs, and Stephens Iron Ore deposits: Lots 10, 11, 12, and 13, Con. IX, Mayo township, Hastings county, Ont.—by Einar Lindeman.

193. Iron Ore deposits: Lots 16, 17, and 18, Cons. V and VI, Carlow township, Hastings county, Ont.—by Einar Lindeman.

194. Bow Lake Iron Ore deposits: Lot 21, Cons. X and XI, Faraday township, Hastings county, Ont.—by Einar Lindeman.

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EUGENE HAANEL, PH.D., DIRECTOR.
1912

Base Map from Office Chief Geographer, Interior Department.
H. E. Baine, Chief Draughtsman, Mines Branch.

To accompany report No. 145 (English) and No. 149 (French) on the Magnetic Iron Sands of Natashkwan River, Quebec.
By Geo. C. MacKenzie, B.Sc.

No. 146

MAP
SHOWING DISTRIBUTION
OF THE
IRON ORE SAND DEPOSITS
ON THE NORTH SHORE
RIVER AND GULF OF ST. LAWRENCE
DOMINION OF CANADA

Scale 100 miles to one inch

Deposit examined
Iron Sand Occurrences

CANADA
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EUGENE HAANEL, PH. D., DIRECTOR
1912

H. E. Baine, Chief Draughtsman
Alvarez Pereira, Draughtsman.

Figures for height of falls and water discharge,
Supplied by Commission of Conservation.

To accompany report on "Magnetic Iron Sands of Natashkwan" By Geo. C. Mackenzie, B.Sc. 1911.

No. 147

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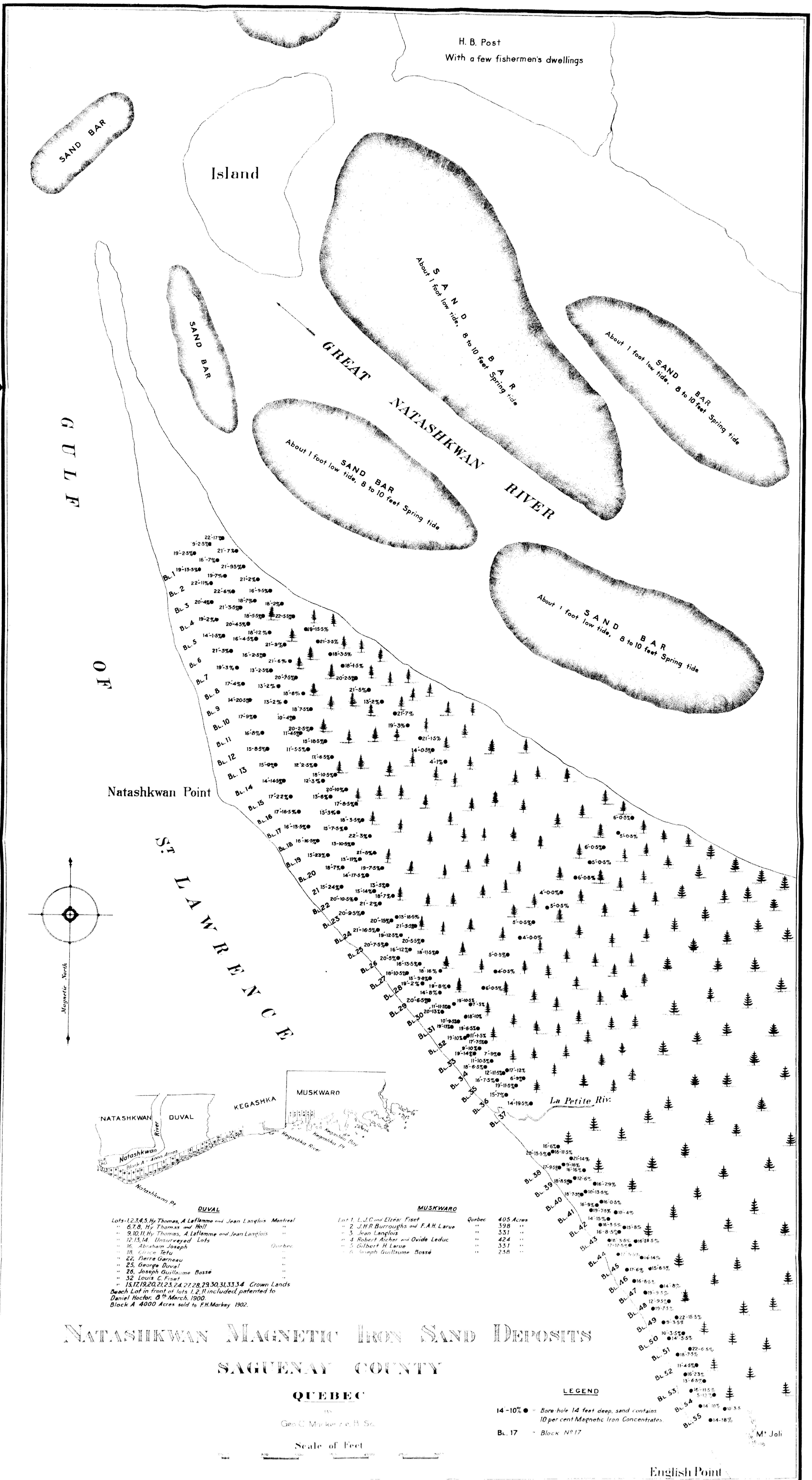
DEPARTMENT OF MINES

MINES BRANCH

HON. W. B. NANTEL, MINISTER. A. P. LOW, LL.D., DEPUTY MINISTER.
EUGENE HAANEL, PH.D., DIRECTOR.

1912



To accompany report on "Magnetic Iron Sands of Natashkwan" by Geo. C. Mackenzie, B.Sc. 1911.

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