CANADA
DEPARTMENT OF MINES
MINES BRANCH

Hon. W. Templeman, Minister; A. P. Low, LL.D., Deputy Minister;
Eugene Haanel, Ph.D., Director.

BULLETIN No. 5

MAGNETIC CONCENTRATION EXPERIMENTS

WITH

IRON ORES OF THE BRISTOL MINES, QUE.
IRON ORES OF THE BATHURST MINES, NEW BRUNSWICK
A COPPER NICKEL ORE FROM NAIRN, ONTARIO

BY

GEORGE C. MACKENZIE, B.Sc.

OTTAWA
GOVERNMENT PRINTING BUREAU
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Dr. EUGENE HAANEL,
Director of Mines Branch,
Department of Mines,
Ottawa.

SIR,—I beg to submit herewith a report upon the magnetic concentration experiments carried out in the Mining Laboratory of the School of Mining, Kingston, Ontario.

I have the honour to be, sir,
Your obedient servant,
(Signed) **George C. Mackenzie.**

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MAGNETIC CONCENTRATION EXPERIMENTS

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IRON ORES OF THE BRISTOL MINES, QUE.; IRON ORES OF THE BATHURST MINES, NEW BRUNSWICK; A COPPER NICKEL ORE FROM NAIRN, ONT.,

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GEO. C. MACKENZIE, B.Sc.

Introductory.

It is a well-known fact to those conversant with the situation, that the deposits of merchantable iron ores hitherto discovered in Canada are very limited in extent; indeed the supply is so far behind the tonnage required for home consumption, that blast furnace companies operating in the Province of Ontario found it necessary to import from the United States over 71 per cent of the amount of ore smelted in 1909.

The rapidly increasing drain upon the merchantable iron ore resources of the United States, especially in the Lake Superior district, has had the effect of raising the price per ton of the more desirable ores, and has stimulated the search for newer deposits. Within the last few years, a number of new deposits have been opened out, and proved; but the rate at which these new discoveries have been made and exploited is not keeping up with the demand, hence the exhaustion of the known supply is simply a matter of time. At what precise date this exhaustion of the merchantable ores will occur, is a subject of much debate; but the fact remains that as consumption is steadily increasing, and new discoveries are not keeping pace with this consumption, the vanishing point of the supply of merchantable ore is not many decades away.

While, however, the supply of merchantable iron ore in Canada is limited, enormous quantities of low grade iron ores are known to exist, although not regarded as merchantable. These deposits consist for the most part of the magnetic oxide of iron (magnetite), generally intermixed with siliceous gangue, iron sulphides, and in many instances with phosphates and titanites.

To render these impure ores in fit condition for the manufacture of iron and steel, necessitates the elimination of the deleterious compounds which they contain; in other words, necessitates a concentration of their iron values, allowing the impurities to go to waste. This concentration of the iron may be effected by means of suitable electro-magnetic separating machines: the particles of relatively pure iron oxide being susceptible to magnetic influence, are attracted and lifted away from the non-magnetic impurities, thereby constituting a separation of the valuable iron from the objectionable waste.

The magnetic concentration of low grade iron ores into products equal, and in many instances superior, to the best natural ores obtainable, is a subject of great importance to everyone connected with the Canadian iron and steel industry. Some years ago the profitable concentration of these ores would have been attended by a doubtful margin of profit; but the price, to-day, of the high grade natural ores is such as to warrant the application of this process to many Canadian low grade ores, with the assurance of financial success.

Obviously, the cost of separation, added to the cost of mining, will increase the cost per unit of iron to a comparatively higher figure than if the ore had been naturally merchantable. But the concentrated product—owing to its purity—will command a higher market price than the natural ore; and although the profit per ton on the former may be lower than the profit per ton on the latter, yet, the returns should yield a fair interest on investment: provided the iron content of the low grade crude is commensurate with the mining and treatment costs.

Mining costs will vary with the nature of the deposit; its geographical position controlling costs of supplies; labour, etc., and the personal equation of management. Treatment costs will vary directly as the crude is easy or difficult of comminution preparatory to separation, and inversely as the amount of magnetic oxide contained in the crude. The actual separation process costs but a few cents per ton, and will vary but little within wide limits.

Magnetic separation is based upon the fact that, different mineral species possess different ratios of a physical characteristic called *permeability*: which means the ratio of their conductivity for magnetic lines of force compared to the conductivity of air. The determination of the exact permeability of minerals is exceedingly difficult, on account of the chemical differences in specimens from different localities; as well as the difficulty in securing sufficiently large specimens of the pure minerals. Investigators, however, have arrived at very close approximations. It is found that magnetite is of sufficient permeability to ensure its easy separation from quartz, feldspar, apatite, pyrite, etc., and that the permeability of pyrrhotite and ilmenite approaches the permeability of magnetite so closely that their separation from the latter is much more difficult.

Before magnetic separation can be applied, it is necessary to free, or break apart by crushing, all the constituent minerals forming the crude. Theoretically, the point to which comminution should be carried is that where every particle of mineral is free to be attracted or rejected according to its permeability; this is, of course, the ideal situation, but can not be carried out in practice. Nevertheless, this theoretical point should be aimed at. The practical rule is, to carry the crushing far enough to free the maximum number of valuable mineral particles, having due regard to the cost of crushing, and the saving effected. There is no ironclad rule to be followed for the solution of this problem; the process, as a whole, requires an intimate co-relation of the crushing and separation factors. Different ores require widely different treatment: for one ore, moderately coarse crushing will suffice; for another, excessive pulverization is required to liberate the particles of magnetite, with the consequent added cost of comminution.

As a direct consequence of the foregoing, the concentrates produced will be either coarse or fine-grained, depending upon the crystalline structure of the original crude. With ores possessing a coarse crystallization, the constituent mineral particles are disintegrated by moderately coarse crushing. This type of ore will yield a high grade concentrate by the ordinary dry methods of separation; and the concentrated product, consisting of relatively coarse-grained magnetite, may be utilized directly in the blast furnace. Ores of this type are being concentrated by the Witherbee Sherman Company, of Mineville, N.Y., the concentrates averaging 65 per cent larger than 10 mesh.

On the other hand, ores of finer crystallization require more pulverizing to effect disintegration, and the concentrates produced may be so finely divided that their direct use in the blast furnace is attended with considerable trouble. Magnetites of this type are being concentrated by the Delaware and Hudson railway, at Lyon Mountain, N.Y.; the concentrates in this case averaging 8 per cent larger than 10 mesh, with no less than 15·6 per cent finer than 100 mesh. The use of these concentrates at Standish furnace, N.Y., gave considerable trouble, until a nodulizing kiln was installed for the purpose of agglutinizing the fine material.

Ores of extremely fine, or cryptocrystalline structure, containing pyrites or other objectionable gangue mineral, finely disseminated, require excessive pulverization to liberate the particles of magnetite. Such pulverized material is extremely difficult to concentrate dry, on account of the dusty particles of gangue being carried into the heads, mechanically entangled with particles of magnetite. This difficulty is overcome, however, in the Gröndal system of separation, whereby the crude is pulverized in wet ball mills, and the pulp fed into a weir box underneath the poles of a strong electro magnet; the magnetic particles being lifted out of the water without entraining any undue proportion of gangue particles. This wet process is installed at the plant of the Pennsylvania Steel Company, Lebanon, Pa.; the concentrates produced being in a fine state of subdivision, are partially dewatered, and then nodulized.

It may be stated that concentrates produced by the dry method of separation may, or may not—depending on their fineness—require agglutinizing before they can be used in the blast furnace. But concentrates produced by the wet process will always require agglutinizing before they become acceptable to the furnace man. To meet this requirement, the inventor of the Gröndal separator has devised the Gröndal briquetting system: by which the fine material is pressed into briquettes without any added binder other than the moisture already contained, and then peroxidized and sintered in a long gas-fired furnace of rectangular section. The briquettes produced by this process are hard enough to stand transport, very porous, and thoroughly desulphurized; consequently, they constitute a very desirable raw material for the blast furnace.

As stated previously, immense quantities of these low grade magnetic iron ores are known to exist in Canada. To enumerate all the localities in which they are found would constitute a lengthy report in itself, and is beyond the scope of this paper. It will suffice to mention the numerous deposits of sulphurous magnetites found on the coast of British Columbia. Some of these iron ores contain copper in small amounts, which might constitute a valuable by-product. The siliceous jaspilyte ores of northern Ontario, and the more sulphurous and crystalline ores of western and mid-eastern Ontario, present concentration problems of the utmost importance to Ontario ironmasters. The high sulphur ores of Quebec occurring along the Ottawa and Gatineau rivers; and the large titaniferous deposits found on both sides of the St. Lawrence river, are worthy of exploitation as regards their profitable use in iron manufacturing. The magnetic sands of the St. Lawrence require more accurate investigation as regards their extent, and amenability to concentration. The discovery of large bodies of intermixed siliceous magnetite and hematite in New Brunswick, offer additional concentration problems. At the mines of the Canada Iron Corporation, Limited, Bathurst, N.B., massive bodies of merchantable ore are found associated with leaner and more siliceous portions: hence concentration of these leaner ores becomes of some importance; and as they occur in considerable quantity their utilization is highly desirable.

The separation of the nickel and copper minerals found in the ores of the Ontario Sudbury district has occupied the attention of investigators at different periods; and although much benefit was expected from the result of such experimental work, the conclusions arrived at were not entirely satisfactory.[1]

The earlier experiments were undertaken with the object of making a complete and efficient separation of the nickel-bearing mineral from the copper pyrites. It was found, however, that the nickel occurred in these ores as a sulphide *pentlandite,* which was so feebly magnetic that its removal by magnetic separators was exceedingly difficult, if not impossible.

Of late years the problem of making nickeliferous pyrrhotite concentrates free from copper, with the view of manufacturing therefrom ferro-nickel pig, has become of economic importance. This application of the electro-magnetic separating process appears feasible, and promises a satisfactory solution of the problems involved in the use of certain of the Sudbury ores which have hitherto been regarded as too high in iron for smelting in the copper blast furnace.

The products resulting from such a separation process would be, nickeliferous pyrrhotite concentrates low in copper, for subsequent manufacture of ferro-nickel pig; and tailings high in copper and nickel, but comparatively low in iron, for subsequent production of copper-nickel matte.

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[1] The Ore Deposits of Sudbury, Ontario, by C. W. Dickenson, Ph.D., Transactions American Institute of Mining Engineers, 1903.

The Nickel and Copper Deposits of Sudbury, Ontario, by Alfred E. Barlow, Geological Survey of Canada, Annual Report, 1901.

The experimental work described in this report was carried out by the writer in the Mining Laboratory of Queen's University, Kingston, arrangements having been made with the university authorities for the rental of this laboratory until such time as the ore testing and concentrating plant of the Department of Mines, now being installed in connexion with the Fuel Testing Station, Ottawa, was ready.

The ores experimented upon are as follows:—

Iron Ores.

Bristol ore.—Two samples from the Bristol mines, situated on lots 21 and 22, range II, township of Bristol, county of Pontiac, Quebec.

Bathurst ore.—Two samples from the mines of the Canada Iron Corporation, Limited, situated on lot 12, range XVII, township of Bathurst, county of Gloucester, New Brunswick.

Copper-Nickel Ore.

Worthington ore.—One sample from the Worthington mine, situated on lot 2, concession II, township of Drury, Ontario. This sample was shipped by Mr. F. C. Hirsch, St. Sacrament street, Montreal.

All of the analyses were made by the writer from samples dried from and at 105° C. for one hour.

MAGNETIC CONCENTRATION OF BRISTOL ORES.

Shipment No. 1.—This sample was taken from the mine dump at Shaft No. 1. In selecting the sample larger pieces of rock matter were cobbed out; but no attempt was made to select pieces of ore free from pyrites, as it was intended to show that the subsequent separation process would eliminate the sulphides to a considerable extent. The ore consists of fairly coarse-grained magnetite in a gangue of feldspar, hornblende quartz, and calcite. Iron pyrites is present in considerable quantity, not finely disseminated, but occurring in stringers and nodular masses throughout the matrix.

Shipment No. 2.—This sample was taken from a small dump, the ore being mined some years ago, from Pit No. 2, situated 550 feet southeast of Shaft No. 1. Considerable picking over had to be resorted to in order to obtain pieces of ore that were free from oxidation; and although much cobbing was done, the sample selected cannot be regarded as representative of the ore as originally mined.

This ore differs radically from shipment No. 1 in that it contains a marked proportion of hematite. No doubt a portion of this hematite has resulted from the oxidation of the pyrite: but the fact that hematite is an original constituent is clearly illustrated by examination of freshly broken specimens; and many of the specimens exhibit the characteristic red streak of the peroxide of iron. The crystallization of this ore is finer than that of shipment No. 1; and the gangue

—consisting for the most part of calcite, feldspar, and pyrite—is intimately associated with the particles of magnetite and hematite.

Both samples were bagged and freighted to Kingston, Ontario.

Preparatory Treatment of the Ore for Separation.

The ores were first broken to ¾″ in a Blake crusher, and thence fed to Cornish rolls, crushing to ⅛″; the discharge from the rolls passing over a 6 mesh impact screen; oversize being returned to the rolls until all of the ore had been reduced to ⅛″.

After crushing, the ores were piled upon a sheet-iron floor and carefully sampled by the split shovel method, these samples representing the ores as received were marked general samples 'A.'

ANALYSES OF GENERAL SAMPLES 'A.'

Description.	Ferrous Oxide.	Ferric Oxide.	Insoluble.	Sulphur.	Phosphorus.	Iron.
Shipment No. 1......	23·65	50·14	17·46	2·62	0·011	53·49
" " 2......	9·51	63·47	9·97	2·79	0·008	51·83

Each shipment was then divided into approximately two equal parts; one-half of the ore being tested by the ordinary dry separation process, the remaining half being tested by the Gröndal wet process. This division of the ores was accomplished by taking alternate shovelsful from a coned pile, thus ensuring that each portion would be fairly represented by the general sample 'A.'

The portion taken for dry separation was then sized over impact screens: the object of this sizing process being to assemble particles of the same size, irrespective of specific gravity; the effect of which is twofold, (1) an increased efficiency in the separation process, and (2) the subsequent separation of each size, independently: illustrating the maximum crushing required for the highest efficiency of separation. The sizing process yielded four products, (1) particles of 40 mesh and finer, (2) on 40 mesh and through 20 mesh, (3) on 20 mesh and through 10 mesh, and (4) on 10 mesh and through 6 mesh. Each of the above sized products was then sampled by the split shovel; the samples being marked Nos. 1, 2, 3, and 4 for the 40, 20, 10, and 6 mesh sizes, respectively. A summation of the analyses of these four sizes should approximate with the analysis of the general sample 'A': thus affording a check upon the whole.

Each of these sized portions of the original crude were then separated independently by the Ball and Norton belt magnetic separator, the concentrates and tailings in each operation being caught in suitable receptacles, and weighed; the dust loss being obtained by the difference in weight of the crude, and the weight of the concentrates, plus tailings. After weighing, the concentrates and tailings were carefully sampled for subsequent analysis.

The remaining half of the shipment reserved for wet separation was then split into three portions. The first portion being ground in a Krupp dry ball mill to a fineness of 10 mesh; the second to a fineness of 20 mesh; and the third to a fineness of 40 mesh. Sampling of these pulverized materials was not considered necessary, as they were each a portion of the original crude, and, therefore, represented by the general sample 'A.'

The three portions were then separated independently by the Gröndal magnetic separator, the concentrates and tailings being caught in settling tanks; and after drawing off the surplus water, were dried and weighed. The slime loss in each case was obtained by the difference in weight of the original crude, and the weight of the concentrates, plus tailings. Concentrates and tailings were then carefully sampled for subsequent analysis.

Results of Separation.

The complete results of the separation processes—both dry and wet—for shipments No. 1 and No. 2 are given in the accompanying tables. These tables show the analysis of the original crude, and the sized crude; also the weight and percentages of concentrates and tailings, with analyses; and the percentages of recovery and loss for each process.

Shipment No. 1.—This ore yielded exceptionally good results, as would be expected from its analysis and physical structure. In the dry process, over 70 per cent of the sulphur in the original crude was eliminated. Phosphorus, although below the Bessemer limit in the crude, was depressed in the concentrates to a point that should make these concentrates valuable for the production of special low phosphorus iron. The total loss in iron—3·54 per cent of that contained in the original crude—is very satisfactory, and affords a low ratio of concentration: being only 1·211; a figure of some importance if mining costs should happen to be above the normal.

The results obtained with wet separation, as regards the purity of the concentrates, are better than the results of dry separation; the reduction of sulphur by this method being over 90 per cent, with phosphorus reduced to practically a trace. The total loss in iron is hardly 2 per cent; the ratio of concentration in this case being 1·3: a little higher than the dry separation ratio, owing to the higher iron content of the heads.

Shipment No. 2.—Concentration of this ore yielded results that are much inferior to those obtained from No. 1 shipment. This difference is due almost entirely to the large proportion of hematite contained in the ore. The iron existing as the non-magnetic peroxide, was, of course, unaffected by the tractive force of the magnets, and consequently entered the tailings, constituting a heavy loss. The concentrates obtained by both dry and wet methods, although satisfactory as regards depression of sulphur, and phosphorus, are not as high in iron as the concentrates produced from No. 1 shipment. This may be accounted for by the fact that comminution was carried hardly far enough to completely free the constituent minerals, and, therefore, particles consisting partly of magnetite, hematite, and siliceous gangue were drawn into the heads, together with the cleaner particles of magnetite. To remedy this, and to produce a concentrate of higher iron content, would necessitate finer crushing; but as the subsequent separation would undoubtedly result in a further loss of iron, it would seem advisable to place the point to which comminution should be carried, with definite relation to the loss of iron incurred: the maximum loss of iron allowable being fixed by the mining costs of the crude and the value of the concentrated product.

Briquetting or Nodulizing.

The concentrates produced from the Bristol ores will, without doubt, be too finely divided for direct use in either the blast furnace or the modern electric shaft furnace. They will, therefore, require agglutinizing before they can be smelted economically. This agglutination or sintering of the fine material may be accomplished by either one of two methods: (1) briquetting by the Gröndal system in which the moist concentrates are pressed into briquettes without the addition of any added binder, and subsequently oxidized and sintered into firm porous briquettes, in long gas-fired furnaces of rectangular section; (2) by the nodulizing process, in which the concentrates are fed into the upper end of an inclined rotating tubular kiln: the kiln being fired by blowing in coal dust at its lower or discharge end. The concentrates are first sintered into masses by the intense heat, and then broken up into nodules by the rotating movement of the kiln, and discharged at the lower end. These nodules are of varying dimensions, from egg to pea size, and more or less peroxidized.

By either of the above briefly described methods, the concentrates from Bristol ores would yield very desirable low sulphur material for the manufacture of iron by either the electric furnace or ordinary blast furnace.

MAGNETIC CONCENTRATION OF BATHURST ORES.

After an examination of No. 1 and No. 2 deposits, in company with the superintendent, Mr. T. T. Fulton, it was decided to select the samples for concentration experiments from the leaner banded material of these deposits that would, in the ordinary process of mining, be cobbed out from the richer ore. That, as mining progresses, a considerable tonnage of this low grade material will, in the course of time, be accumulated is extremely probable, and therefore, the recovery of the iron values contained therein becomes a question of some importance.

Shipment No. 1.—This sample was taken from the northeast end of No. 1 deposit, on top of, and about 100 feet back from the edge of the bluff that faces Austin brook. The sample selected was of distinctly low grade, banded character, and consisted of cryptocrystalline magnetite and hematite, interbanded with siliceous material. The siliceous bands—consisting almost entirely of quartz—vary from $\frac{1}{16}''$ to $1''$ in thickness, and impart to the ore a laminated structure. Iron pyrites occurs with this banded material, but in limited amount, and the sample selected exhibited minute crystals of pyrite, with but intermittent occurrence.

Shipment No. 2.—This sample was taken from the southwesterly end of No. 2 deposit, on the face of the slope looking towards Austin brook. This ore is similar to No. 1, possessing the same cryptocrystalline banded structure, but containing more magnetite and less hematite, and the siliceous bands are not so numerous or so wide.

Both samples were bagged and shipped to Kingston, Ontario.

Preparatory Treatment of the Ore for Separation.

The ores were first broken to ¾″ by a Blake crusher, and thence fed to Cornish rolls, crushing to ⅛″, the discharge from the rolls passing over a 6 mesh impact screen; oversize being returned to the rolls until all of the ore had been reduced to ⅛″.

After crushing, the ores were piled upon a sheet-iron floor, and carefully sampled by the split shovel method. This sample, representing the ore as received, was marked 'general sample A.'

Analyses of General Samples A.

—	Ferrous Oxide.	Ferric Oxide.	Insoluble.	Sulphur.	Phosphorus.	Iron.
Shipment 1..........	6·17	34·42	55·06	0·039	0·35	28·88
" 2..........	13·63	44·57	30·66	0·095	0·751	41·81

The ores were then divided into approximately two equal portions, one-half of each shipment being tested by the ordinary dry separation process, the remaining half being tested by the Gröndal wet system. This division was made by taking alternate shovelsful for each test, thus ensuring that each portion would be fairly represented by the general sample 'A.'

The portion taken for dry separation was then sized over impact screens. The object of this sizing process was to assemble particles of the same size irrespective of specific gravity, the effect of which is twofold: first, an increased efficiency in the separation process, and secondly, the subsequent separation of each size independently; illustrating the maximum crushing required for the highest efficiency of separation. The sizing process yielded four products: (1) 40 mesh and finer; (2) on 40 mesh and through 20 mesh; (3) on 20 mesh and through 10 mesh, and (4) on 10 mesh and through 6 mesh.

Each of the above sized products was then sampled by the split shovel; the samples being marked 1, 2, 3, and 4, for the 40, 20, 10, and 6 mesh sizes, respectively. A summation of the analyses of these four sizes should approximate with the analyses of the general samples 'A,' affording a check upon the whole.

The four sizes of each ore were then separated independently by the Ball and Norton belt separator; the concentrates and tailings being caught in suitable receptacles and weighed; the dust loss being obtained by the difference in weight of the crude and the weight of the concentrates plus tailings. After weighing, the concentrates and tailings were sampled carefully for subsequent analyses.

The remaining half of the shipments reserved for wet separation were then split into three portions: the first portion being ground in a Krupp dry ball mill to a fineness of 20 mesh, the second likewise to a fineness of 40 mesh, and the third in similar manner to a fineness of 60 mesh. Sampling of these ground materials was not considered necessary as they were each a portion of the original crude, and therefore, represented by the general sample 'A.'

The three pulverized portions of each shipment were then separated by the Gröndal magnetic separator. The concentrates and tailings were caught in settling tanks, and after draining off the surplus water, were dried and weighed, the slime loss being obtained by the difference in weight of the original crude and the weight of the concentrates plus tailings. The concentrates and tailings were then carefully sampled for subsequent analysis.

The concentrates obtained from the separation of the 60 mesh material were of the highest iron content, although still too low in iron to be regarded as a merchantable product. They were, therefore, reground to a fineness of 150 mesh, and reconcentrated; the final product being accepted as satisfactory. The tailings from this secondary separation were added to the tailings of the first operation.

The Separation Process.

The complete results of the separation processes, both dry and wet, for shipments No. 1 and No. 2, are given in the accompanying tables. These tables show the analyses of the original crude, and sized crude; also the weights and percentages with analyses of concentrates and tailings, and the percentages of recovery and loss.

Shipment No. 1.—The dry separation after sizing yielded results that demonstrate the impracticability of concentrating this ore by the dry process. The crystallization is so fine that separation after comminution to ⅛" failed to eliminate more than 56 per cent of the siliceous gangue. Further crushing would result in a better separation; but it is improbable that a merchantable concentrate would be obtained, as the dry separation of finely pulverized iron ore is never efficient.

Wet separation of the 20 and 40 mesh sizes yielded results about on a par with the results of dry separation. Concentration of the 60 mesh size was a little more satisfactory than the foregoing, but it was found necesssary to regrind the 60 mesh heads, with subsequent reseparation before a merchantable product could be obtained. The final product, containing 62·13 per cent of iron, was obtained with a concentration ratio of 4·11, but as the crude from which these concentrates are obtained would be cobbed waste from the run of mine, the cost of the crude would not affect the final costs of the concentrates produced as much as the cost of crushing. The loss of iron at 47·73 per cent (41·24 per cent in tailings plus 6·49 per cent in slime) is due in large measure to the fact that part of the iron in the original crude exists as hematite, which being non-magnetic enters the tailings. It will be noted that phosphorus was reduced to just within the Bessemer limit.

Shipment No. 2.—The dry separation of this ore is not satisfactorry, and the foregoing remarks upon the dry separation of No. 1 shipment would also apply here.

Wet separation of the 20, 40, and 60 mesh sizes yielded more encouraging results; but it was only after a regrinding and reseparation of the 60 mesh heads that a merchantable concentrate was obtained. The concentration ratio at 1·87 in this case means much less grinding than for No. 1 shipment, in the production of a unit of concentrate. Therefore, costs under this heading would be lower. The total loss of iron at 19·46 per cent (16·28 per cent in tailings, plus 3·18 per cent in slimes) is illustrative of the fact that this ore contains much less hematite than No. 1. Phosphorus was not depressed to the Bessemer limit, hence the concentrates would be non-Bessemer.

It is almost unnecessary to add that, these extremely fine concentrates would require either nodulizing or briquetting before they could be utilized in the blast furnace for the manufacture of pig iron.

MAGNETIC SEPARATION OF A COPPER-NICKEL ORE.

The ore experimented upon was shipped to the writer from Nairn, Ontario, on the Sault Ste. Marie branch of the Canadian Pacific railway. The sample weighed 1,268 pounds, and consisted of copper pyrites and nickeliferous pyrrhotite, contained in a dark coloured eruptive rock gangue, probably norite.

The experiments made rested upon the determination of the following points:—

(1) Will magnetic concentration yield a nickeliferous heads product, practically free from copper?

(2) Is it possible to make this nickeliferous heads product, and at the same time leave the cupiferous tailings practically free from nickel?

Preliminary Treatment of the Ore.

The ore was first broken to ¾" size, in a Blake crusher, and thence reduced to ¼" by Cornish rolls. After this preliminary comminution the ore was piled upon a sheet-iron floor and thoroughly mixed by repeated conings. It was then sampled by the ordinary split-shovel method. Analysis of this sample gave the following results:—

ANALYSIS OF CRUDE ORE.

Copper, per cent..	3·49
Nickel, per cent..	4·56

The crushed ore was then subdivided into three portions; the first portion being ground in a Krupp ball mill to a fineness of 20 mesh, the second portion to a fineness of 40 mesh, and the third to a fineness of 60 mesh. Each of these three portions, pulverized to different finenesses, were then separated by the Gröndal wet magnetic separator; the idea of concentrating the ore at different points of comminution being to gain information as regards the behaviour of the copper and nickel bearing minerals when treated at different sizes.

Concentration of the Ore.

Three products were obtained from the separation of this ore: the first being magnetic heads, which were caught in a spitzkasten settling tank; the second, slimes, which, being in a fine state of subdivision, floated off from the heads and were caught in a lower settling tank; and the third, tailings, which were caught in a second pair of settling tanks.

After each operation of the separator, the above tanks were allowed to settle, the water was then siphoned off, and the three products collected, dried, weighed, and carefully sampled.

With the concentration of the 60 and 40 mesh sizes, the separator was operated with an exciting current of 5 amperes, at 110 volts. With the concentration of the 20 mesh the exciting current was reduced to 3 amperes, at 110 volts. An explanation for this reduction of the exciting current in the latter case will be made later.

Concentration of the 60 Mesh Size

Analysis of the heads and tailings after the first pass of this material gave the following results:—

Analysis of Heads and Tails: First Pass of Crude.

	Copper, per cent.	Nickel, per cent.
Heads	1·96	4·02
Tails	5·23	5·58

From the above analysis, it is apparent that a considerable portion of the nickel-bearing mineral is either very feebly or non-magnetic. Therefore, the tailings were repassed twice in an effort to lower their nickel contents, and in order to increase the tractive force of the magnets the coils were changed from series to parallel arrangement, increasing the current from 5 to 20 amperes. The results of this reconcentration of the tailings is illustrated by the following analysis:—

Analysis of Heads and Tails: First and Second Pass of Tails.

	Copper, per cent.	Nickel, per cent.
Heads	5·16	5·59
Tails	6·79	5·28

The above results seem to indicate that a clean separation of the nickel-bearing mineral from the copper and gangue minerals cannot be accomplished by the Gröndal wet method of concentration. It would, no doubt, be possible to lower the nickel contents of the above tailings by passing them through the field of a high tension machine, such as the Wetherill separator; but it is doubtful that a complete saving of the nickel would be made, and as the Wetherill machine operates on dry material only, the heads product from such a separation would contain appreciable amounts of copper pyrites mechanically entangled.

Concentration of the 40 Mesh Size.

After the first pass of this material through the separator, analyses of the heads and tails were as follows:—

Analysis of Heads and Tails: First Pass of Crude.

	Copper, per cent.	Nickel, per cent
Heads	1·80	4·22
Tails	6·09	5·39

The tailings from the above operation were then repassed, with the following result:—

Analysis of Heads and Tails: First and Second Pass of Tails.

	Copper, per cent.	Nickel, per cent.
Heads	5·08	5·68
Tailings	7·44	5·68

The above results tally approximately with those obtained after separation of the 60 mesh material, and furnish additional proof that a large proportion of the nickel-bearing mineral is feebly magnetic.

Concentration of the 20 Mesh Size.

The concentration of the 60 and 40 mesh sizes having demonstrated the impracticability of recovering in the magnetic heads more than approximately 50 per cent of the original nickel contents, it was decided that the first-named condition of the problem, namely, the production of magnetic heads free from copper, should receive its due share of attention.

A glance at the analyses of the head products from concentration of the 60 and 40 mesh sizes, indicates that they contain over 30 per cent of the original copper. This fact needs some explanation. Copper pyrites, when pulverized to a fine state of subdivision, has a marked tendency to slime, and when water is being utilized as a carrying medium for this finely divided pulp the slimed chalcopyrite will float on the surface. This peculiarity of the slimed mineral in resisting submersion is, no doubt, due to the action of surface tension. Now in the Gröndal system of magnetic separation the various mineral particles are brought into the magnetic field by being held in suspension in a stream of water that is flowing through a weir box situated immediately below the magnets. The tractive force of the magnets draws the magnetic minerals out of the water, while the non-magnetic minerals escape as tailings. It will be readily understood then, that in this particular problem the fine copper slimes floating unsubmerged on the surface will adhere, mechanically, to the particles of pyrrrhotite as they are lifted through the surface of the water towards the magnetic field. It would appear, therefore, that a solution of the problem might be realized if in the preparation of the ore for concentration, precautions were taken to avoid or to eliminate any serious production of slimes. This could, no doubt, be accomplished by the use of crushing machinery that would yield a more granular product; or, by a preliminary classification of the crude by means of hydraulic classifiers.

In the concentration of the 20 mesh material an attempt was made to produce magnetic heads of low copper content. The only adjustment available was a reduction of the exciting current from 5 to 3 amperes. This, of course, means a lower percentage of magnetic heads recovered, but the copper contents of these heads is relatively lower.

Analyses of the heads and tails after the first pass of the 20 mesh crude are as follows:—

	Copper, per cent.	Nickel, per cent.
Heads	0·53	3·62
Tails	5·25	3·58

The tailings from the above were reconcentrated with the exciting current at 20 amperes. Analyses of the resulting heads and tails gave the following figures:—

	Copper, per cent.	Nickel, per cent.
Heads	5·01	5·45
Tails	6·90	4·49

It will be noted that a material reduction was effected in the copper contents of the magnetic heads from the first pass. This was obtained at the expense of the percentage of magnetic heads recovered, but was naturally expected.

The substantial reduction in the copper contents effected by the first pass of the crude encouraged the belief that a secondary concentration of the heads would yield proportionally similar results; therefore, the 20 mesh concentrates were repassed with an exciting current of 5 ampères. The reduction in copper resulting from this secondary operation was, however, much below the expectation, the heads still retained 0·31 per cent of that metal, and, therefore, could not be regarded as a satisfactory product.

Analysis of the heads product from this secondary concentration is as follows:—

Copper, per cent	0·31
Nickel, per cent	3·51

Complete results of the concentration of the three different sizes, namely, 60, 40, and 20 mesh, are given in the subjoined table. The magnetic heads from the first separation are called concentrates; while the magnetic heads from the secondary separation of tails are termed middlings; the final non-magnetic product being termed tailings.

Tabulated Results of the Magnetic Concentration of the Three Sizes 60, 40 and 20 Mesh.

Crushed to Mesh.	CRUDE ORE.			EXCITING CURRENT.		CONCENTRATES.				MIDDLINGS.				SLIME FROM CONCENTRATES.				TAILINGS.				SLIME LOSS.	
	Weight, Pounds.	Analysis.		Amperes.	Volts.	Weight, Pounds.	Per cent.	Analysis.		Weight, Pounds.	Per cent.	Analysis.		Weight, Pounds.	Per cent.	Analysis.		Weight, Pounds.	Per cent.	Analysis.		Weight, Pounds.	Per cent.
		Cu.	Ni.					Cu.	Ni.			Cu.	Ni.			Cu.	Ni.			Cu.	Ni.		
		%	%					%	%			%	%			%	%			%	%		
60	393	3·49	4·56	5	110	215·5	54·83	1·96	4·02	86	21·89	5·16	5·59	16·5	4·19	4·49	3·69	49	12·47	6·79	5·28	16	4·07
40	348	3·49	4·56	5	110	206·5	59·34	1·80	4·22	59	16·95	5·08	5·68	12·5	3·59	4·37	3·96	53	15·23	7·44	4·94	10	2·87
20	368·5	3·49	4·56	3	110	145·5	39·48	0·53	3·68	131	35·55	5·01	5·45	10·5	2·85	4·15	3·62	56	15·17	6·90	4·49	9	2·44

NOTE—60 mesh size, 10 pounds were lost in handling, and for samples, equal to 2·54 per cent of original weight.
40 " " 7 " " " " " " 2·01 " " "
20 " " 16·5 " " " " " " 4·48 " " "

NOTE—After the first pass of the crude, the tailings were repassed twice with the exciting coils at 20 amperes. This reconcentration of tailings was carried out in each case and yielded a middling product and the final tailings, as tabulated above.

Comparing the results of the concentration of the three different sizes as tabulated above, it is apparent that there is very little difference in the saving of the original nickel contents. It is true that the percentage of nickel in the 20 mesh tailings is 0·79 lower than in the 60 mesh tailings; but this difference is not enough to promise a much larger saving if concentrated at a still larger size, say 10 mesh. On the other hand, there is sufficient evidence to show that the production of magnetic heads free from copper will depend to some extent upon the fineness to which the ore is crushed, preliminary to separation. The concentrates from the 60 mesh contained nearly 2 per cent, whereas the concentrates from the 20 mesh contained only 0·53 per cent of copper. It should not be forgotten, however, that the lower copper contents of the 20 mesh concentrates was due, in part, to the fact that, the material was separated at a lower amperage, resulting in a much lower percentage of magnetic heads recovered.

In the light of the above experiments it is reasonable to assume that a much better separation would have resulted if the ore had received a partial crushing—followed by dry magnetic cobbing—before finer grinding and wet concentration were resorted to. Such preliminary treatment would eliminate a considerable portion of the copper pyrites at say ¼″ size; and it is quite possible that cobbing, at this size, would concentrate the nickel values, thus rendering a heads product that would, with subsequent wet concentration, yield a magnetic product higher in nickel and lower in copper than any result so far attained. Had there been a sufficiency of crude ore to work upon, this method would have been tried; but as the whole of the original crude had been used for the experiments described above, the only alternative was, a retreatment of the three heads products, with a view of making a further reduction in their copper contents.

The tendency of copper pyrites under comminution to form slime has already been referred to, and it is, therefore, hardly necessary to state that by far the largest proportion of copper in the concentrates will be found as slimed chalcopyrite. To eliminate these slimes requires in this particular case hydraulic classification, and in order to determine with approximation the results that might be expected from hydraulic classification, the following sieve tests were made upon the dry 60, 40, and 20 mesh concentrates.

Sieve Test on 60 Mesh Concentrates, Dry.

Screen.	Weight, Grms.	Per Cent of Total.	Copper Content, Per Cent.	Distribution of Copper. Per Cent of Total.
Through 58 on 60	3.1	0·139	1·31	0·0964
" 60 " 70	248·8	11·183	0·99	5·8451
" 70 " 80	16·7	0·750	1·08	0·4283
" 80 " 90	204·1	9·173	1·24	6·0106
" 90 " 100	86·1	3·870	1·24	2·5356
" 100 " 120	181·2	8·145	1·38	5·9387
" 120 " 150	199·2	8·953	1·65	7·8060
" 150 " 200	359·2	16·145	1·76	15·0144
" 200 " —	926·4	41·634	2·56	56·3245
Totals	....	99·992	....	99·9996

Sieve Test on 40 Mesh Concentrates, Dry.

Screen.	Weight, Grms.	Per Cent of Total.	Copper Content, Per Cent.	Distribution of Copper, Per Cent of Total.
Through 30 on 40	6·95	0·306	1·06	0·174
" 40 " 50	379·30	16·721	1·36	12·120
" 50 " 60	236·45	10·426	1·41	7·830
" 60 " 70	248·38	10·952	1·23	7·175
" 70 " 80	22·78	1·004	1·20	0·642
" 80 " 90	166·20	7·329	1·41	5·510
" 90 " 100	79·50	3·505	1·40	2·619
" 100 " 120	97·24	4·288	1·59	3·633
" 120 " 150	124·82	5·504	1·79	5·249
" 150 " 200	237·70	10·484	2·15	12·010
" 200 " —	668·38	29·473	2·74	43·090
Totals	....	99·990	....	100·052

Sieve Test on 20 Mesh Concentrates, Dry. After Secondary Separation.

Screen.	Weight, Grms.	Per Cent of Total.	Copper Content, Per Cent.	Distribution of Copper, Per Cent of Total.
Through 16 on 20	0·65	0·0026	....	....
" 20 " 30	192·55	7·87	0·38	11·555
" 30 " 40	437·10	17·91	0·21	15·198
" 40 " 50	374·20	15·32	0·22	13·000
" 50 " 60	188·70	7·74	0·29	8·650
" 60 " 70	192·70	7·89	0·28	8·530
" 70 " 80	54·40	2·22	0·29	2·491
" 80 " 90	131·90	5·41	0·31	6·451
" 90 " 100	70·95	2·91	0·32	3·588
" 100 " 120	92·20	3·78	0·24	3·494
" 120 " 150	116·10	4·76	0·18	3·301
" 150 " 200	178·40	7·31	0·22	6·210
" 200 " —	411·90	16·83	0·27	17·580
Totals	....	99·9526	....	100·048

The screens used for the above tests were the standard screens, recently adopted by The Institution of Mining and Metallurgy of Great Britain. The various sizes, with diameter of wire and mesh aperture, are given below.

Table.—I.M.M. Standard Laboratory Screens.

Mesh or apertures per linear inch.	DIAMETER OF WIRE.		APERTURE.		SCREENING AREAS.
	In.	Mm.	In.	Mm.	Per Cent.
5	0·1	2·540	0·1	2·540	25·00
8	0·063	1·600	0·062	1·574	24·60
10	0·05	1·270	0·05	1·270	25·00
12	0·0417	1·059	0·0416	1·056	24·92
16	0·0313	0·795	0·0312	0·792	24·92
20	0·025	0·635	0·025	0·635	25·00
30	0·0167	0·424	0·0166	0·421	24·80
40	0·0125	0·317	0·0125	0·317	25·00
50	0·01	0·254	0·01	0·254	25·00
60	0·0083	0·211	0·0083	0·211	24·80
70	0·0071	0·180	0·0071	0·180	24·70
80	0·0063	0·160	0·0062	0·157	24·60
90	0·0055	0·139	0·0055	0·139	24·50
100	0·005	0·127	0·005	0·127	25·00
120	0·0041	0·104	0·0042	0·107	25·40
150	0·0033	0·084	0·0032	0·084	24·50
200	0·0025	0·063	0·0025	0·063	25·00

The above sieve tests illustrate clearly the tendency of the copper pyrites to slime. In the 60 mesh concentrates over 56 per cent of the total copper was contained in particles finer than 200 mesh. In the 40 mesh this proportion was reduced to 43, and in the 20 mesh to 17 per cent. Hence it is apparent that fine grinding is opposed to a subsequent wet separation by the Gröndal separator. In this connexion it should be noted that, the Krupp ball mill is evidently unsuited for the work of comminution; and had the crushing been carried out by means of a wet ball mill the amount of slimes produced would probably have been much less.

The screen tests having shown that most of the copper contained in the heads existed as slimed particles, it remained to be proved that hydraulic classification would remove the major portion of these cupiferous slimes. For this work an ordinary 5 ft. Colorado cone classifier was used, the classified products being as follows: heads from the spigot discharge, and slimes carried off by the overflow, and allowed to settle in a three compartment spitzkasten; the overflow from the spitzkasten being caught in a large settling tank. After classification of each of the 60, 40, and 20 mesh concentrates, the heads from the spigot discharge were passed through the magnetic separator, the exciting current being maintained at 5 ampères for each operation.

Complete results of the hydraulic classification, with subsequent magnetic separation, are tabulated below:—

HYDRAULIC CLASSIFICATION, 60 MESH CONCENTRATES.

CONCENTRATES FEED.			SPIGOT HEADS.				SPITZKASTEN.												SLIME TANK.				SLIME LOSS.	
	Analysis.				Analysis.		1st Compartment.				2nd Compartment.				3rd Compartment.						Analysis.			
									Analysis.				Analysis.				Analysis.							
Weight.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.
Lbs.	%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs.	
188	1·96	4·02	113·5	60·46	0·93	3·93	24·5	13·02	3·25	3·87	24·5	13·02	3·20	3·64	7·5	3·96	4·14	3·52	6	3·18	3·61	3·94	12	6·36

WET MAGNETIC SEPARATION OF THE ABOVE HYDRAULIC SPIGOT HEADS.

EXCITING CURRENT.		HYDRAULIC HEADS FEED.			CONCENTRATES.				TAILINGS.				LOSS.	
			Analysis.				Analysis.				Analysis.			
Amperes.	Volts.	Weight.	Cu.	Ni.	Weight.	~~Per cent.~~	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.
		Lbs.	%	%	Lbs.		%	%	Lbs.		%		Lbs.	
5	110	112·5	0·93	3·93	84	74·62	0·17	2·05	22·5	20·00	3·07	7·51	6	5·37

HYDRAULIC CLASSIFICATION, 40 MESH CONCENTRATES.

Concentrates Feed.			Spigot Heads.				Spitzkasten.												Slime Tank.				Slime Loss.	
	Analysis.				Analysis.		1st Compartment.				2nd Compartment.				3rd Compartment.						Analysis.			
Weight.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight	Per cent.	Analysis. Cu.	Analysis. Ni.	Weight	Per cent.	Analysis. Cu.	Analysis. Ni.	Weight	Per cent	Analysis. Cu.	Analysis. Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.
Lbs.	%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs		%	%	Lbs.	
182	1·80	4·22	142·5	78.35	1·28	3·93	10	5·49	4·33	4·01	13	7·14	4·54	3·82	5	2·73	4·74	3·43	5·5	3·01	4·77	3·75	6	3·28

WET MAGNETIC SEPARATION OF THE ABOVE HYDRAULIC SPIGOT HEADS.

Exciting Current.		Hydraulic Heads Feeds.			Concentrates.				Tailings.				Loss.	
			Analysis.				Analysis.				Analysis.			
Amperes.	Volts.	Weight.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.
		Lbs.	%	%	Lbs.		%	%	Lbs.		%	%	Lbs.	
5	110	141·5	1·28	3·93	107	75·64	0·19	2·12	27·5	19·42	4·79	8·19	7	4·94

HYDRAULIC CLASSIFICATION, 20 MESH CONCENTRATES.

Concentrates Feed.			Spigot Heads.				Spitzkasten.												Slime Tank.				Slime Loss.	
	Analysis.				Analysis.		1st Compartment.				2nd Compartment.				3rd Compartment.						Analysis.			
									Analysis.				Analysis.				Analysis.							
Weight.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight	Per cent.	Cu.	Ni.	Weight	Per cent.	Cu.	Ni.	Weight	Per cent	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.
Lbs.	%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs.		%	%	Lbs		%	%	Lbs.	
98·5	0·31	3·51	90	91·35	0·28	3·35	3·5	3·55	0·36	3·41	3·5	3·55	0·60	2·61	0·75	0·71	1·06	2·04	0·25	0·26	1·45	1·62	0·5	0·55

WET MAGNETIC SEPARATION OF THE ABOVE HYDRAULIC SPIGOT HEADS.

Exciting Current.		Hydraulic Heads Feed.			Concentrates.				Tailings.				Loss.	
			Analysis.				Analysis.				Analysis.			
Amperes.	Volts.	Weight.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.	Cu.	Ni.	Weight.	Per cent.
		Lbs.	%	%	Lbs.		%	%	Lbs.		%	%	Lbs.	
5	110	88	0·28	3·35	82	93·18	0·16	2·37	4	4·54	0·94	5·44	2	2·27

It will be noted that the nickel content of the magnetic heads has suffered further reduction. This was to be expected, however, as the preliminary work had shown that the nickel-bearing mineral was feebly magnetic. It is also to be noted that the nickel content of the magnetic heads increases with the size of the concentrate particles; the nickel contained in the three final heads products of the 60, 40, and 20 mesh, being 2·05, 2·12, and 2·37 per cent respectively. The percentage of recovery of magnetic heads indicates that concentration at coarse sizes will yield the maximum saving, viz., 93·18 per cent of 20 mesh concentrates were recovered; whereas the saving of the 40 mesh was 75·64 per cent, and the saving of the 60 mesh, 74·62 per cent of the original feed.

As regards elimination of copper, there is but little difference in the copper contents of the 20, 40, and 60 mesh concentrates; the percentages being 0·16, 0·19, and 0·17, respectively. These figures cannot, however, be regarded as completely satisfactory, and it is probable that for commercial work the copper should not exceed 0·05 per cent.

For the production of nickeliferous pyrrhotite concentrates containing not more than 0·05 per cent of copper from crude ore containing as much as 3·49 per cent, it would probably be necessary to subject the crude to a preliminary treatment of coarse crushing and dry magnetic cobbing; this preliminary treatment being followed by finer crushing for hydraulic classification, and finally, wet magnetic concentration of the material from the hydraulic classifiers.

In order to render such finely divided sulphurous concentrates in fit condition for the production of ferro-nickel pig in the blast furnace, or modern electric shaft furnace, would require roasting and briquetting.

To accomplish the production of non-sulphurous hard porous briquettes, the concentrates would first require preliminary roasting in a mechanically rabbled furnace, such as the 'McDougall'; then, after the sulphur had been reduced to within 1 or 2 per cent, the roasted material would be in a fit condition for briquetting by the Gröndal system.

The above is offered merely as a suggestion. Had time permitted, experiments would have been undertaken with the view of testing the feasibility of such a process.

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1. Mining Conditions of the Klondike, Yukon. Report on—by Eugene Haanel, Ph.D., 1902.
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3. Investigation of the different electro-thermic processes for the smelting of iron ores, and the making of steel, in operation in Europe. Report of Special Commission—by Eugene Haanel, Ph.D., 1904. (Out of print.)
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5. On the location and examination of magnetic ore deposits by magnetometric measurements. Eugene Haanel, Ph.D., 1904.
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11. Asbestos: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (Out of print: see No. 69.)

    Exploitation. Report of the Commission appointed to investigate—by W. R. Ingalls, 1905.
16. Experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Final Report on—by Eugene Haanel, Ph.D., 1907.
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21. Summary Report of Mines Branch, 1907-8.
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23. Iron Ore Deposits along the Ottawa (Quebec side) and Gatineau rivers. Report on—by Fritz Cirkel, M.E.
24. General Report on the Mining and Metallurgical Industries of Canada, 1907-8.
25. The Tungsten Ores of Canada. Report on—by Dr. T. L. Walker.
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27. The Mineral Production of Canada, 1908. Preliminary Report on—by John McLeish, B.A.
28. Summary Report of Mines Branch, 1908.
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62. Mineral Production of Canada, 1909. Preliminary Report on—by John McLeish, B.A.
63. Summary Report of Mines Branch, 1909.
67. Iron Ore Deposits of the Bristol Mine, Pontiac County, Quebec. Bulletin No. 2—Einar Lindeman, M.E., and Geo. C. Mackenzie, B.Sc.

Schedule of Charges for Chemical Analyses and Assays.

68. Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—Dr. Eugene Haanel.
69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel, M.E. (Second Edition, enlarged.)

71. Investigation of the Peat Bogs, and Peat Industry of Canada, 1909-10: to which is appended Mr. Alf. Larson's Paper on Dr. M. Ekenberg's Wet-Carbonizing Process: from Teknisk Tidskrift, No. 12, December 26, 1908—translation by Mr. A. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet entitled 'A Solution of the Peat Problem,' 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—A. Anrep, Peat Expert. (Second Edition, enlarged.)

79. Production of Iron and Steel in Canada during the calendar year 1909. Bulletin on—by John McLeish, B.A.

80. Production of Coal and Coke in Canada during the calendar year 1909. Bulletin on—by John McLeish, B.A.

82. Magnetic Concentration Experiments. Bulletin No. 5—by Geo. C. Mackenzie.

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89. Reprint of Presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Eugene Haanel, Ph.D.

90. Proceedings of Conference on Explosives.

IN THE PRESS.

83. An investigation of the Coals of Canada with reference to their Economic Qualities: as conducted at McGill University under the auspices of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., and R. J. Durley, Ma.E.

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88. The Mineral Production of Canada, 1909. Annual Report on—by John McLeish, B.A.

IN PREPARATION.

91. Coal and Coal Mining in Nova Scotia. Report on—by J. G. S. Hudson.

92. Molybdenum Ores of Canada. Report on—by Dr. T. L. Walker.

MAPS.

6. Magnetometric Survey of Calabogie mine, Bagot township, Renfrew county, Ontario. Vertical Intensity—by E. Nyström, M.E., 1904.

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

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

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

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

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

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

37. Survey of Alfred Peat Bog, Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
38. Survey of Welland Peat Bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
39. Survey of Newington Peat Bog, Osnabruck, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
40. Survey of Perth Peat Bog, Drummond township, Lanark county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
41. Survey of Victoria Road Peat Bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nyström, M.E., and A. Anrep, Peat Expert.
48. Magnetometric Map of Iron Crown claim at Klaanch river, Vancouver island, B.C.—by Einar Lindeman, M.E.
49. Magnetometric Map of Western Steel Iron claim, at Sechart, Vancouver island, B.C.—by Einar Lindeman, M.E.
50. Vancouver island, B.C.—by Einar Lindeman, M.E.
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, M.E.
54. Iron Ore Occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel, M.E.
57. The Productive Chrome Iron Ore District of Quebec—by Fritz Cirkel, M.E.
60. Magnetometric Survey of the Bristol mine, Pontiac county, Quebec—by Einar Lindeman, M.E.
61. Topographical Map of Bristol mine, Pontiac county, Quebec—by Einar Lindeman, M.E.
70. Magnetometric Survey of Northwest Arm Iron Range, Lake Timagami, Nipissing district, Ontario—by Einar Lindeman, M.E.
72. Brunner Peat Bog, Ontario—by A. Anrep, Peat Expert.
73. Komoka Peat Bog, Ontario— " "
74. Brockville Peat Bog, Ontario— " "
75. Rondeau Peat Bog, Ontario— " "
76. Alfred Peat Bog, Ontario— " "
77. Alfred Peat Bog, Ontario: Main Ditch profile—by A. Anrep.
78. Map of Asbestos Region, Province of Quebec, 1910—by Fritz Cirkel, M.E.
86. Map showing general distribution of Serpentine in the Eastern Townships—by Fritz Cirkel, M.E.

IN PREPARATION.

64. Index Map of Nova Scotia: Gypsum—by W. F. Jennison, M.E.
65. Index Map of New Brunswick: Gypsum—by W. F. Jennison, M.E.
66. Map of Magdalen islands: Gypsum—by W. F. Jennison, M.E.
87. Key Map for Mica Report—by Hugh S. de Schmid.

FIG. 1

MAGNETIC CONCENTRATION, BRISTOL ORE, SHIPMENT No. 1

ANALYSIS

Ferrous Oxide.	Ferric Oxide.	Insoluble.	Sulphur.	Phosphorus.	Iron.
23·65	50·14	17·46	2·62	0·011	53·49

1836 POUNDS TO DRY TEST ←

DRY CONCENTRATION.

Crude Ore Sized.								Concentrates.						Tailings.				Dust Loss.		Efficiency.		
Sample Number	Through Mesh.	Weight and Per cent.		Analyses.				Weight and Per cent.		Analyses.				Weight and Per cent.		Analyses.				Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude per Unit of Concentrate.
		Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds.	Per cent.			
1	40	714	38·85	55·70	16·32	2·25	0·009	558	78·15	69·12	2·59	0·202	0·0003	141	19·74	7·81	70·88	15	2·11	96·95	3·05	1·280
2	20	355	19·35	58·43	12·00	2·28	0·015	296	83·58	68·23	3·43	0·341	0·0007	52	14·64	9·63	66·79	7	1·98	97·31	2·69	1·200
3	10	378	20·60	51·44	17·89	3·00	0·012	313	82·80	59·41	12·43	1·403	0·0020	61	16·13	12·64	64·75	4	1·07	95·93	4·07	1·204
4	6	389	21·20	47·51	28·03	3·06	0·014	349	89·71	51·00	22·43	2·560	0·0010	37	9·51	17·23	63·67	3	0·78	96·71	3·29	1·112
Totals		1,836	100·00	52·73	18·08	2·57	0·012	1,516	82·57	62·77	8·95	1·010	0·0010	291	15·84	10·34	67·94	29	1·59	96·71	3·29	1·208

RECAPITULATION FOR TOTALS.

Pounds of iron in crude, 986·48.	
" concentrate	951·59
" tailings	30·08
" dust	4·81
Totals	986·48

Per cent saved in concentrate	96·46
" lost in tailings	3·04
" lost in dust	0·50
Totals	100·00

Units of crude required per unit of concentrate, 1·211.

→ POUNDS TO WET TEST **1922**

WET CONCENTRATION.

Crude Ore.							Concentrates.						Tailings.				Slime Loss.		Efficiency.		
Sample Number.	Ground to Mesh.	Weight in Pounds.	Analyses.				Weight and Per cent.		Analyses.				Weight and Per cent.		Analyses.				Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude per Unit of Concentrates.
			Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds.	Per cent.			
1	10	639	53·49	17·46	2·62	0·011	532	83·25	64·45	6·37	0·539	0·0010	100	15·64	6·92	68·47	7	1·11	97·56	2·44	1·235
2	20	535	53·49	17·46	2·62	0·011	424	79·25	64·24	5·45	0·516	0·0010	101	18·87	5·91	70·72	10	1·88	98·04	1·96	1·225
3	40	648	53·49	17·46	2·62	0·011	504	77·77	67·42	3·70	0·361	0·0004	132	20·37	5·03	67·28	12	1·86	97·93	2·07	1·287

RECAPITULATION FOR SAMPLE No. 3.

Pounds of iron in crude, 346·61.	
" concentrate	339·79
" tailings	6·63
" slime	0·19
Totals	346·61

Per cent saved in concentrate	98·03
" lost in tailings	1·89
" lost in slime	0·08
Totals	100·00

Units of crude required per unit of concentrate, 1·30.

FIG. 2

MAGNETIC CONCENTRATION, BRISTOL ORE, SHIPMENT No. 2

ANALYSIS

Ferrous Oxide.	Ferric Oxide.	Insoluble.	Sulphur.	Phosphorus.	Iron.
9·51	63·47	9·97	2·79	0·008	51·83

2319 POUNDS TO DRY TEST ←——— ———→ POUNDS TO WET TEST **1904**

DRY CONCENTRATION.

Crude Ore Sized.								Concentrates.						Tailings.				Dust Loss.		Efficiency.		
Sample Number	Through Mesh.	Weight and per cent.		Analyses.				Weight and per cent.		Analyses.				Weight and per cent.		Analyses.				Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude Per Unit of Concentrate.
		Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds.	Per cent.			
1	40	866	37·40	56·21	7·65	2·257	0·004	498	57·50	64·22	3·58	0·375	0·0007	342	39·49	44·60	13·01	26	3·01	68·00	32·00	1·68
2	20	303	13·08	52·79	10·34	3·523	0·011	177	58·41	59·31	7·05	0·840	0·0020	115	37·95	43·10	16·32	11	3·64	67·27	32·73	1·67
3	10	525	22·64	47·51	13·63	3·585	0·012	272	51·81	53·00	10·91	1·360	0·0020	247	47·04	41·62	17·55	6	1·15	58·11	41·89	1·92
4	6	625	26·88	49·10	13·75	2·505	0·007	330	52·80	52·41	11·07	1·240	0·0030	291	46·56	45·42	15·68	4	0·64	56·47	43·53	1·89
Totals.....		2,319	100·00	51·87	10·99	2·780	0·007	1,277	55·06	58·10	7·63	0·870	0·0020	995	42·91	44·92	15·29	47	2·03	59·26	40·74	1·89

RECAPITULATION FOR TOTALS.

Pounds of iron in crude, 1,202·86—	
" concentrate	741·94
" tailings	446·95
" dust	13·97
Totals	1,202·86

Per cent saved in concentrate	61·68
" lost in tailings	37·15
" lost in dust	1·17
	100·00

Units of crude required per unit of concentrate, 1·81.

7325—b

WET CONCENTRATION.

Crude Ore.							Concentrates.						Tailings.				Slime Loss.		Efficiency.		
Sample Number.	Ground to Mesh.	Weight in Pounds.	Analyses.				Weight and per cent.		Analyses.				Weight and per cent.		Analyses.				Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude Per Unit of Concentrate.
			Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds.	Per cent.			
1	10	664	51·83	9·97	2·79	0·008	472	71·08	56·92	8·40	1·12	0·0007	172	25·90	37·41	18·50	20	3·02	81·34	18·66	1·35
2	20	622	51·83	9·97	2·79	0·008	392	63·02	59·99	6·95	0·74	0·0007	199	31·99	38·62	19·39	31	4·99	71·45	28·55	1·62
3	40	618	51·83	9·97	2·79	0·008	346	55·98	61·48	5·96	0·42	0·0003	229	37·05	38·43	20·07	43	6·97	69·36	30·64	1·71

RECAPITULATION FOR SAMPLE No. 3.

Pounds of iron in crude, 320·31—	
" concentrate	213·92
" tailings	88·00
slime	18·39
Totals	320·31

Per cent saved in concentrate	66·78
" lost in tailings	27·47
" lost in slime	5·75
	100·00

Units of crude required per unit of concentrate, 1·71.

FIG. 3

MAGNETIC CONCENTRATION, BATHURST ORE, SHIPMENT No. 1

ANALYSIS

Ferrous Oxide.	Ferric Oxide.	Insoluble.	Sulphur.	Phosphorus.	Iron.
6·17	34·42	55·06	0·039	0·35	28·88

1927 POUNDS TO DRY TEST

DRY CONCENTRATION.

Sample Number	Through Mesh.	Crude Ore Sized.						Concentrates.						Tailings.				Dust Loss.		Efficiency.		
		Weight and Per cent.		Analyses.				Weight and Per cent.		Analyses.				Weight and Per cent.		Analyses.						
		Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds.	Per cent.	Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude per Unit of Concentrate.
1	40	447	23·19	21·18	65·93	0·054	0·26	195	43·62	37·21	42·62	0·008	0·22	224	54·58	8·64	85·25	8	1·8	77·40	22·60	2·27
2	20	124	6·44	28·40	51·43	0·059	0·36	47	39·90	40·25	39·68	0·005	0·183	75	60·49	21·42	64·98	2	1·61	52·68	47·32	2·69
3	10	416	21·59	31·85	49·60	0·054	0·37	229	55·04	36·42	44·78	0·006	0·173	184	44·24	26·23	58·35	3	0·72	63·15	36·85	1·81
4	6	940	48·78	31·49	51·02	0·024	0·35	568	60·42	34·83	47·69	0·001	0·197	367	39·04	26·36	58·60	5	0·54	67·04	32·96	1·65
Totals		1,927	100·00	28·97	54·71	0·038	0·34	1,039	53·92	35·87	45·64	0·003	0·195	870	45·15	20·73	64·61	18	0·93	67·66	32·34	1·83

RECAPITULATION FOR TOTALS.

Pounds of iron in crude, 558·25.	
" concentrate	372·74
" tailings	180·43
" dust	5·08
Totals	558·25

Per cent saved in concentrate	66·76
" lost in tailings	32·32
" lost in dust	0·91
Totals	100·00

Units of crude required per unit of concentrate, 1·85.

POUNDS TO WET TEST 1484

WET CONCENTRATION.

Sample Number.	Ground to Mesh.	Crude Ore.					Concentrates.						Tailings.				Slime Loss.		Efficiency.		
		Weight in Pounds.	Analyses.				Weight and Per cent.		Analyses.				Weight and Per cent.		Analyses.						
			Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds.	Per cent.	Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude per Unit of Concentrates.
1	20	494	28·88	55·06	0·039	0·35	287	58·09	40·09	39·46	0·002	0·197	194	39·27	13·60	76·35	13	2·64	80·71	19·29	1·72
2	40	492	28·88	55·06	0·039	0·35	263	53·45	42·07	36·08	0·001	0·182	210	42·68	13·86	76·37	19	3·87	77·90	22·10	1·87
3	60	498	28·88	55·06	0·039	0·35	......	......	47·12	30·82	0·002	0·144	......	......	......	......	......	......	......	......	......
3c	150	......	47·12	30·82	0.002	0·144	121	24·29	62·13	11·36	Trace.	0·053	329	66·06	18·03	69·40	48	9·65	53·03	46·97	4·06

RECAPITULATION FOR SAMPLE No. 33c.

Pounds of iron in crude, 143·82.	
" concentrate	75·18
" tailings	59·32
" slime	9·32
Totals	143·82

Per cent saved in concentrate.	52·27
" lost in tailings	41·24
" lost in slime.	6·49
Totals	100·00

Units of crude required per unit of concentrate, 4·11.

FIG. 4

MAGNETIC CONCENTRATION, BATHURST ORE, SHIPMENT No. 2

ANALYSIS

Ferrous Oxide.	Ferric Oxide.	Insoluble.	Sulphur.	Phosphorus.	Iron.
13·63	44·57	30·66	0·095	0·751	41·81

2124 POUNDS TO DRY TEST ←——— ———→ POUNDS TO WET TEST 1423

DRY CONCENTRATION.

6

Sample Number	Through Mesh.	Crude Ore Sized.						Concentrates.						Tailings.				Dust Loss.		Efficiency.		
		Weight and per cent.		Analyses.				Weight and per cent.		Analyses.				Weight and per cent.		Analyses.						
		Pounds	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds	Per cent.	Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude Per Unit of Concentrate.
1	40	437	20·57	41·31	31·12	0·148	0·757	364	83·27	46·81	26·42	0·011	0·531	66	15·10	13·22	58·09	7	1·63	94·03	5·97	1·19
2	20	178	8·38	41·99	32·58	0·072	0·748	150	84·26	46·23	27·31	0·005	0·567	25	14·04	17·61	52·22	3	1·69	94·09	5·91	1·17
3	10	637	29·99	41·91	30·76	0·079	0·794	464	72·84	47·17	26·39	0·007	0·470	168	26·37	27·82	44·68	5	0·79	82·16	17·84	1·37
4	6	872	41·06	42·39	29·93	0·081	0·679	783	89·78	41·42	28·39	0·006	0·484	85	9·73	25·01	48·38	4	0·49	94·41	5·59	1·11
Totals		2,124	100·00	41·94	30·64	0·093	0·738	1,761	82·90	45·78	27·36	0·007	0·496	344	16·19	23·57	48·71	19	0·91	90·95	9·05	1·20

RECAPITULATION FOR TOTALS.

Pounds of iron in crude, 890·80

" concentrate	806·33	Per cent saved in concentrate	90·50
" tailings	81·11	" lost in tailings	9·10
" dust	3·36	" lost in dust.	0·40
Totals	890·80		100·00

Units of crude required per unit of concentrate, 1·20.

WET CONCENTRATION.

Sample Number.	Crude Ore.						Concentrates.						Tailings.				Slime Loss.		Efficiency.		
	Ground to Mesh.	Weight in Pounds.	Analyses.				Weight and per cent.		Analyses.				Weight and per cent.		Analyses.						
			Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Sulphur, per cent.	Phosphorus, per cent.	Pounds.	Per cent.	Iron, per cent.	Insoluble, per cent.	Pounds	Per cent.	Per cent of Iron Saved.	Per cent of Iron Lost.	Units of Crude Per Unit of Concentrate.
1	20	494	41·81	30·66	0·095	0·751	423	85·62	46·33	26·38	0·005	0·526	61	12·32	14·41	55·32	10	2·06	95·52	4·48	1·16
2	40	491	41·81	30·66	0·095	0·751	389	79·22	49·00	24·43	0·006	0·498	86	17·54	14·22	56·08	16	3·27	93·01	6·99	1·26
3	60	448	41·81	30·66	0·095	0·751	......	......	51·31	22·07	0·005	0·344	......	......	......	......	......	......	......	......	......
3c	150	......	51·31	22·07	0·005	0·344	239	53·34	63·12	10·75	Trace.	0·151	175	39·06	17·43	59·18	34	7·60	80·73	19·27	1·87

RECAPITULATION FOR SAMPLE No. 33c.

Pounds of iron in crude, 187·31

" concentrate	150·86	Per cent saved in concentrate	80·54
" tailings	30·50	" lost in tailings	16·28
" slime	5·95	" lost in slime	3·18
Totals	187·31		100·00

Units of crude required per unit of concentrate, 1·87.