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SUMMARY REPORT

OF THE

MINES BRANCH

OF THE

DEPARTMENT OF MINES

FOR THE CALENDAR YEAR ENDING DECEMBER 31

1914

PRINTED BY ORDER OF PARLIAMENT.

OTTAWA
PRINTED BY J. DE L. TACHÉ, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY.
1915

To Field Marshal, His Royal Highness Prince Arthur William Patrick Albert, Duke of Connaught and of Strathearn, K.G., K.T., K.P., etc., etc., etc., Governor General and Commander in Chief of the Dominion of Canada.

MAY IT PLEASE YOUR ROYAL HIGHNESS:

The undersigned has the honour to lay before Your Royal Highness, in compliance with 6-7 Edward VII, chapter 29, section 18, the Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1914.

LOUIS CODERRE,
Minister of Mines.

Hon. Louis Coderre,
Minister of Mines,
Ottawa.

Sir,—I have the honour to submit herewith, the Director's Summary Report of the work of the Mines Branch of the Department of Mines during the calendar year ending December 31, 1914.

I am, Sir, your obedient servant,

R. G. McCONNELL,
Deputy Minister.

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SUMMARY REPORT

OF THE

MINES BRANCH OF THE DEPARTMENT OF MINES

FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1914

R. G. McConnell, Esq., B.A.,
Deputy Minister,
Department of Mines.

Sir,—I have the honour to submit, herewith, the Summary Report of the Mines Branch for the calendar year ending December 31, 1914.

CHANGES IN STAFF.

The following additions were made to the staff of the Mines Branch during 1914:—

Appointments—

David Westwood, appointed April 1, 1914, as draughtsman.
E. O'Leary, appointed June 1, 1914, as messenger.
Miss Della M. Stewart, M.A., appointed July 1, 1914, as technical typewriter.
H. C. Mabee, B.Sc., appointed August 19, 1914, as chemist, Ore Dressing and Metallurgical Division.
T. W. Hardy, B.Sc., appointed October 10, 1914, as assistant engineering chemist, Fuels and Fuel Testing Division.
H. H. Nicolls, M.Sc., appointed November 6, 1914, as assistant engineering chemist, Fuels and Fuel Testing Division.
E. S. Malloch, B.Sc., appointed December 10, 1914, as assistant technical engineer, Fuels and Fuel Testing Division.

Transferred—

L. J. MacMartin was transferred, January 1, 1914, from the messenger staff to a 3B clerkship in the Fuels and Fuel Testing Division.

Deceased—

C. T. Cartwright, B.Sc., assistant engineer, in the Division of Mineral Resources and Statistics, died October 26, 1914.

ORGANIZATION: CLASSIFIED LIST OF STAFF.

The following is a complete list of the technical officers and other employees at present on the staff of the Mines Branch:—

Administration Staff—

M. M. Farnham, B.A., secretary to the Mines Branch.
Miss J. Orme, private secretary.
W. Vincent, filing clerk.

Administration Staff—Continued.

G. Simpson, distribution clerk.
Miss I. McLeish, typewriter.
Miss W. Westman, typewriter.
Miss M. E. Young, typewriter.
Mrs. O. P. R. Ogilvie, librarian.
A. F. Purcell, messenger.
E. O'Leary, messenger.
John H. Fortune, caretaker.

Division of Mineral Resources and Statistics—

J. McLeish, B.A., chief of division.
J. Casey, clerk.
Mrs. W. Sparks, clerk.
Miss G. C. MacGregor, B.A., clerk.
Miss B. Davidson, typewriter.

Division of Fuels and Fuel Testing—

B. F. Haanel, B.Sc., chief of division.
J. Blizard, B.Sc., technical engineer.
E. S. Malloch, B.Sc., assistant technical engineer.
A. Stansfield, M.Sc., engineering chemist.
F. E. Carter, B.Sc., Dr. Ing., assistant engineering chemist.
F. W. Hardy, B.Sc., assistant chemist.
H. H. Nicholls, M.Sc., assistant chemist.
A. von Anrep, peat expert.
L. J. MacMartin, clerk.

Ore Dressing and Metallurgical Division—

G. C. Mackenzie, B.Sc., chief of the division.
W. B. Timm, B.Sc., assistant engineer.
H. C. Mabee, B.Sc., chemist.

Division of Chemistry—

F. G. Wait, M.A., chemist, chief of the division.
M. F. Connor, B.A.Sc., assistant chemist.
H. A. Leverin, Ch.E., assistant chemist.
N. L. Turner, M.A., assistant chemist.

Division of Metalliferous Deposits—

A. W. G. Wilson, M.A., Ph.D., chief of the division
E. Lindeman, M.E., assistant engineer.
A. H. A. Robinson, B.A.Sc., assistant engineer.
Miss Della M. Stewart, M.A., technical typewriter.

Division of Non-metalliferous Deposits—

H. Fréchette, M.Sc., chief of division.
H. S. de Schmid, M.E., assistant engineer.
L. H. Cole, B.Sc., assistant engineer.
S. C. Ells, B.A., B.Sc., assistant engineer.

Division of Explosives—

J. G. S. Hudson.

NOTE.—This division will be fully organized when the Explosives Act has been put in force.

Draughting Division—

H. E. Baine, chief of the division.
L. H. S. Pereira, assistant draughtsman.
A. Pereira, draughtsman.
E. Juneau, draughtsman.
D. Westwood, draughtsman.
Wm. Campion, mechanical draughtsman.

OUTSIDE SERVICE.

Dominion of Canada Assay Office, Vancouver, B.C.—

G. Middleton, manager.
J. B. Farquhar, chief assayer.
A. Kaye, assistant assayer.
H. Freeman, assistant assayer.
D. Robinson, chief melter.
R. Allison, assistant melter.
G. N. Ford, computer and book-keeper.
T. B. Younger, clerk.
E. A. Pritchett, janitor.

INTRODUCTORY.

The work of the Mines Branch, especially that part concerning investigations dealing with subjects of great magnitude, necessitates the continuance, to a certain extent, of the programmes initiated in former years.

Consequently, the activities of this department during the year 1914 have been confined primarily to investigations in connexion with our metallic and non-metallic deposits; the testing of ores and fuels; the examination and analysis of mineral specimens; together with the compiling of statistics relative to the mineral production of Canada, and the collecting of data with respect to our mineral resources.

Aside from the above programme, mention might be made of the continuance of the examination of the bituminous sand deposits of northern Alberta; the continued investigation of the building and ornamental stones of Canada; and the experiments being made in connexion with the metal cobalt, in an effort to find a greater field of usefulness for this mineral, so as to utilize the large quantities of cobalt residues which at present exist as a by-product: the result of the smelting of the silver ores of northern Ontario.

In addition to the above scope of work, the Mines Branch has inaugurated an investigation of the mineral waters of Canada, to determine, especially, their radioactive properties; has undertaken the analysis of oil and gas samples; and has taken up the examination of mine air samples with a view to assisting the mine owner to safeguard, to some extent, against serious explosions like those which have, of late, caused such a great loss of life, by giving him a definite idea of the nature and quantity of constituent gases that account for the atmospheric conditions of his mine.

Summary statements covering the specific work done by the different members of the staff will be found in succeeding sections of this report; and it is our intention, in the case of special investigations, to issue preliminary reports as early as possible, to be followed later, when completed data has been obtained, by final reports.

ORE DRESSING AND METALLURGICAL LABORATORIES.

The ore dressing and metallurgical laboratories of the Mines Branch, which are now equipped with the most modern machinery and apparatus, have, during the year, conducted tests, both on a large and small scale, with various Canadian ores and minerals.

The work accomplished in these laboratories has the approval of the mining industry of the country, since the tests carried out furnish the mine owner, in respect to his product, with the best and most economical method of ore dressing, and also aid him in solving certain metallurgical difficulties, which in the past prevented him from making his ore a marketable commodity.

To more fully cope with the many demands of the mining industry, an experimental roasting and sintering plant has been erected in conjunction with the above laboratories.

FUELS, AND FUEL TESTING.

The work of the Division of Fuels and Fuel Testing consisted in the continuation of the testing and detailed investigation of coals from the producing mines of western provinces; the investigation of peat bogs; and the investigation in the chemical laboratories of this division, of mineral samples of coals, peats, natural gas, oils, and—towards the close of the year—of mine air samples. This latter work was undertaken for the purpose of furnishing the coal mine operators with information concerning the composition of the air in the mine, so that defective ventilation might be remedied, and the serious accidents heretofore directly traceable to gassy mines be avoided.

Arrangements are being made to undertake an investigation, during 1915, into the feasibility of briquetting western lignites.

ZINC INVESTIGATION.

Investigation of Processes for Smelting Zinc Ores.

During the years 1912 and 1913, experiments in the electric smelting of zinc ores, on a small scale, were conducted for the Mines Branch at McGill University, under the supervision of Dr. Alfred Stansfield and Mr. E. Dedolph, and Mr. W. R. Ingalls of New York, acting in the capacity of consulting engineer to the Dominion Government.

Early in 1913, the experimenters developed an electric furnace that gave encouraging results: operating at the rate of 250 pounds of ore per twenty-four hours.

After making a series of test runs with this small furnace, it became evident that demonstrations on a larger scale were both necessary and desirable; accordingly, steps were taken to lease from the British Columbia Government, the old plant of the Canada Zinc Company at Nelson, B.C.

In accordance with instructions received from the Director of the Mines Branch, on October 2, 1913, Mr. G. C. Mackenzie proceeded to Nelson, B.C., to take control, for the Mines Branch, of the large-scale experiments to be undertaken.

Active construction was commenced shortly after his arrival; but owing to the difficulties of assembling material and supplies at a point so remote as Nelson, the furnace was not made ready until January of 1914.

The plant comprised a preheating furnace, an electric zinc furnace, and a small Wetherill furnace for making zinc oxide.

Experiments in the electric smelting of zinc ores, and in the fine concentration of zinc ores by means of the Wetherill furnace were carried on until the end of April, 1914.

In July, Mr. G. C. Mackenzie, in company with Mr. B. F. Haanel, and Messrs. Leverin and Parsons, of the Mines Branch, was sent to Hartford, Conn., to represent the Canadian Government at a test of the Johnson electric zinc furnace.

A detailed report of the whole zinc investigation, comprising experiments at McGill University; large-scale experiments at Nelson; and a test of the "Johnson" electric furnace is now being prepared by Mr. W. R. Ingalls, and will, in due course, be placed before the public.

SPECIAL METALLURGICAL INVESTIGATIONS.

Cobalt.

The special investigation of the metal cobalt, being conducted for the Mines Branch at the Research Laboratories of the School of Mining, Kingston, under the supervision of Dr. Kalmus, was undertaken—as stated in previous annual summary reports—to determine the properties of cobalt; to examine its adaptability as an alloy; and to find out some new commercial uses for the metal; all in an attempt to make marketable the large quantities of cobalt, as a by-product, resulting from the reduction of silver-cobalt ores: one of the greatest mineral assets of northern Ontario.

The results of the experiments, so far conducted, have been highly satisfactory, and it is found, as was suspected, that cobalt possesses, like nickel, physical properties which made it suitable as an alloy, thus giving the metal a value of considerable economic importance. Moreover, it has been found that cobalt can be economically used for plating purposes: the results obtained being more satisfactory, from a commercial standpoint, than those produced from nickel.

There have already been published by the Mines Branch—covering this field of experiments—the following technical papers, which are available for public distribution:—

"The Preparation of Metallic Cobalt by Reduction of the Oxide."
"A Study of the Physical Properties of the Metal Cobalt."

In addition to the foregoing the following papers are to be issued:—

"Electro-Plating with Cobalt and its Alloys." (In the press.)
"Cobalt Alloys of Extreme Hardness."
"Cobalt Alloys with Non-corrosive Properties."
"The Magnetic Properties of Cobalt, and of Fe_2Co."

On page 131 will be found a short report by Dr. Kalmus, on the progress of the investigations made during the year 1914.

ELECTROTHERMIC SMELTING OF IRON ORES.

In 1907, a report was published by the Mines Branch describing the experiments conducted at Sault Ste. Marie, Ont., under Government direction, in connexion with the smelting of Canadian iron ores by the electrothermic process. So great has been the demand for this publication, that the edition has been entirely exhausted. Moreover, many inquiries are still being received asking for information regarding the commercial results obtained from the electrolytic treatment of iron ores.

During the past few years, there has been considerable activity in the progress of electric smelting in European countries: especially in Norway and Sweden. In order to obtain information regarding the present status of the industry in Europe, Dr. Alfred Stansfield, Professor of Metallurgy, McGill University, was commissioned, early in 1914, to proceed to Sweden, and there obtain data for a report furnishing complete information regarding the electric smelting plants at present in operation, or under construction.

Dr. Stansfield's report, entitled "Electrothermic Smelting of Iron Ores in Sweden", is now in press, and will be available for distribution in 1915.

CHEMICAL LABORATORIES.

An important part of the work of the Mines Branch is that carried on in its chemical laboratories. All the laboratories are equipped with the most up-to-date apparatus and appliances. Each section is in charge of technical experts; and the important work being done is meeting the requirements of the general mining public.

The scope of investigations undertaken include the chemical determinations of metalliferous ores and non-metallic minerals; the physical examination of mineral specimens; and chemical analyses of coal, gas, and oil samples. As mentioned in the Summary Report for the year 1913, the necessary apparatus for water analysis has now been installed, and a specialist in water analysis engaged; hence, many samples of spring and mineral waters have been examined and reported upon during the year. Throughout the season of 1914, the working capacity of the different laboratories has been heavily taxed—although additional assistant chemists have been procured—in consequence of the increasing demands of those interested in the mining industry of the Dominion.

DOMINION ASSAY OFFICE, VANCOUVER, B.C.

In the Summary Report for 1913, attention was drawn to the fact that owing to the passing of an Order in Council, January 16, 1913, authorizing the abolition of the assaying and stamping charge of one-eighth of one per cent on the gross value of the gold and silver contained in deposits received at the Dominion of Canada Assay Office, Vancouver, B.C., there had been a considerable increase in the business done over that of the previous year.

That the above reform was much needed, is evidenced by the fact that, during the present year the amount of business exceeded that of 1913; the net value of deposits during 1914 was $580,625.94 in excess of that of 1913; and exceeded that of 1912 by $1,055,174.17.

During the year ~~1912,~~ 1914 deposits of gold were made requiring 1,300 melts and 1,300 assays: including the assembling and remelting of the individual deposits after purchase, into bars weighing about 1,000 troy ounces, and the assaying of the same. The net value of the gold and silver contained in the deposits was $2,029,251.31.

COPPER METAL MINES.

During the year Dr. Wilson spent ten days in the Eastern Townships of Quebec, visiting the operating copper mines. A visit was also made to the Tetrault zinc mine near Notre Dame des Anges, Que. In the autumn he spent about a month visiting the mines and concentrating plants in the vicinity of Cobalt and Porcupine, northern Ontario, for the purpose of acquiring a knowledge of the present mining practice in these localities, and also to obtain data for use in the compilation of the volume on metal mines which will constitute the first part of the proposed new edition of the report on the Mining and Metallurgical Industries of Canada.

Various office duties assigned to Dr. Wilson required his presence in Ottawa during most of the year. Apart from his regular duties, I found it necessary to assign certain special work to him. Early in the year the report on Natural Gas and Petroleum Resources of Canada was placed in his charge. He has had general supervision over the preparation of the various maps and drawings for this publication, and found it necessary to re-write most of the sections dealing with the geology of the various provinces. He also read one copy of the proofs of this report.

IRON ORES.

Mr. Lindeman and a party of assistants spent the field season investigating iron ore deposits along the line of the Canadian Northern railway, between Winnipeg and Port Arthur.

The first part of the season was taken up in mapping some 8 miles of the Atikokan iron range: a narrow belt of iron-bearing rocks, following, in a general way, the course of the Atikokan river. The iron occurs as magnetite, pyrrhotite, and pyrite, in roughly lenticular bodies of varying size, scattered irregularly through the enclosing rock.

On the western part of the range, sulphides predominate to such an extent that, on some of the claims the iron-bearing mineral consists exclusively of pyrrhotite: a mineral not usually regarded as an ore of iron.

On the eastern part of the range, east of Sabawe lake, the Atikokan Iron Company has done considerable development work on some bodies of relatively pure magnetite. The mine is now idle, but during the period of operation, 90,608 tons of magnetite, averaging 59·8 per cent iron, and about 2 per cent sulphur, were shipped to Port Arthur, and used, after roasting, for the production of pig-iron in the blast furnace. Development work has disclosed considerable ore reserves on this property, some of it, however, very high in sulphur. The association of the ore with the enclosing rocks is here, as on the rest of the range, very irregular, so that it is difficult to make any tonnage estimates.

During the latter part of the season the various parties were engaged in surveying and mapping out the Matawin range. At Shabogna about 4 miles in length of the range was covered; and at Kaministikwia, about 1 square mile.

The Matawin range consists of jasper or other closely related siliceous material, with which is interbanded magnetite and hematite, in varying proportions. A very large quantity of this material is available close to transportation. It is, however, so low grade—usually less than 30 per cent of iron—that fine crushing and concentration, followed by briquetting or nodulizing, will be necessary before it can be made marketable. Taking into consideration the low iron content and the physical character of the ore, it does not seem feasible that such operations could be profitably undertaken at the present time.

SOME WESTERN ONTARIO IRON DEPOSITS.

The months of June, July, and August, of the field season of 1914, were spent by Mr. A. H. A. Robinson, making magnetometric and topographical surveys of the eastern part of the Atikokan iron range. At the end of August the party was moved to Kaministikwia, and similar work was carried on in that neighbourhood, in the townships of Ware and Conmee, until the middle of November.

Mr. R. E. Jamieson acted as field assistant throughout the season, and performed his duties in a highly satisfactory manner.

To Mr. J. Dix Fraser, general manager of the Atikokan Iron Company; Mr. F. Roda, superintendent at Atikokan mine; and to Mr. W. A. Matheson, barrister, Fort William, acknowledgment is due for many courtesies, and for much valuable assistance received during the progress of the work.

Complete magnetometric and topographical maps of the areas surveyed are now being prepared for reproduction, and will be published in due course.

LIMESTONES OF THE PROVINCE OF QUEBEC.

An investigation of the limestones and limestone industry in the province of Quebec was commenced this year by Mr. Fréchette. He spent the field season in examining outcrops and quarries along the Ottawa valley and the southern part of the Eastern Townships. Samples were secured representative of the limestones throughout these districts, analyses of which appear in his summary report, on p. 35. The field work will be continued during the season of 1915.

INVESTIGATING CERTAIN NON-METALLIC MINERALS.

Mr. de Schmid visited a number of the more important producers of barytes, manganese, infusorial earth, talc, etc., in order to secure for the Mines Branch first-hand information as to the status and immediate possibilities of these industries. This line of work will be continued during the ensuing season, and, if deemed expedient, the data obtained will be published in the form of brief individual bulletins on the different minerals.

INVESTIGATION OF THE SAND AREAS OF THE PROVINCE OF QUEBEC.

Mr. L. H. Cole, together with an assistant, was engaged during the field season of 1914 in the study of the sands and sandstones of the province of Quebec, with a view to determining their suitability for use in the building and manufacturing industries.

A special feature of this investigation was the search for sands suitable for glass manufacture, and for foundry purposes.

BITUMINOUS SAND OF NORTHERN ALBERTA.

The investigation of the bituminous sands of northern Alberta was continued during the season of 1914. A consideration of the results of preliminary field work undertaken during the preceding year indicated the desirability of securing further and more detailed information regarding these extensive deposits.

In order to demonstrate in a practical manner the possible value Canadian bituminous sand may have as a material for road construction, it was decided to lay a small section of experimental pavement in the city of Edmonton. For this purpose upwards of 60 tons of the sand was mined, sacked, and stored for shipment during the winter months.

Owing to the large number of exposures available, and to the wide variation in the bituminous sand itself, considerable care was required in the selection of the outcrop, or outcrops, from which a trial shipment could best be taken. Accurate core samples were, therefore, secured at a large number of points, and examined in a field laboratory. Finally, from results obtained in this manner, a selection of bituminous sand was made.

During the work of the preceding year, frequent exposures of clay were noted, and small samples collected at that time appeared to indicate the presence of bodies of economic value, hence a considerable number of larger clay samples were secured from representative outcrops for accurate laboratory determination. A number of samples of mineral water were also secured and forwarded to the laboratory at Ottawa.

In addition to the above, instrumental surveys were made of sections of a number of the streams tributary to the Athabaska.

BUILDING AND ORNAMENTAL STONES OF CANADA.

Dr. W. A. Parks, of Toronto University, has, under the direction of the Mines Branch, continued the investigation of the building and ornamental stones of Canada.

In previous Mines Branch Summary reports, reference was made to the progressive stages of this investigation, as conducted in the province of Ontario, the Maritime Provinces, and the province of Quebec. The field work for 1914 was confined to the province of Manitoba: the examination being part of the proposed investigation covering the three western provinces of Manitoba, Saskatchewan, and Alberta.

The information so far published in connexion with this investigation has been of great service to those interested in the stone-working industry. Data are furnished giving the localities producing the different varieties of stones, the character and magnitude of the deposits, the suitability of the products for various purposes, together with their commercial possibilities, judged from transportation, mining, and other conditions affecting production. In cases where quarries which formerly were large producers, but which, for various reasons, have now been abandoned, inquiries have been made, and suggestions furnished, with a view to remedying the cause that occasioned the removal of the product from the market.

Three volumes, describing the investigations so far completed, are now available for public distribution. Volume I, consisting of parts 1 and 2, contains a systematic investigation of the building and ornamental stones of Ontario; volume II, is descriptive of the deposits of the Maritime Provinces; while volume III, deals with the building and ornamental stones of Quebec. It is expected that the complete information regarding the building and ornamental stones of the western provinces will be obtained during the field season of 1915, and that a report covering the examination will be available for the public early in 1916.

INVESTIGATION OF PEAT BOGS.

During the field season, Mr. A. von Aurep, Peat Expert of the Mines Branch, examined a number of bog areas in the provinces of Quebec, Prince Edward Island. and Nova Scotia.

The work undertaken ascertained the extent, depth, and quality of the peat contained in the several bogs visited.

ORE DRESSING AND METALLURGICAL DIVISION.

The enlarged ore dressing laboratories, completely equipped for either large or small scale testing of Canadian ores, were practically completed during 1914.

The construction of a roaster building was started during April, and the building completed and partially equipped by December. This annex to the main testing laboratory consists of a steel and corrugated iron building, 58 feet long, and 30 feet wide, situated about 20 feet from, and at right angles to, the main laboratory.

Its equipment will consist of an 8-foot Wilfley roaster, specially adapted for testing purposes, and a Dwight and Lloyd duplex sintering pan, of the stationary type.

The roaster and pans for ore roasting and sintering will be driven by means of a 35-horsepower stationary engine. The fume and gas flues from the various apparatus will be connected with a large main, leading to a 24-inch by 60-foot self-supporting stack, placed outside of the building.

Additional apparatus, installed in the main testing laboratory during the year, consist of: two Plumb pneumatic jigs—one standard and one laboratory size; one belt-driven air compressor for supplying air to the pneumatic jigs; two James automatic ore jigs mounted in tandem; one laboratory apparatus for cyanide agitation tests; and one laboratory apparatus for the separation of minerals by oil flotation.

During the year, the staff of the laboratory completed a number of tests on various Canadian ores, of which the following may be mentioned: magnetite from central Ontario; banded iron ores from Algoma; magnetic sands from Quebec; zinc-lead and iron-copper ores from British Columbia; zinc-lead-copper ores from Quebec; and iron pyrites from northern Ontario.

Applications have been received, asking for tests to be made on United States ores; but inasmuch as the laboratories were installed for purposes of testing Canadian ores only, these applications had to be met with a somewhat heavy scale of charges, consequently the tests did not materialize.

In May, Mr. G. C. Mackenzie, Chief of the Division, returned from Nelson, B.C., where he had resided since the previous October, being in charge of the Zinc Investigation for the Mines Branch. In July, Mr. Mackenzie, in company with Mr. B. F. Haanel, assisted by Messrs. C. S. Parsons and H. A. Leverin, represented the Mines Branch at Hartford, Conn., during an experimental test run of the Johnson electric zinc process.

In October and November, Mr. Mackenzie visited the more important iron centres in the eastern and southern United States, where he collected information for the departmental committee preparing a special report on the iron industry—of which committee he is a member. During this tour, Mr. Mackenzie represented the Mines Branch at the annual meeting of the American Iron and Steel Institute held in Birmingham, Ala., at the end of October.

DIVISION OF MINERAL RESOURCES AND STATISTICS.

This division undertook the usual annual collection, compilation, and publication of statistics of mining the metallurgical production in Canada. In addition to the statistical reports, of which seven were published during the year, a revised edition of the report on "Economic Minerals and Mining Industries of Canada" was prepared for distribution at the Panama Pacific Exhibition.

Mr. McLeish, in charge of the division, prepared the reports on the production of Iron and Steel; Coal and Coke; Cement, Clay Products, etc., and all other non-metallic products, while Mr. Cartwright prepared the report on production of Gold, Silver, Copper, Lead, Nickel, Zinc, and other metals.

The death of Mr. Cartwright in October, left the division with an accumulation of work at the end of the year, the appointment of a successor not being completed until February, 1915.

A preliminary report on the Mineral Production of Canada during 1914, was, as usual, separately published two months after the close of the previous year, and is included as an appendix to this report, p. 197.

DIVISION OF EXPLOSIVES

Explosives Act.

On May 5, 1914, the Minister of Mines (Hon. Louis Coderre) gave notice in the House of Commons that he purposed introducing a Bill: "It being expedient to regulate and control the manufacture, importation, and use of explosives, also the construction, licensing, and occupation of premises to be used for the manufacturing and storage of explosives, and to authorize the making of official inquiries when accidents in explosive factories were reported."

On May 12, 1914, the new Explosives Bill—as prepared by Mr. Coderre, Minister of Mines—was read for the first time in the House of Commons.

On May 16, 1914, the Explosives Bill was in Committee of the whole House. The principal changes made from the original Explosives Bill 79 (1910-11), were in clause (*d*), section 2, in the interpretation of the words "explosive" and "magazine," and of the addition of a subsection (2) to section 7: allowing, under certain conditions, the blending of certain component parts of explosives, at or near the point of use, in which case the place where the blending is done shall not be deemed a factory or magazine, within the meaning of the Act.

In the regulations, a subsection was added governing the blending of the non-explosive components of an authorized explosive; and an addition was made to section 26, which reads:—

> Nothing in this Act shall relieve any person of the obligation to comply with the requirements of any license law, or other law or by-law of any province or municipality lawfully enacted, with regard to the storage, handling, sale, or other dealing with explosives, nor of any liability or penalty imposed by such law or by-law for any violation thereof.

On May 19, the Explosives Bill for Canada, passed its third reading in the House of Commons, without discussion; May 30, passed the Senate; and on June 12, 1914, the Bill was finally assented to, and became law. It is confidently expected that now the Explosives Act has become law, that action will be taken to put its provisions into force; to have the much-needed government inspection of explosives factories and magazines undertaken without delay; and, that the establishment of the explosives testing station will be proceeded with, at once, so that Canada will be in a position to determine the causes of the disastrous mining accidents that are constantly occurring. The following tabular statement shows the fatal and non-fatal accidents due to explosives in Canada during 1914, which has been compiled from information furnished by the Department of Labour.

The analysis of the accidents reported to the chief inspectors of mines from some of the provinces show that the larger percentage of accidents underground are due to explosions; especially is this so when metalliferous mines are under consideration.

Province of Ontario—

Fatal accidents due to explosives—(from 23rd annual report of the Bureau of Mines, 1914, page 55):—

Explosive accidents—	1913.	1912.
Premature explosion while loading or lighting holes..	8	0
Drilling into bottom of old or missed holes........	5	1
Asphyxiation from gases from explosives..........	1	5
Picking or putting bar into old hole containing explosive....................................	0	1
	14	7

This shows that 43·7 per cent of underground fatal accidents were due to explosives: an increase of 100 per cent in the number of fatalities.

Province of British Columbia—

Accidents in metalliferous mines—

(See Quarterly Statement of Coal and Metal Mine Fatalities in British Columbia, compiled by Mr. Thomas Graham, Chief Inspector of Mines, Fourth Quarter, 1914. Table 4—Number of men killed in and around the metal mines of British Columbia, for the year 1914, with the fatalities classified according to cause.)

	1914.	1913.
Picking or drilling with unexploded powder..	1	3
Premature blasts..	5	1
Gassing or suffocation from powder fumes..	3	1
Returning on unexploded shots..	1	0
Falling in chutes, raises, winzes, etc..	1	2
Falls of ground..	3	3
Mine cars and haulage..	1	2
	15	12

This statement shows that 66·66 per cent of all fatalities, underground, in the year 1914, were due to explosives; and that 41·66 per cent were due to the same cause in 1913—an increase of 25 per cent in one year. It is evident from the above statements, that the necessity for putting the Explosives Act into force is of great urgency. The fatalities in Canada are so startling—when compared with those in countries where Explosives Acts have been enforced, owing to irresistible public opinion impressing on the Governments of those countries the duty of taking every precaution to safeguard human life—that action in carrying out the expressed legislative will of the people should not be much longer delayed.

A copy of the Explosives Act will be found as an appendix to this report, p. 217.

DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C.

The report of the business done at the Dominion of Canada Assay Office, Vancouver, B.C., during the year ending December 31, 1914, has shown a considerable increase over that of the previous year. This fact shows that the results anticipated by the passing of an Order in Council, in January, 1913, authorizing the abolition of an assaying and stamping charge of one-eighth of one per cent on the gross value of the gold and silver contained in the deposits, are being fully realized.

There were 166,148·83 troy ounces of gold and silver deposited with the Assay Office during the year 1914, as compared with 111,479·95 troy ounces for 1913, and 59,068·53 troy ounces for 1912: an increase over the two previous years, of 54,669·28 and 107,080·30 troy ounces, respectively.

In order to cope with the increase of business of the Assay Office during the year, it was found necessary to make the following changes in, and additions to, the staff:—

R. Allison, who was formerly assistant melter and janitor, was appointed as assistant melter, June 20, 1914.

E. A. Pritchett was appointed janitor, June 20, 1914.

R. D. McLellan was appointed general assistant, June 29, 1914 (resigned September 11, 1914).

H. E. Warburton was appointed temporary clerk, July 4, 1914; called out on military duty, August 10, 1914, left service October 3, 1914.

During the year 1912, deposits of gold were made, requiring 1,300 melts and 1,300 assays, including the assembling and remelting of the individual deposits after purchase, into bars weighing about 1,000 troy ounces each, and the assaying of the same. The net value of the gold and silver contained in the deposits was $2,029,251.31.

The above deposits received came from the following sources:—

Source.	Number of deposits.	Weight.		Net value.
		Before melting.	After melting.	
				$ cts.
British Columbia	893	109,037·86	106,591·28	1,105,489 01
Yukon Territory	209	56,720·31	56,567·34	916,914 44
Alberta	1	30·08	29·70	511 55
Alaska	9	360·58	355·30	6,336 31
	1,112	166,148·83	163,543·62	2,029,251 31

Weight before melting	166,148·83	troy ounces.
" after "	163,543·62	"
Loss by melting	2,605·21	"
Loss percentage by melting	1·5680	

MISCELLANEOUS MATTERS.

ELECTRO-PLATING WITH COBALT.

It was mentioned in another section of this report that the investigation conducted in the Research Laboratories of the School of Mining, Kingston, in connexion with the metal cobalt, showed that for plating purposes this metal possesses qualities far superior to those of nickel.

In order to confirm the experiments made in the laboratory at Kingston, tests were made on a commercial scale at the plant of the Russell Motor Car Company, West Toronto. The results were highly satisfactory, and substantiated our statement as to the plating qualities of cobalt. In connexion with the above experiments, Mr. Barrows, foreman electroplater of the Russell Motor Car Company, writes to Dr. Kalmus, as follows:—

628 Dovercourt Road,
Toronto, November 2, 1914.

H. T. Kalmus, Esq.,
Queens University,
Kingston, Ont.

Dear Sir,—After preparing a cobalt plating solution according to your formula for bath IB, the same being equipped with cast anodes of 98·0 per cent cobalt, the bath being used daily during the past eight weeks plating a great variety of copper, brass, iron, steel, tin, German silver, lead and Britannia metal articles of different shapes and sizes, under exactly the same conditions as met with in general nickel plating at the factory of the Russell Motor Car Company, West Toronto, and after regarding the characteristics of this particular solution absolutely from a commercial viewpoint, I can heartily confirm any statement you have made to me regarding this remarkable solution.

The runs made have varied from 5 minutes to 24 hours, and in each case the bath has proved wonderfully efficient.

The cobalt plates obtained were smooth, white, and fine grained, very adherent and uniform. In fact the surface of these deposits after several hours run were so very smooth and uniform that a 4-inch cotton buff coloured them to a mirror finish quite easily. We use 14-inch and 16-inch buffs to colour 3-hour deposits of nickel.

To test the hardness of the cobalt as compared with nickel with reference to either buffing or polishing with emery, we plated strips of brass one-half the surface with cobalt, and one-half with nickel, always giving the nickelled portion the thickest plate, then by buffing or polishing across the two deposits, we found that invariably the nickel was removed from the brass before the cobalt, and in some cases in one-half the time.

Though so hard and firm, these plates colour beautifully, with little effort, and require the use of much less buffing composition than comparatively thin plates of nickel. Automobile parts of irregular shape were plated for 10 and 20 minutes, and finished on a 6-inch buff operated at 3,000 r.p.m. without the slightest evidence of a defect in the plating.

As a protective coating for iron or steel surfaces, I am convinced that a comparatively thin plate of cobalt will prove equally as effective as a thick plate of nickel from an ordinary double sulphate nickel bath, and the time and power required for the production of such plates is decidedly in favour of the cobalt.

The deposits are also very adherent, no difficulty having been experienced in this respect, although tests were made repeatedly by bending, hammering, and burnishing.

One of the weak points of several so-called rapid nickel-plating solutions which we have tried commercially, is their poor "throwing" powers, i.e., they do not deposit the nickel readily in the indentations or cavities of the cathode. The cobalt solution IB meets this requirement in a most efficient manner, the deposits on the distant portions of the cathode withstand the tests imposed in every case.

Another very noticeable feature of this solution which should commend itself to every practical plater and manufacturer of plated wares, is the extremely high current density at which this solution may be employed, without danger of pitting the plated surface.

As a further test we plated steel tubes of 1″ diameter, two hours, with a current density of 27 amps. per square foot, and then drew the tubes down to ⅝″ diameter, without injuring the deposit. Though extremely hard, the ductility of the deposited metal proved remarkable.

All our tests have been made in a still solution without agitation of any kind, and the plates were subjected to the most severe treatment considered practical for high-grade metallic coatings on the various metals heretofore mentioned.

We are also of the opinion that the anodes in the cobalt bath IB will remain free from coatings such as characterize average anodes used in nickel baths, and that the cost of maintenance will be practically nothing compared to double sulphate nickel solutions.

I can assure you that my experience thus far with these cobalt solutions has been intensely interesting, and I sincerely believe that their use commercially would revolutionize the art of electro plating such wares as are now nickel plated.

The simplicity of its composition, its self sustaining qualities, and remarkable speed of deposition, together with the several points mentioned previously, should appeal to the commercial requirements of this progressive age.

I remain,

Very truly yours,

(Sgd.) WALTER S. BARROWS,
Foreman Electroplater,
Russell Motor Car Co.,
West Toronto, Ont

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628 DOVERCOURT ROAD,
TORONTO, December 1, 1914.

DR. HERBERT T. KALMUS,
Queens University,
Kingston, Ont.

DEAR SIR,—After thoroughly testing cobalt plating bath XIII B, made according to your formula, I take pleasure in submitting the following report.

I found the bath very simple to prepare, and at once began to operate the solution with high current densities. The results obtained were exceedingly gratifying. Evidently bath XIII B will require no prolonged ageing treatment, as splendid white, hard, perfect deposits were obtained with extremely high current densities within three hours after bath was prepared. The experiments have been varied and the tests of plates severe and deliberate; the results have invariably been such as to cause me to regard cobalt bath XIII B the greatest achievement in modern electro plating improvements.

The operation of the bath is positively fascinating, the limit of speed for commercial plating is astonishing, while the excellence of the plates produced is superior to those of nickel for many reasons.

The efficiency of the freshly prepared solution together with the self sustaining qualities of the bath are without parallel in any plating solution of any kind I have ever used.

Thin embossed brass stampings were plated in bath XIII B for only one minute, then given to a buffer who did not know the bath existed and who was accustomed to buffing 1¼ hour nickel deposits on these same stampings. This man buffed the cobalt plates upon a 10″ cotton buff wheel revolving at 3,000 r.p.m. The finish was perfect with no edges exposed. These stampings have been plated in two dozen lots for one minute and from a total of 500 stampings we have found but three stampings imperfect after buffing. Each stamping is formed to a spiral after finishing without injury to the deposit. Grey iron castings with raised designs upon the surface were plated one minute in cobalt bath XIII B, then burnished with 400 lbs. of ⅛″ steel balls for ¼ hour without the slightest injury to the cobalt coating, as was proven by a 36 hour immersion in 15 ozs. of water acidulated with 1 oz. of sulphuric acid.

While attempting to reach the limit of current densities which would be practical with this bath XIII B, I have plated brass automobile trimmings with a current density of 244 amperes per square foot. The pieces were plated in lots of 6, and a total of 100 were plated, buffed and ready for stock in 1 hour's time. No unusual preparation was made for the run and the work was performed by one man. Size of piece plated, 1½″ × 5″.

Automobile hub-caps were plated three minutes in cobalt bath XIII B and buffed to a beautiful lustre of deep rich bluish tone by use of a 7″ cotton buff revolving at 1,200 r.p.m. The deposits were ample for severe treatment usually received by such articles. Comparative tests of these deposits were made as follows: Same style castings plated in double sulphate nickel solution one hour were suspended as anodes in a solution of equal parts muriatic acid and water, sheet lead cathodes were used and a current of 200 amperes at 10 volts passes through the bath. The nickel was removed from the castings in 30 seconds while 45 seconds' time was required to remove the cobalt plates.

The above mentioned plating tests were made with still solution, no form of agitation being employed. By aid of mechanical agitators these current densities could be greatly exceeded with highly satisfactory results.

These cobalt plates were very hard, white and adherent and coloured easily with slight effort.

Several plates were produced upon sharp steel surgical instruments; these instruments finished perfectly and owing to the hardness of the cobalt plate only a thin deposit was required to equal the best nickel deposits which we received as samples. Cobalt deposits should prove especially valuable for electro plating surgical instruments for this reason, non-adherent thick deposits of nickel being very dangerous for this class of work.

Owing to the unusual mild weather in this locality during the past month, I have not concluded test with cobalt plates on highly tempered nickel steel blades, but judging from appearances and various severe indoor tests, we do not hesitate to report success in this direction. A three minute deposit from bath XIII B resists corrosion equally as long as a one hour nickel deposit, the finish is even superior to nickel, while every test employed during the process of manufacturing the nickel plated article has proven equally ineffective with cobalt plates, therefore by reason of the effectiveness of thin cobalt deposits we believe cobalt plates should prove wonderfully efficient on skates, or any keen edged tool requiring a protective metallic coating.

The runs made with bath XIII B have varied from one minute to 15½ hours, and in each case the results were remarkable. Electrotypes were reproduced 1/16″ thick. Electro-dies were faced with cobalt ⅛″ thick, the electrotype being graphite covered wax and lead moulds, while the dies were made on oxidized silver faced Britannia metal.

The deposits from cobalt bath XIII B were very adherent and pliable; by proper regulation of the current beautiful white, hard, tough plates may be produced quickly on any conducting surface.

The "throwing" powers of cobalt bath XIII B make possible its employment for plating deeply indented or grooved articles such as reflectors, channel bars or articles with projecting portion.

We also obtained the best plates with extremely high current densities, although plates finished with 75 amperes per square foot were of good colour and easily buffed. The production of excellent plates with a current density of 150 amperes proved particularly easy, and densities in this neighbourhood were employed for the greater portion of our tests.

Cobalt bath XIII B will produce excellent hard, white, tough plates absolutely free from pits or blemish at a current density of 150 amperes per square foot and under ordinary commercial conditions. This is fifteen times the speed of our fastest commercial nickel solution.

Furthermore, the anode tops and hooks remain free from creeping salts. The solution retains its original clean appearance and the anodes dissolve satisfactorily, no slime or coating formed, brushing or cleaning anodes therefore will be unnecessary. The anodes used with this bath were 98·75 per cent cobalt which were sent me from your laboratory. The bath at the commencement of our tests was strongly acid to litmus, and has remained unchanged throughout our experiments. The specific gravity of the solution when freshly prepared was 1·24 and is the same to-day.

The rich deep bluish-white tone of cobalt plates upon polished brass surfaces is particularly noteworthy; this feature should assist greatly in making cobalt deposits very popular for brass fixtures, trimmings and plumbers' supplies.

My experience with cobalt bath XIII B is by no means at an end. I intend to continue its use until present supplies are exhausted and then equip a larger bath if supplies are obtainable. As a commercial proposition I am satisfied it is wonderfully efficient and economical.

Taking into account the difference in cost of cobalt as compared with nickel, I am satisfied the metal costs for plating a given quantity of work with cobalt would be considerably less than for nickel plating a like quantity.

Furthermore the use of cobalt bath XIII B equipped with automatic apparatus for conveying parts through the bath would reduce the labour cost 75 per cent; such apparatus would be practical for a greater variety of wares than is now the case with nickel.

We cannot speak too highly of cobalt bath XIII B, and confidently believe its future history will surpass the history of any electro plating bath now in general use.

In conclusion, please accept my warmest congratulations upon your successes with cobalt solutions, and heartily appreciating the opportunity of testing these solutions, I desire to sincerely thank you, kind sir, for the benefits derived therefrom.

Very truly yours,

(Sgd.) WALTER S. BARROWS,
Foreman Electroplater,
Russell Motor Car Co.,
West Toronto, Ontario.

CERAMIC LABORATORY.

During the year 1914, provision was made for the establishment of a Division of Ceramics in connexion with the Mines Branch, and the necessary steps were taken to equip laboratories for the testing of clays, shales, and other materials used in our various ceramic industries. The need for this important departure is fully apparent when it is considered of what value a scientific investigation of our clay deposits will be to the public.

It has been known that there exist certain clay deposits in Manitoba, Saskatchewan, Alberta, Quebec, and Nova Scotia, and the character of their products has been examined as far as a chemical analysis is concerned. But before it can be fully decided whether a clay specimen is suitable for the manufacture of tiles, bricks, sewer pipe, or other clay products, a further investigation is necessary, which requires that the sample be submitted to a physical examination after it comes from the muffle.

Therefore, in order to ascertain, not only the true value of our known clay deposits, but also to assist in the opening up of new locations, the ceramic laboratory in charge of a well trained and experienced engineer, will materially advance the clay industry of the country. The clay operator will be furnished with complete information regarding his product, thereby enabling him to take advantage of the increasing demand for clay materials, which, during the last eight years, has advanced 170 per cent.

Moreover, it is expected that when the commercial value of the numerous deposits, now undeveloped, is ascertained, there will be available for the market, as the increasing demand requires, a sufficient supply of our domestic clays to offset, to a certain extent, the amount being imported, which in 1912 reached 38 per cent of a total consumption valued at $17,149,659.

The following tabulated statement of the production of clay materials for the year 1913, gives those interested some idea of the activity of the industry:—

Brick, common	$5,917,373
Brick, pressed	1,458,733
Brick, paving	75,669
Brick, ornamental	15,423
Fireclay and fireclay products	142,738
Fireproofing	461,387
Pottery	53,533
Sewer pipe	1,035,906
Tiles	338,552
Kaolin	5,000
Total value	$9,504,314

TECHNICAL LIBRARY.

During the calendar year 1913, the growth of the Technical Library of the Mines Branch was such that, early in 1914, it was found necessary to move into larger quarters—on the ground floor. This transfer to more commodious quarters involved a complete reorganization of the library, and the addition of new stacks, filing cabinets, magazine rack, desk, reading tables, chairs, and other modern library equipment.

In order that the general arrangement and disposition of the books, etc., should be up-to-date, the librarian thoroughly investigated the conditions at McGill University, and, in addition, took a special course of study in librarycraft at Columbia University, New York. As a result of these investigations and studies in the art of library keeping, the books have been arranged according to the "Dewey" decimal system of classification; the most approved methods of library economy have been adopted; and a beginning has been made toward establishing a very thorough and comprehensive card catalogue.

Much time has been devoted to completing broken files of periodicals, and preparing the same for binding.

The efforts toward inaugurating exchange of publications with scientific institutions, both foreign and domestic, have met with most gratifying results: 57 exchanges have been secured during the year.

Accessions to the Library for 1914.

Three hundred and twelve volumes have been added by purchase; 339 volumes have been bound; 3,039 reports, monographs, memoirs, pamphlets, maps, and atlases from international Geological Surveys, and similar institutions, have been received, in exchange for the publications of the Mines Branch; 467 bulletins, journals, proceedings, and transactions of scientific societies, have been received in exchange; 12 periodicals have been subscribed for; and 13 periodicals received in exchange. Total number of accessions for 1914=4,377.

I have the honour to be,
sir,
Your obedient servant,
(Signed) **Eugene Haanel,**
Director of Mines.

INDIVIDUAL SUMMARY REPORT

METALLIFEROUS DIVISION.

I.

EXAMINATION OF CERTAIN COPPER DEPOSITS IN QUEBEC, OTHER METAL MINES, AND OFFICE WORK.

Alfred W. G. Wilson.

Chief of the Division.

Various duties assigned the writer necessitated his remaining in Ottawa the greater part of the year. During this time, in accordance with instructions, a revision was made of the report on the Petroleum and Natural Gas Resources of Canada, and also the paragraphs bearing on Pyrites, Copper, and Nickel, appearing in the second edition of the pamphlet on Economic Minerals and Mining Industries of Canada.

A considerable amount of attention was given to the organization of the different field parties of the Mines Branch, and also to the preparation of the Summary Report.

Very little direct progress has been made in the preparation of the manuscript of the report on the Copper Mines and Copper Mining Industry of Canada. An exhaustive card index and bibliography is being prepared, covering all the published references we have been able to find, relating to the occurrence of copper ores and copper minerals in Canada. The number of recorded references has not yet been counted, but it is probably in excess of seven thousand. The large amount of material to be studied and summarized, coupled with the numerous interruptions which appear to be unavoidable in office work in Ottawa, renders progress on this report very slow, and at the present time it is impossible to tell when it will be completed.

During the summer, two short field trips were made between the 15th of August and the 13th of October. About ten days were spent in the Eastern Townships of Quebec, on a visit of inspection to the mines at Eustis, Weedon, Eastman, and St. Gerard, for the purpose of bringing the information with respect to the copper-producing mines in Quebec up to date.

Before returning to Ottawa, a visit was made to the Tetrault zinc mine near Notre Dame des Anges, Quebec. The sulphide of zinc, sphalerite, has been found on this and on several adjoining locations, and much prospecting has been done during the past three years. On the Tetrault property a promising ore body has been partially developed, with four prospecting shafts, 58, 85, 92, and 57 feet, respectively, in depth. There was also a total of about 200 feet of drifting. The shafts were partially filled with water at the end of August, 1914, and little of the underground work was visible. Some of the ore recovered during development work has been hand-picked, and shipped to a chemical works.

The latter part of September and the first two weeks of October were spent in Northern Ontario, visiting the mines and concentrating mills in the vicinity of Cobalt and Porcupine, for the purpose of obtaining data for use in the Metal Mine volume of the projected report on the Mining and Metallurgical Industries of Canada.

II.

THE ATIKOKAN AND MATAWIN IRON RANGES.

E. Lindeman.

During the field season of 1914, field work was carried on from June 2 to November 15 on the Atikokan and Matawin iron ranges. The work consisted of magnetometric and topographical surveys, conducted in connexion with a geological examination of the ore deposits. The writer was ably assisted in this work by Messrs. A. H. A. Robinson, H. Kennedy, and M. Meikle, each being in charge of a party of five men. The months of July, August, and September were spent by the writer, in Ottawa, preparing a report on the iron ore deposits of Canada for the Iron Committee, appointed by the Government in September, 1914.

ATIKOKAN IRON RANGE.

Between Kawene and Atikokan stations on the Canadian Northern railway, outcrops of magnetite and pyrrhotite have been found, intermittently, along the Atikokan river, for a distance of about 16 miles. Numerous locations have, in the past, been taken up, and a considerable amount of prospecting and development work has been done on some of these claims. Amongst the locations which have attracted most attention are E 10 and E 11. These lie east of Sabawe lake. They were formerly known as the McKellar property, and now as the Atikokan Iron Company's mine. Mining operations have been carried on here at intervals since 1907, and 90,000 tons of iron ore are reported to have been shipped. The mine is connected by a branch line, 3 miles long, with the Canadian Northern railway, at Iron Spur, the distance from this junction to Port Arthur being 128 miles. A description of the mine, and the eastern part of the range, is given by Mr. A. H. A. Robinson in his summary report.

Locations R 400 and R 401—Location R 400 is situated about 2 miles west of Sabawe lake, and about 1½ miles northwest of Hematite station, on the Canadian Northern railway.

The claim is 40 chains long and 20 wide, and adjoins claim 401, to the west, which has about the same area. Both claims are bounded by the Atikokan river, R 400, on its southwest corner, and R 401, along the whole extent of its south side.

The two claims are traversed from east to west by diorite intrusives, in which magnetite, pyrrhotite, and iron pyrite occur concentrated into irregular lenses or are found disseminated in small amounts throughout the rock. Outcrops of greenstone, carrying some magnetite and sulphides of iron, are first met with about 1,100 feet west of the boundary line, between claims 400 and 401. From this place the iron-bearing rock may be traced through claim 400 into 401, a distance of 2,200 feet, being specially well exposed near the boundary line, between the two claims where the south side of the ridge descends abruptly towards the river. About 100 feet west of this line, and at an elevation of about 35 feet above the river, a tunnel has been driven into the steep hillside. The length of the tunnel is 74 feet. About 37 feet in from its mouth a vertical shaft, 52 feet deep, has been sunk. The rock formation exposed by the tunnel consists of greenstone, with irregular patches of magnetite mixed with pyrrhotite, or magnetite and pyrrhotite disseminated throughout the diorite.

In addition to this development work, several trenches and cross-cuts have been made at various points along the ridge. The principal open-cut on lot 400 is 1,050 feet northeast of the tunnel, exposing the iron-bearing formation across the hill for a distance of 32 feet. The character of the formation is here the same as that seen in the tunnel. An average sample taken along the cut gave the following analysis:—

Fe	53·10	per cent
SiO_2	11·20	”
S	3·87	”
P	0·045	”

A similar open-cut has been made on the hillside towards the river, about 450 feet west of the tunnel, on claim 401. The cut is 45 feet long, 4 feet wide, and 6 feet deep, trending north and south, and exposing a good magnetite in places, but also sulphides of iron and rock. An average sample taken along the cut gave the following analysis:—

Fe	48·80	per cent
SiO_2	16·32	”
S	3·84	”
P	0·088	”

Going westward from this cut, the country slopes gently, and no outcrops can be seen for a distance of about 1,000 feet. At this point a narrow ridge rises above the surrounding muskeg, and extends along the river for a distance of 2,300 feet. The greenstone is well exposed on this ridge, often exhibiting a rusty appearance, owing to the oxidation of iron sulphides with which the rock is heavily charged.

The following analysis represents an average sample taken across the formation at the western end of the ridge. The length of the trench from which the sample was taken is 54 feet:—

Fe	38·56	per cent
SiO_2	41·97	”
S	3·50	”
P	0·020	”

Crossing the Atikokan river, and going westward on claim 212 X, no magnetic attraction is noticed for a distance of 1,500 feet, when another magnetic area is met with, which has a total length of 2,800 feet, and extends from claim 212 X into R 403. The only exposure of the iron bearing formation on claim 212 X, is in an open pit near its western boundary line, where a considerable amount of pyrrhotite has been exposed. Farther west, on claim 403 R, the country becomes higher, and the iron bearing formation is found along a ridge rising in places 60 to 70 feet above the river. Numerous trenches and test pits have been made along this ridge, exposing in most cases pyrrhotite with some magnetite, and showing the iron bearing minerals to occur in irregular lenses throughout the diorite. The width of the area within which these lenses occur may roughly be estimated at 100 feet. An average sample taken from one of the trenches gave the following analysis:—

Fe	51·00	per cent
SiO_2	2·58	”
S	15·28	”
P	0·025	”

West of this mineralized area there is no indication of any iron ore deposits for a distance of one mile, or before claim 139 X is reached. This claim lies north of the Atikokan river, near mile post 135 on the Canadian Northern railway. The iron bearing formation is here exposed in numerous places along a high ridge which extends from claim 139 X into the adjoining claim 138 X. It consists of the same type of diorite as found on the other claims previously described, with magnetite and pyrrhotite disseminated throughout the rock. In places, the pyrrhotite and magnetite are found concentrated into irregular lenses or pockets. The iron and sulphur content of the ore varies considerably. Diamond drill records kindly furnished the writer by Mr. R. H. Flaherty show the iron content to range from 62 to 38 per cent with a variation in sulphur of from 3 to 25 per cent. The phosphorus content is generally low, ranging from 0·006 to 0·045 per cent, while the silica varies from 2 to 16 per cent.

Judging from the magnetometric survey, the length of the area within which pyrrhotite and magnetite may be found on these two claims is roughly estimated at 2,000 feet, with a maximum width of about 250 feet.

A few hundred feet farther west several small detached magnetic areas indicate the presence of pyrrhotite and magnetite. They are, however, of too small extent to be of economic interest.

Iron location near mile post 140.—This property lies about 5 miles west of Hematite station near mile post 140, and about 2½ miles east of the Atikokan station on the Canadian Northern railway.

The area covered by the summer's field work is 1 mile long and 2,000 feet wide; the greater part of which is occupied by basic igneous rocks of the diorite type. In the southern part a typical micaceous slate is well exposed along the railway for a distance of about 2,000 feet. The general strike of the slate is N. 72° E., with an almost vertical dip.

The chief iron-bearing minerals are iron pyrite, with some magnetite. They are found disseminated in small amounts throughout the diorite in several detached areas. These areas generally show a rusty appearance owing to the oxidation of the iron pyrite. The principal occurrence is on a hill about 900 feet northwest of mile post 140. The red brown gossan can here be traced along the top and flank of the ridge for a distance of 600 feet. At the west end a trench, 50 feet long and 5 feet deep, has been made across the top of the hill, exposing a fine grained rusty looking basic rock, with magnetite and iron pyrite disseminated throughout the mass. An average sample taken along the trench gave the following analysis:—

Fe	39·50	per cent
SiO_2	20·10	"
S	5·37	"
P	0·021	"

Judging from the magnetometric survey, the total length of this mineralized area is about 830 feet, with a maximum width of 110 feet. The magnetic attraction is, however, very irregular within the area, indicating an irregular and pockety distribution of the magnetite in the diorite, and giving little encouragement for finding any ore body of economic importance.

About 800 feet west-southwest of the area just described, another occurrence of gossan outcrops on the top and along the south side of a small hill. It has a length of 250 feet with a width of about 50 feet. Crossing the Atikokan river, several small areas showing the same rusty looking rock are found on the steep hill immediately south of the railway track. Several trenches and test pits have been made on this hill, but without revealing any ore body of economic interest.

COMMERCIAL POSSIBILITIES OF THE ATIKOKAN IRON RANGE.

With various intervals, mining operations have been carried on at the Atikokan mine since 1907, and about 90,000 tons of magnetite have been shipped by the Atikokan Iron Company to its blast furnace in Port Arthur, and there smelted after first being roasted. The average iron content of the crude ore is reported by the company to be 59·8 per cent, with a sulphur content of 2·01 per cent.

On the western part of the range, i.e., on the properties west of Sabawe lake, the conditions are somewhat different. The ores here are generally much higher in sulphur, and on some of the claims the iron-bearing mineral consists exclusively of pyrrhotite, which mineral is not generally looked upon, at the present time, as a source of iron ore. But assuming, as claimed by certain parties, that it is metallurgically possible to roast these high sulphur ores in specially constructed furnaces, down to a sulphur content of less than one-half of 1 per cent, the cost of roasting the ore, added to that of mining, which, owing to the irregular and pockety character of the ores is likely to be rather high, would, in all probability, render it impossible to carry out such a process economically at the present time.

MATAWIN IRON RANGE.

This range, as far as it has been traced, has a total length of 35 or 40 miles, and extends from Greenwater lake eastward, south of Lake Shebandowan, to Kaministikwia on the Canadian Pacific railway. The iron formation consists of interbanded jasper and other closely related siliceous material, usually magnetite, although at times the iron-bearing mineral associated with the jasper is hematite. The iron range is not continuous for all this distance, but forms a series of detached areas or lenses of various size, which, generally, have an east and west trend, with an almost vertical dip. The distance between the various areas of the iron formation varies considerably, but may reach several miles in places.

The part of the range which has so far attracted most attention, is in the vicinity of Shabaqua station, on the Canadian Northern railway, about 53 miles west of Port Arthur, where a large number of claims have been staked on both sides of the Matawin and Shebandowan rivers.

The latter part of the field season of 1914 was devoted to this locality, and a topographical and magnetometric survey made of the following claims: W 216; W 217; W 218; W 219; W 220; W 221; and W 223.

Location W 216 is situated on the south side of Matawin river where the Shebandowan river flows into it. The Canadian Northern railway traverses nearly the whole north part of the location.

The iron formation is well exposed on a hill about one-fourth of a mile south of the railway track, and about 800 feet west of the eastern boundary of the claim. It consists of a fine grained bluish grey siliceous slate, through which exceedingly fine crystals of magnetite—hardly visible to the naked eye—are disseminated. The average iron content of the formation is very low. Two samples taken at the east and west ends of the exposure and representing a width of 57 and 35 feet, respectively, gave the following analyses:—

	No. 1.	No. 2.
Fe	20·99	20·90
SiO_2	61·26	63·04
S	Trace.	0·085
P	0·015	0·087

Going westward, several other smaller exposures of iron formation can be seen on this claim. The iron bearing series is, however, of even a leaner character than that previously described, and may more appropriately be classed as ferruginous slate. Sufficient magnetite is present in the rock to enable it to be traced across the claim by magnetic readings, but from an economic point of view it is of no importance.

Location W 217 is situated due west of W 216. It is heavily drift covered and no outcrops of the iron bearing series are visible, but by magnetometric readings it can be traced across the whole width of the claim, i.e., about half a mile.

Location W 218 is due west of W 217, and is 1 mile long and half a mile wide. The iron formation is prominently exposed near the western boundary line of the claim, on a big cliff rising about 25 feet above the surrounding country, and having an elevation of 1,450 feet. The character of the iron formation is similar to that previously described, although its iron content seems to be somewhat higher as shown by the following analysis representing an average sample taken across an outcrop 47 feet wide near the cliff:—

Fe	29·49 per cent.
SiO_2	52·14 "

Another sample taken about 500 feet farther east, and representing an outcrop 17 feet wide, give the following analysis:—

Fe	30·25 per cent.
SiO_2	51·25 "

Judging from the magnetometric readings, and a few outcrops, the iron bearing formation can be traced across the whole width of the claim, reaching its maximum width of 300 feet about 700 feet east of the western boundary line of the claim.

Claim W 219 adjoins W 218 to the west. It is 1 mile long and half a mile wide, and is divided into two parts by the Matawin river. The iron-bearing formation can be traced, by magnetic readings, from the eastern boundary line of the claim westward to the Matawin river, a distance of 1,200 feet. It is well exposed in a ravine south of the old camps, and yet more prominently along two small knolls farther west, near the river. The iron formation is leaner than that of the previous claim described. Four samples taken at various points across the formation, and representing a width of 47, 75, 52, and 33 feet, respectively, gave the following analyses:—

—	No. 1.	No. 2.	No. 3.	No. 4.
Fe	13·38	24·28	17·31	17·81
SiO_2	70·03	58·78	66·70	65·05

For a distance of about 1,700 feet west of the Matawin river, the magnetometric survey gives no indication of any continuous iron formation, and a few very small scattered magnetic areas are all that can be found on this part of the claim.

But at a point about 350 feet west of the boundary line between W 219 and W 220, the magnetic attraction comes in again, hence, westward, the iron formation can be traced by outcrops and magnetic readings, with one or two small intervals, through claims W 220, W 221, and W 222, a distance of 7,000 feet. Judging from the magnetometric survey the width of the iron-bearing formation on claim W 220 may be roughly estimated at 50 to 200 feet. It increases, however, considerably on claim W 221, and reaches a width of over 1,000 feet near the boundary line between W 221 and W 222. Going farther west on W 222, the iron formation decreases again in width, being 100 to 400 feet wide.

On claims W 221 and W 222, the iron formation consists chiefly of a fine grained siliceous hematite, interbanded with siliceous material, black and red chert. Judging from the magnetic character of the formation, magnetite is also present. Four samples, taken across the exposed formation at various points, gave the following analyses:—

—	No. 1.	No. 2.	No. 3.	No. 4.
Fe	25·07	29·35	30·89	27·86
SiO_2	54·20	48·76	46·34	49·44

The width of the exposures from which the samples were taken were 100, 35, 36, and 47 feet, respectively. Samples Nos. 1 and 2 are from claim W 221; 3 and 4 from W 222.

From what has been said in regard to the extent of the iron formation on these seven claims, it is evident that a large quantity of low grade ore is available, all of which, however, requires fine crushing and concentration, with subsequent briquetting or nodulizing before it can be made marketable. To carry on such an operation profitably, at the present time, does not seem feasible, owing to the low iron content of the ore, and the extreme fineness to which the grinding would have to be carried before a satisfactory separation could be attained. The iron formation of the western claims, W 221 and W 222, offers also another objectionable feature for magnetic separation, on account of the iron-bearing mineral being present there, chiefly in the form of hematite.

III.

ATIKOKAN IRON RANGE.

A. H. A. Robinson.

The Atikokan iron range is situated in the district of Rainy River, not far west of the boundary of Thunder Bay district, and lies close to, and just to the north of, the main line of the Canadian Northern railway between Port Arthur and Winnipeg. Starting about a mile and a half east of Atikokan station, it can be traced eastward as a broken chain of iron deposits, following the general course of the Atikokan river for a distance of some 16 miles; the outcrops often standing out on low hills in the river valley.

The eastern portion of the range, with which the present report deals, extends from Sabawe lake—a lake expansion of Atikokan river—in a direction N. 87° 27′ E. (astronomical), for a distance of a little over 3 miles, to Attraction lake, a small stagnant pond lying a short distance north of the river. Starting at Sabawe lake, a small, unimportant outcrop of the iron formation is found on the lake shore, just south of the mouth of the river. Eastward from this outcrop no continuous attraction is found for a distance of half a mile, when the compass needle again indicates the presence of the range beneath the covering of drift. Hence, eastward, the magnetic attraction is continuous—with one or two minor breaks—to Attraction lake. Between Sabawe and Attraction lakes the magnetic belt crosses the following mining claims, given in order from west to east:—24 E, 23 E, 10 E, 11 E, 12 E, 25 E, and 26 E.

A spur line, 3 miles long, connects the Atikokan Iron Company's workings on E 10 and E 11 with the main line of the C.N.R. at Iron Spur, 128 miles west of Port Arthur.

The district traversed by the iron range shows considerable variety in the character of the rocks which occur in it. According to Dr. A. C. Lawson (G. S. C., No. 24, Geological Series), the iron-bearing belt lies at, or very close to, the contact between a Keewatin series of greenstones, felsites, quartz-porphyries, etc., and their schistose equivalents, and a later sedimentary—Seine—series made up largely of dark, grey and grey-green, micaceous quartzites, and greywackes, grading into sericitic schists. In the immediate vicinity of the iron-bearing belt, on either side of it, the rocks exposed are, at this eastern end of the range, so fine grained and schistose as to make the determination of their original character difficult. A short distance to the north of the ore, however, they are found to grade into schistose Keewatin greenstones, while on the other side, to the south, greywackes and quartzites become distinctly recognizable at a short distance from the ore. Both ore and schists have a vertical dip. The strike of the ore belt is everywhere parallel to the schistosity of the enclosing rocks, and maintains a remarkably straight course of about N. 84° 27′ E. for the three miles between Sabawe and Attraction lakes.

With regard to the origin of the Atikokan ore, it has been usual to refer it to the pegmatite type; it is supposed to have been brought to, or near, the surface in magmas, and extruded from them much as in the case of pegmatite dikes. Dr. A. C Lawson, who has made the most recent detailed study of the geology of the region, suggests, however, a different mode of origin. His idea is, that the iron was derived from the weathering of Keewatin rocks, in pre-Seine or early Seine time, and was afterwards concentrated either in bogs on the old Keewatin surface, or by underground circulation after the burial of the weathered and iron-rich surface by the Seine sediments.[1]

Atikokan Iron Mine: Mining Locations E 10 and E 11.

The Atikokan iron ore deposits were discovered in 1882, by Jim Shogonosh, an Indian trapper in the employ of Mr. G. McLaurin, of Savanne. The latter interested Messrs. McKellar Bros., of Fort William, who applied for, and acquired from the government what is now known as mining locations E 10 and E 11. In 1905, the property was taken over by the Atikokan Iron Co., of Port Arthur, Wm. Mackenzie president, and in 1906-7 the same company built a blast furnace at Port Arthur to use the ore from their Atikokan mine. The first shipment of ore was made in May, 1907, since when shipments have been made as follows:—

1907	19,105	tons.
1908	nil	
1909	14,014	"
1910	26,318	"
1911	30,737	"
1912	434	"

A total of 90,608 tons mined and shipped since the mine was opened.

All the ore was sent to Port Arthur, and, after roasting to remove sulphur, was used in the company's blast furnace there, for the manufacture of foundry pig-iron. No ore has been mined since 1912.

As disclosed on locations E 10 and E 11, the range outcrops as a steep narrow ridge of green schist, with which are inter-bedded irregularly-shaped, roughly lenticular, overlapping bodies of magnetite or magnetite and pyrite. This hill, along which the ore outcrops, is 3,800 feet long, 400 feet wide at the widest place, and has a maximum elevation above the swamp that surrounds it on all sides, of about 100 feet. The rock immediately in contact with the ore is partly a hornblende chlorite schist, partly a massive pyroxenite, often heavily impregnated with pyrite nad pyrrhotite. Beds of a greyish-white chert are also found intercalated with the ore and schist, and, in the ore bodies on the north side of the ridge especially, a dark green slate interlaminated with magnetite in narrow bands, is often found. To the north the ore-bearing belt is bounded by a wall of highly schistose, light-coloured acidic rock.

These two locations, E 10 and E 11, are the only ones on the eastern end of the range on which any extensive development has been done, or from which commercial shipments have been made; they, together with E 12, are the property of the Atikokan Iron Co. The development work consists of: five tunnels, A, B, C, D, and E, named in order from west to east; three shafts Nos. 1, 2, and 3, also in order from west to east; and six diamond drill holes. The first four tunnels, A, B, C, and D, have been driven

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[1] "Archæan Geology of Rainy Lake Re-Studied," by A. C. Lawson.—G. S. C. No. 24, Geological Series.

through the hill from side to side a little above the level of the swamp; the fifth, E, penetrates it from the south for about 100 feet. The shafts are all on the south side of the hill and from the bottoms of Nos. 2 and 3 cross-cuts have been driven north through the ore, at depth of 150 and 126 feet respectively below the level of the tunnels. The No. 1 shaft, sunk on a band of highly pryritiferous ore, was stoped at a depth of 47 feet.

Following, are particulars of sections through the hill at the different tunnels—the sections and analyses being taken from the Atikokan Iron Company's records:—

Tunnel A, 400 feet from the west end of the ridge on E 10.

Section, south to north.

Ore and pyrite	Iron	48·26 per cent.	7·0 feet.
	Silica	6·06 "	
	Sulphur	18·81 "	
	Phosphorus	0·009 "	
Rock			27·0 "
Banded magnetite and pyrite	Iron	45·1 per cent,	26·0 "
	Silica	4·90 "	
	Sulphur	14·93 "	
	Phosphorus	0·060 "	
Rock and lean ore			41·5 "
Mixed ore and rock	Iron	42·3 per cent.	34·5 "
	Silica	18·6 "	
	Sulphur	6·38 "	
	Phosphorus	....	
Rock			5·0 "
Ore	Iron	51·25 percent.	8·0 "
	Silica	15·40 "	
	Sulphur	1·30	
	Phosphorus	....	
Rock			48·0 "

Tunnel B, 1,185 feet east of *A.*

Section, south to north.

Rock			22·0 feet.
Ore and pyrite	Iron	46·8 per cent.	12·0 "
	Silica	16·6 "	
	Sulphur	12·3 "	
	Phosphorus	0·34 "	
Rock			9·0 "
Ore	Iron	52·00 per cent.	8·0 "
	Silica	13·26 "	
	Sulphur	4·77 "	
	Phosphorus	0·85 "	
Rock			3·0 "
Ore	Iron	50·60 per cent.	24·0 "
	Silica	15·34 "	
	Sulphur	6·75 "	
	Phosphorus	0·20 "	
Rock			13·0 "
Ore	Iron	59·00 per cent.	22·0 "
	Silica	8·30 "	
	Sulphur	2·17 "	
	Phosphorus	0·09 "	
Rock			26·0 "
Ore	Iron	45·92 per cent.	9·0 "
	Silica	19·40 "	
	Sulphur	4·41 "	
	Phosphorus	....	
Rock			27·5 "
Ore	Iron	58·39 per cent.	5·0 "
	Silica	9·97 "	
	Sulphur	2·78 "	
	Phosphorus	0·135 "	
Rock			5·0 feet
Ore			1·5 "
Rock			30·0 "

Tunnel C, the main working tunnel, situated 500 feet east of *B*, about half-way along the ridge close to the line between E 10 and E 11.

Section, south to north.

Rock			61·00 feet.
South ore body (stoped)	[1] Iron	60·00 per cent.	47·0 "
	Silica	8·50 "	
	Sulphur	2·01 "	
	Phosphorus	0·11 "	
Rock			62·0 "
North ore body	[2] Iron	47·68 per cent.	42·0 "
	Silica	17·51 "	
	Sulphur	2·30 "	
	Phosphorus	0·193 "	
Rock			60·0 "

[1] Average of three years' shipments.
[2] Average of five analyses.

Tunnel D, 450 feet east of *C*, starts from a small open-cut on the south ore body.

Section, south to north.

South ore body (stoped)	[1] Iron	59·57 per cent.	40·0 feet.
	Silica	8·41 "	
	Sulphur	2·17 "	
	Phosphorus	0·11 "	
Greenstone, chert and chlorite schists			62·0 "
North ore body	[2] Iron	59·40 per cent.	33·0 "
	Silica	8·10 "	
	Sulphur	0·61 "	
	Phosphorus	0·041 "	
Rock			97·0 "

[1] Average of four analyses.
[2] Average of five analyses.

Tunnel E, 510 feet east of *D*, has been driven 98 feet into the hill.

Section, south to north.

Rock			10·0 feet.
Ore with pyrite	[1] Iron	46·86 per cent.	47·0 "
	Silica	15·90 "	
	Sulphur	12·90 "	
	Phosphorus	0·169 "	
Rock			19·0 "
Ore	[2] Iron	56·18 "	17·0 "
	Silica	11·05 "	
	Sulphur	1·97 "	
	Phosphorus	0·157 "	
Rock, to end of tunnel.			

[1] Average of five analyses.
[2] Average of three analyses.

The ore is a hard, dense, magnetite, difficult to mine, and refractory in the blast furnace. Associated with it are pyrite and pyrrhotite in varying quantities, also a little chalcopyrite. The sulphur content is high, running from 2 per cent to 25 per cent and over, so that all the ore has to be roasted before it can be used for the manufacture of pig-iron. Phosphorus is above the Bessemer limit, and nickel is present in minute quantities.

An average analysis of all shipments to date, totalling 90,608 tons, is as follows:—

Silica	8·68 per cent.
Alumina	1·51 "
Metallic iron	59·85 "
Phosphorus	0·11 "
Manganese	0·11 "
Lime (CaO)	3·00 "
Magnesia (MgO)	2·54 "
Sulphur	2·01 "
Titanium	nil
Copper	0·12 "
Nickel	0·11 "

The great bulk of this ore has come from an open-cut about 300 feet long, 40 feet wide, and 60 feet deep, on the south side of the hill at *C* tunnel. Smaller amounts have come from a small open-cut at the south entrance to *D.* tunnel and from development work.

As regards the quantity of ore available, there are, without doubt, some millions of tons scattered through the hill. But as it occurs in bodies very irregular both in their outlines and in their distribution through the enclosing rock, so that the relative proportions of rock and ore over a given width of the ore belt vary greatly within short distances, any accurate estimate of available tonnage is difficult. In addition, the variable and in places very high sulphur content, a matter seriously affecting the value of the ore, would have to be taken into consideration in any estimate of commercial tonnage.

Mining Locations E 12, E 25, and E 26.

From the east end of the ridge on E 11, the ore-bearing belt has been traced eastward over swamp and rock, across mining locations E 12, E 25, and the greater part of E 26. Judging from the magnetometer readings, it has, over this stretch, a width of from 40 to 75 feet, and is continuous, with the exception of two short breaks, for the entire distance.

Very little work has been done on this part of it, so that while outcrops of the decomposed iron-stained rocks of the iron range are of frequent occurrence, actual exposures of magnetite are small and unsatisfactory, and no opportunity is afforded of getting sections through the magnetic belt, or ascertaining the width of ore in it. Judging by what can be seen, however, it is probable that any ore bodies will be found to be much smaller than those occurring on E 10 and E 11, and that the sulphur content will be at least as high as it is there.

Mining Location E 23.

From the westerly end of the ridge on E 10, where it disappears under the swamp, the ore-bearing belt has been traced westward for 2,400 feet, under deep drift all the way. This takes it about two-thirds the way across E 23.

As there are no outcrops, nothing definite is known about either the quantity or quality of the ore here. By referring, however, to the section at tunnel A—the nearest good exposure on the ore-bearing belt—it will be seen that at that point the ore had become highly sulphurous nearly all the way across the belt.

KAMINISTIKWIA.

South of Kaministikwia, a station on the Canadian Pacific railway, 28 miles west of Port Arthur, along both sides of the Kaministikwia river, in the townships of Ware and Conmee, there occur numerous outcrops of banded iron ore and jasper. These from part of what is sometimes known as the Matawin iron range; a belt of banded iron formation which runs from Greenwater lake eastward, south of Lake Shebandowan, to Kaministikwia—a distance of 30 or 40 miles. For the purpose of outlining the areas actually underlaid by this iron-bearing material, a magnetometric and topographical survey of the district was undertaken, and about one square mile of it between Kaministikwia and Mokomon—a station on the Canadian Northern railway 2 miles south of Kaministikwia—was covered during the season. Maps showing the results of this survey are now being prepared for publication.

The iron formation consists of jasper, or other closely related siliceous material, with which is interbanded narrow seams of mixed magnetite and hematite. The magnetite-hematite bands run usually from a mere film, up to an inch in width, and form but a small proportion of the whole formation. A number of average samples taken across the outcrops in different parts of the field yielded, on analysis, 16 to 30 per cent of iron, and 50 to 70 per cent of silica. Nowhere was the iron found concentrated in sufficiently large bodies to be workable. Picked samples of the magnetite-hematite bands freed from jasper are of fair grade and quality. They occur too sparingly, however, to afford much promise of any scheme for their mechanical concentration being commercially profitable.

TOWNSHIP OF MISCAMPBELL.

In the early part of August, a visit was paid to a reported discovery of iron ore near Fort Frances, Ont., on lots 4 and 5 in the second concession of the township of Miscampbell.

As far as can be seen on the comparatively small outcrops exposed, the deposit consists of large blocks of a low grade iron-bearing formation included in eruptive granite. The included material consists of finely granular magnetite and quartz in more or less distinct bands. It is distinctly crystalline, and rather friable in character. Crystals of pyrite and garnets are found scattered through it, in small amounts.

Several diamond drill holes were put down on the property by Fort Frances parties, but nothing of importance was found.

Should large continuous bodies of this material be found so located as to be easily and cheaply mined, it might, on account of its granular, friable nature, offer possibilities as a concentrating proposition. Found here, however—as inclusions in granite—it gives little promise of commercial value.

NON-METALLIFEROUS DIVISION.

I.

LIMESTONES OF THE PROVINCE OF QUEBEC.

Howells Fréchette.

Chief of Division.

In the summer of 1914, an examination of the limestones throughout the province of Quebec was begun, with a view to investigating their economic importance and their suitability for various uses in the manufacturing industries. Samples were collected from over a hundred localities, and these have since been analyzed by Mr. H. Leverin, of the Mines Branch. Note was made of quarrying possibilities at the various outcrops, and of transportation facilities. Working and abandoned quarries were also visited and sampled.

The sections of the province covered were as follows: from Bryson to Quyon; Hull and vicinity; the Gatineau valley, from Wakefield to Aylwin; Buckingham and vicinity; Argenteuil county; Ste. Thérèse and vicinity; Montreal and vicinity; and that portion of the province lying south of a line drawn through Valleyfield, Beloeil. St. Hyacinthe, Drummondville, and D'Israeli. Within these areas there are a number of localities which will be visited and examined later.

Mr. J. A. Fournier, a student at Queen's University, was field assistant, and fulfilled his duties well.

The following is a brief description of the limestones in those parts of the province visited, and analyses are quoted of samples, both from the more important occurrences, and also from those sections in which only impure material was found to exist.

BRYSON—QUYON.

Throughout the townships of Litchfield, Clarendon, and Bristol, there are numerous exposures of crystalline limestone. In the neighbourhood of Bryson and Portage du Fort the rock appears to be much freer from impurities than elsewhere.

At Bryson, Robert B. Carswell owns and operates a quarry and lime-kiln. There are two small quarry openings very close to one another. The western one furnishes the limestone for burning, which is fairly coarsely crystalline and is banded with dark streaks of impurities, principally graphite with some yellowish granules. In the eastern pit the stone is somewhat coarser in texture and is almost free from the graphite banding. This stone is used for building purposes.

Sample 4 is from the western pit, and 5, which is seen to be a true dolomite, is from the eastern pit Both are of good grade:—

—	4.	5.
Insoluble mineral matter	1·34	2·08
Oxide of iron—all expressed as ferric oxide	0·36	0·07
Alumina	1·44	0·32
Calcium carbonate[1]	75·89	52·76
Magnesium carbonate[2]	21·21	44·96
Graphite	0·30	.....
[1] Equivalent to lime	42·50	29·55
[2] Equivalent to magnesia	10·15	21·51

At Portage du Fort, a large marble quarry has been opened by the Pontiac Marble and Lime Co., Ltd. The workings are to the north of the town, beside the right of way of the Canadian Northern railway which is under construction.

The stone is coarse grained, and varies from a pure white to white with yellow patches and veinlets. The waste rock and spalls should be of value as a source of dolomite for wood-pulp making. The following analysis is from a general sample taken of all the exposed beds:—

—	3.
Insoluble mineral matter	0·15
Oxide of iron—all expressed as ferric oxide	0·22
Alumina	0·06
Calcium carbonate[1]	57·14
Magnesium carbonate[2]	43·12
[1]Equivalent to lime	32·00
[2]Equivalent to magnesia	20·63

Along the Ottawa river at Portage du Fort, and on the island immediately opposite, there are numerous exposures of similar coarse grained dolomitic limestone.

In the eastern portion of the township of Clarendon the crystalline limestones, which outcrop frequently, are much less dolomitic, and are dirtier in appearance, containing almost 1 per cent of graphite as well as small quantities of mica, tourmaline, and tremolite. The average of several analyses of these limestones shows 7·3 per cent of magnesium carbonate, and 90·0 per cent of calcium carbonate.

Along the Canadian Northern railway new roadway, crystalline limestone has been exposed at a number of points in Bristol township; the stone being similar to that in the eastern portion of Clarendon.

Two exposures of what is probably Beekmantown limestone were observed, one at Quyon and the other at Portage du Fort. While suitable for rough building purposes, they are high in insoluble matter, iron and alumina, and would produce a very poor grade of lime.

HULL.

At Hull, Trenton limestone has been extensively quarried for building stone, macadam, lime-burning, and cement-making. A number of the beds produce a very high grade of building stone.

The stone is brownish in colour, and varies from very fine grained to fairly coarse. It produces a good grade of high calcium lime, when burned. Two analyses will serve to indicate the general composition:—

—	10.	11.
Insoluble mineral matter	3·24	0·84
Oxide of iron—all expressed as ferric oxide	0·21	0·21
Alumina	0·39	0·25
Calcium carbonate[1]	93·84	97·14
Magnesium carbonate[2]	1·31	1·48
[1]Equivalent to lime	52·55	54·40
[2]Equivalent to magnesia	0·63	0·71

GATINEAU VALLEY.

Throughout the Gatineau valley, crystalline limestones are found in many places, frequently extending in long bands for many miles. They are, as a rule, very coarse grained, and contain a noticeable quantity of impurities, such as mica, graphite, apatite, tourmaline, serpentine, chondrodite, and pyrite, and possess, consquently a dirty appearance.

Due to the rough nature of the country, there are numerous hills and knolls into which quarries could be easily developed; but this same roughness means hilly roads and expensive haulage charges, so that possible quarry locations are confined to a narrow strip, close to the railroad.

The following analyses are of samples from the best exposures of limestone visited:—

——	12.	13.	14.	15.	16.	17.
Insoluble mineral matter	1·00	3·39	2·00	3·80	1·42	1·44
Oxide of iron all expressed as ferric oxide	0·14	0·28	0·30	0·24	0·14	0·14
Alumina	0 06	0·06	0·06	0·02	0·04	0·06
Calcium carbonate[1]	85·00	88·48	85·89	93·57	95·09	92·59
Magnesium carbonate[2]	13·66	6 56	12·24	1·98	2·38	6·45
Carbon (graphite)	0·42	1·07	....	....	0·42	....
[1]Equivalent to lime	47·60	49·55	48·10	52·40	53·25	51·85
[2]Equivalent to magnesia	6·54	3·14	5·86	0·95	1·14	3·09

12. From small quarry at Ste. Cecile de Masham.
13. From rock cut on railroad at Farrelton.
14. From foot of Paugen falls, west side of Gatineau river.
15. From lot 39, range VIII, Aylwin township.
16. From lot 16, range III, Aylwin township.
17. From farm of Thos. McCombley, lots 6 and 7, range VI, Aylwin township. A small quantity of lime is burned here for local use.

BUCKINGHAM.

The crystalline limestones seen in the district around Buckingham, are all very impure, and are unsuitable for lime-burning purposes.

ARGENTEUIL COUNTY.

The rocks of the major part of the county of Argenteuil are of Laurentian age. Crystalline limestones are fairly abundant, extending in long narrow belts in a generally norht and south direction. The southeastern portion of the county is overlain by more recent rocks, and, for the greater part, has a continuous covering of soil. Limestones of Calciferous age are to be seen in a few places.

In the township of Grenville, the crystalline limestones vary greatly in character and purity. On lot 15, range IX, and lot 18, range XI, quarries have been opened in deposits of a super-magnesia dolomite or calcareous magnesite. On lot 15, range IX, a calcining kiln about 40 feet high, and 7 feet internal diameter, has been built by the Canadian Magnesite Co., Ltd.,—owners of both properties. Most of the haulage is done in the winter, owing to the poor summer roads.

The following analyses are of general samples, "21" being from lot 15, range IX, and "X" from lot 18, range XI:—

—	21.	X.
Insoluble mineral matter	2·20	[1]1·67
Oxide of iron—all expressed as ferric oxide	0·13	0·17
Alumina	0·03	Not det.
Magnesia	39·12	42·00
Lime	8·80	7·40
Carbon dioxide	[2]49·72	47·56

[1]Silica. [2]By difference.

The crystalline limestones of this county vary greatly in content of magnesia, and range from less than one per cent, to very highly magnesian. As a rule they contain noticeable amounts of graphite, chondrodite, and other impurities.

Immediately south of Lachute, a fine grained, hard, bluish limestone is being quarried for road metal on the farm of George Fraser. It is probably of Calciferous age. The following is the analysis of a sample taken at this quarry:—

—	26.
Insoluble mineral matter	18·80
Oxide of iron—all expressed as ferric oxide	0·55
Alumina	1·45
Calcium carbonate[1]	45·44
Magnesium carbonate[2]	33·15
[1]Equivalent to lime	25·45
[2]Equivalent to magnesia	15·86

There are many exposures of limestone along the Ottawa river, between Carillon and Grenville. In some places, the beds are of fair thickness, but in others are thin, and full of shale partings. The two following analyses will serve to indicate the composition of the limestone exposed in this part of the county:—

—	28.	29.
Insoluble mineral matter	3·70	6·90
Oxide of iron—all expressed as ferric oxide	0·55	0·70
Alumina	0·25	0·90
Calcium carbonate[1]	91·96	82·59
Magnesium carbonate[2]	2·13	7·10
[2]Equivalent to lime	51·50	46·25
[1]Equivalent to magnesia	1·02	3·40

Sample 28.—From an old quarry near the head of Carillon canal. One bed is 18 inches thick.

Sample 29.—From cliff, on bank of Ottawa river, between Cushing and Stonefield. Here the beds are thin with shale partings.

STE. THÉRÈSE.

Three miles north of Ste. Thérèse, there is a quarry, and an old fashioned lime-kiln, owned by Placide Sauche. Some of the stone from this quarry has been used for building purposes. It is of good texture, and occurs in beds of workable thickness. It probably belongs to Chazy age. The following analysis is from a sample taken in this quarry:—

——	30.
Insoluble mineral matter	1·90
Oxide of iron—all expressed as ferric oxide	0·70
Alumina	0·16
Calcium carbonate[1]	94·64
Magnesium carbonate[2]	2·38
[1] Equivalent to lime	53·00
[2] Equivalent to magnesia	1·14

Within the town of Ste. Thérèse, and to the south of the town, are two quarries from which limestone is being taken for road metal. The rock is close-grained, hard, and appears to be well suited to the purpose. The two following analyses are of samples taken from these quarries:—

——	31.	32.
Insoluble mineral matter	13·84	6·70
Iron oxide—all expressed as ferric oxide	1·21	1·13
Alumina	0·21	2·40
Calcium carbonate[1]	49·91	61·16
Magnesium carbonate[2]	34·36	25·91
[1] Equivalent to lime	27·95	34·25
[2] Equivalent to magnesia	16·44	12·40

Sample 31 from quarry, in Ste. Thérèse, owned by J. Fred Pare.
Sample 32 from quarry one-half mile south of Ste. Thérèse station.

MONTREAL AND VICINITY.

On the island of Montreal there are numerous limestone quarries, large and small. Some of these were visited during the past season, but much work remains to be done during the field season of 1915. The following analyses are given as an indication of the composition of the stone from the various districts:—

——	38.	39.	41.	43.
Insoluble mineral matter	5·04	14·00	1·64	1·86
Iron oxide—all expressed as ferric oxide	0·43	0·40	0·93	0·50
Alumina	0·97	0·10	0·17	0·34
Calcium carbonate[1]	91·96	79·91	88·39	90·44
Magnesium carbonate[2]	1·92	2·75	8·94	2·31
[1] Equivalent to lime	51·50	44·75	49·50	50·65
[2] Equivalent to magnesia	0·92	1·32	4·28	1·11

Sample 38 from quarry operated by Norman M. McLeod at Point Clair. General sample of face about 40 feet high.

Sample 39 from quarry of Canada Cement Co., Ltd., at Pointe aux Trembles. General sample of face about 30 feet high.

Sample 41 from St. Denis quarry, in the Villeray group of quarries.

Sample 43 from one of the quarries on the property of M. S. Jarry, Mile End group.

The first, second, and fourth of these quarries are in Trenton limestone and the third in Chazy limestone.

On Ile Jésus, which lies to the north of Montreal island, there are a number of quarries situated at St. Vincent de Paul, St. Martin, Cap St. Martin, Village Belanger, and St. Francois de Salles. The field work on these quarries is not yet complete:—

—	34.	35.	36.	37.
Insoluble mineral matter	2·30	1·44	3·76	1·30
Iron oxide—all expressed as ferric oxide	0·70	0·64	0·71	0·50
Alumina	1·40	0·12	0·33	0·14
Calcium carbonate[1]	93·75	95·93	91·60	95·98
Magnesium carbonate[2]	1·46	1·58	2·17	1·58
[1] Equivalent to lime	52·50	53·50	51·30	53·75
[2] Equivalent to magnesia	0·70	0·76	1·04	0·76

Sample 34 from quarry of N. Brunet, near St. Vincent de Paul.

Sample 35 from quarry of Joseph Monette, Village Belanger.

Sample 36 from Paquette and Gauthier's quarry, Cap St. Martin.

Sample 37 from quarry of Théodule Saumure, Cap St. Martin, one-half mile east of sample 36.

VALLEYFIELD AND HUNTINGDON.

That portion of the province of Quebec lying between the International Boundary and the St. Lawrence river, and west of St. Timothe, St. Etienne, and Ormstown, is underlain, almost entirely, by Calciferous beds.

The surface soil or clay is very thin in many places, and outcrops of rock are frequently met with. At Valleyfield, two quarries, opened in highly siliceous beds, are being operated at present. The product of these quarries consists of building and curbstones and broken stone for concrete and road metal. The stone is very hard, and breaks with a subconchoidal fracture.

A sample taken from one of these quarries contained 46·5 per cent of insoluble mineral matter, 15·5 per cent lime, and 9·64 per cent magnesia.

About 7 miles southeast of Valleyfield, near St. Louis de Gonzague, there are two quarries, from which stone is being taken for road metal. The stone is similar to that being quarried at Valleyfield, but is less siliceous. A sample taken from the quarry of Théoret and Leduc contained 32·0 per cent insoluble mineral matter, 20·70 per cent lime, and 13·24 per cent magnesia.

In the township of Godmanchester, two quarries, from which limestone was being taken for road metal and concrete, were visited. That owned by O'Connor Brothers, and located on lot No. 416, about 2 miles west of Huntingdon, shows about 11 feet of strata.

One mile west of the above, Ross, Church, and Company have recently opened a quarry for road metal. About 8 feet of hard, tough, fine grained, grey limestone are exposed:—

——	59A.	59B.	60.
Insoluble mineral matter	7·64	3·40	15·30
Iron oxide—all expressed as ferric oxide	0·93	0·86	0·86
Alumina	1·33	0·60	0·38
Calcium carbonate[1]	57·85	52·23	45·53
Magnesium carbonate[2]	31·22	41·80	36·62
Phosphorus	Not det.	Not det.	0·008
Sulphur	Not det.	Not det.	0·458
[1] Equivalent to lime	32·40	29·25	25·50
[2] Equivalent to magnesia	14·92	20·00	17·52

Sample 59A represents the top 6 feet of O'Connor Brothers' quarry.

Sample 59B represents the lower 5 feet of O'Connor Brothers' quarry.

Sample 60 was taken in the quarry of Ross, Church, and Company.

Near Caughnawaga, there are a number of quarries from which much limestone has been taken for building stone, and lime-burning, also, for rubble and concrete. At the time of my visit, only one quarry was in operation. It was the old "Indian Quarry," situated about a mile to the west of the village. Here, G. H. Leahy, of Montreal, was removing spalls and waste rock for rubble work. A sample taken down the face of the quarry gave the following analysis:—

——	55.
Insoluble mineral matter	4·66
Iron oxide—all expressed as ferric oxide	1·43
Alumina	0·57
Calcium carbonate[1]	89·10
Magnesium carbonate[2]	3·97
[1] Equivalent to lime	49·90
[2] Equivalent to magnesia	1·90

RICHELIEU VALLEY, SOUTH.

To the west of the Richelieu river, and south of St. Johns, there are numerous exposures of limestone suitable for lime-burning, building purposes, and for road metal.

Between St. Johns and L'Acadie, two quarries were visited. Lord and Herbert's quarry, situated about 2 miles due west of St. Johns, is at present closed. One mile farther west is the quarry of David Brault. This quarry is producing crushed stone only, as, also, did that of Lord and Herbert. The following analysis is of an average sample from Brault's quarry: —

—	45.
Insoluble mineral matter	10·20
Iron oxide—all expressed as ferric oxide	0·63
Alumina	0·17
Calcium carbonate[1]	84·64
Magnesium carbonate[2]	2·90
[1] Equivalent to lime	47·40
[2] Equivalent to magnesia	1·39

Near Grande Ligne, there is a large and well equipped quarry—at present idle—owned by the Otis Quarries, Ltd. It is situated about a mile and a half north of the village, and is connected with the Grnad Trunk railway by a spur about one-half mile in length. The limestone there is found is fairly massive beds, some being 18 to 24 inches thick, and is of good colour and texture. At the time of my visit, there was much water in the pit, but a sample was secured representative of the upper ten feet of the beds; this yielded:—

—	48.
Insoluble mineral matter	2·72
Iron oxide—all expressed as ferric oxide	0·71
Alumina	0·17
Calcium carbonate[1]	85·35
Magnesium carbonate[2]	10·24
[1] Equivalent to lime	47·80
[2] Equivalent to magnesia	4·90

About 6 miles south of Grande Ligne, and 1 mile northwest of Stottsville, there is an old quarry from which stone was taken many years ago, for lime-burning and building purposes.

The following analysis is of a sample taken in this pit:—

—	51.
Insoluble mineral matter	2·06
Iron oxide—all expressed as ferric oxide	0·14
Alumina	0·06
Calcium carbonate[1]	90·44
Magnesium carbonate[2]	5·22
[1] Equivalent to lime	50·65
[2] Equivalent to magnesia	2·50

About 2½ miles west of Lacolle village, on range IV of Lacolle township, there is an extensive exposure of a close grained, bluish-grey limestone, on the property of O. Duchêne. This stone occurs in beds from one to three feet thick, and should prove suitable for building stone or road metal. A partial analysis showed:—

Insoluble mineral matter	34·30
Lime	27·75
Magnesia	6·56

West of Napierville, two old abandoned quarries were visited. One is on the property of Arthur Fortin, one mile west of Napierville, and the other one mile farther west, near Douglas Corner, on the property of Hormidas Bechard. Some years ago lime was burned at both pits:—

—	52.	53.
Insoluble mineral matter	3·76	3·30
Iron oxide—all expressed as ferric oxide	0·14	0·50
Alumina	0·06	0·06
Calcium carbonate[1]	91·60	72·19
Magnesium carbonate[2]	3·44	24·45
[1] Equivalent to lime	51·30	40·42
[2] Equivalent to magnesia	1·65	11·70

Sample 52 was taken from property of A. Fortin.

Sample 53 was taken from property of H. Bechard.

On lot 6, Côte St. Marc, Laprairie county, a little over 2 miles northwest of St. Jacques, there is an old quarry from which building stone has been taken. There was much water in the pit at the time of my visit, but the beds appeared to be of considerable thickness, and to consist of a good grade of building stone. The following analysis is of a sample taken from the upper beds:—

—	54.
Insoluble mineral matter	1·40
Iron oxide—all expressed as ferric oxide	0·40
Alumina	0·04
Calcium carbonate[1]	90·27
Magnesium carbonate[2]	7·27
[1] Equivalent to lime	50·55
[2] Equivalent to magnesia	3·48

MISSISQUOI COUNTY.

From an economic standpoint, the limestones in this county may be placed into three groups.

The first group of samples, including numbers 69, 71, 72, 74A, 74B, and 75, are all very low in insoluble mineral matter and other impurities. These samples were taken over a rather narrow strip of country extending from the southwest corner of St. Armand township, on the shore of Missisquoi bay, to a point about 1 mile southwest of the town of Bedford. The stone is light bluish-grey for the most part, and is extremely fine grained. At Philipsburg, the rock is variegated, and yields a beautifully marked marble. The whole of the above area is in close proximity to railroads and lies within 55 miles of Montreal. It should, therefore, be classed as one of the most important limestone localities within the province.

At Philipsburg, the Missisquoi-Lautz Corporation, Ltd., operate a modern lime-kiln in connexion with their large quarry and polishing works:—

—	69.	71.	72.	74A.	74B.	75.
Insoluble mineral matter	1·50	0·40	0·28	1·14	3·94	1·60
Iron oxide all expressed as ferric oxide.	Trace.	0·07	Trace.	0·14	0·28	0·24
Alumina	0·10	0·04	0·04	0·06	0·18	0·02
Calcium carbonate[1]	95·80	98·75	98·93	96·25	94·91	96·16
Magnesium carbonate[2]	1·90	1·21	1·07	1·44	0·98	1·75
Phosphorus	Not det.	Not det.	Not det.	Not det.	Not det.	0·041
Sulphur	Not det.	Not det.	Not det.	Not det.	Not det.	0·016
[1]Equivalent to lime	53·65	55·30	55·40	53·90	53·15	53·85
[2]Equivalent to magnesia	0·91	0·58	0·51	0·69	0·47	0·86

Sample 69 was taken on the farm of D. J. Pells, lot 2, range VII, Stanbridge township.

Sample 71 was taken on lot 6, range VII, Stanbridge township.

Sample 72 was taken on the farm of E. H. Morgan, lot 2, range IX, Stanbridge township.

Samples 74A and 74B were taken from the spalls at the marble quarry of the Missisquoi-Lautz Corporation, Ltd., at Philipsburg. Sample 74A represents the white and light coloured spalls, and 74B the darker and less pure spalls.

Sample 75 was taken on lot 21, West Parish of St. Armand, owned by M. McNamara, of Bedford.

The accompanying map shows the localities from which the samples were taken.

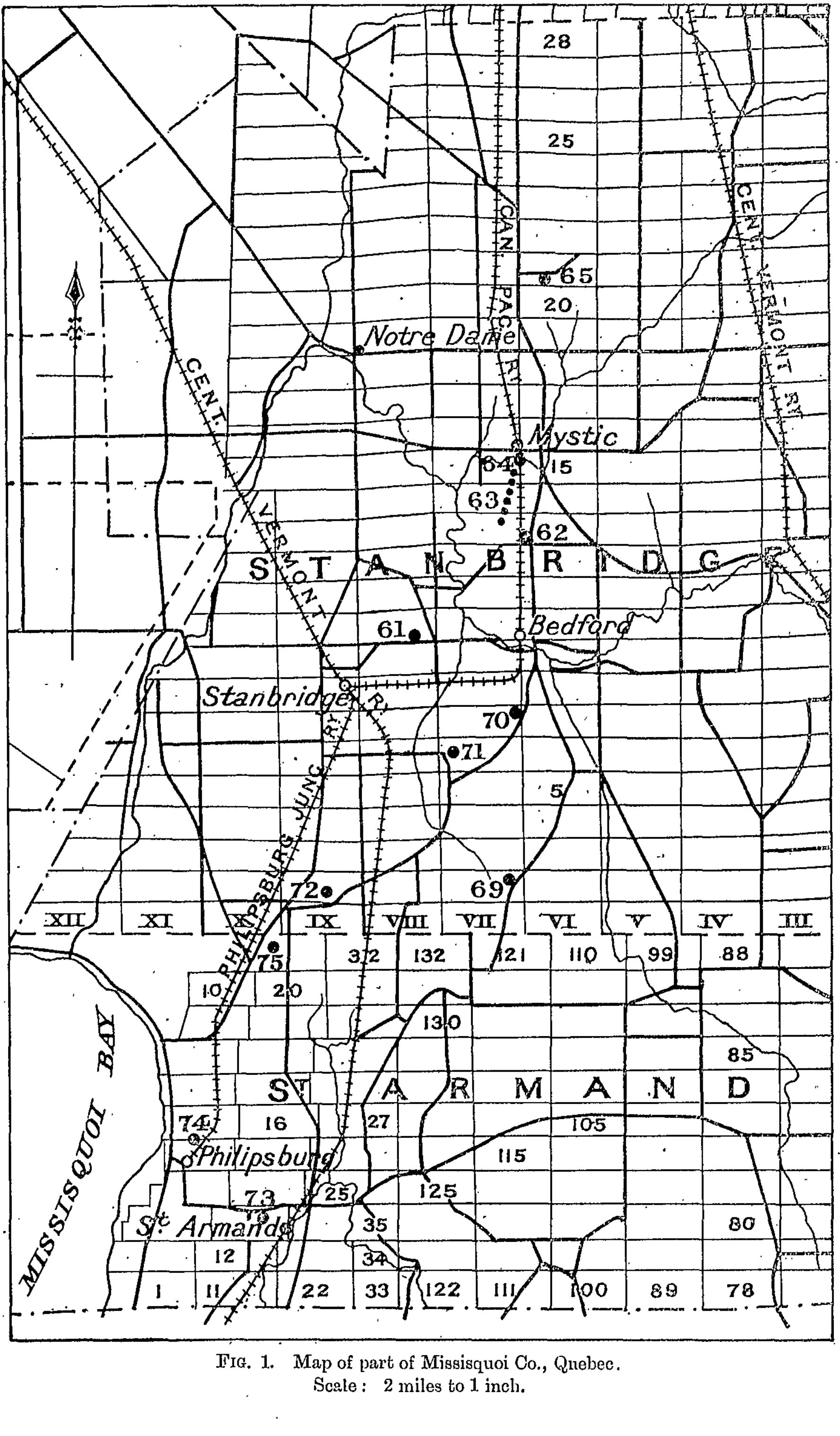

FIG. 1. Map of part of Missisquoi Co., Quebec.
Scale: 2 miles to 1 inch.

The second group of samples, including numbers 61, 63, 64, and 65, were taken along a ridge which extends north and south for a number of miles through Mystic, and about one mile to the east of Bedford. The limestone is a brecciated, light grey to bluish-grey, fine grained stone, much interveined in places with calcite. Sample 69, of the first group, while much purer, is also a brecciated limestone:—

—	61.	63.	64.	65.
Insoluble mineral matter	5·46	5·30	5·50	5·04
Iron oxide —all expressed as ferric oxide	0·27	0·43	0·28	0·45
Alumina	0·13	0·07	0·08	0·11
Calcium carbonate[1]	90·53	90·80	91·78	91·43
Magnesium carbonate[2]	1·81	1·75	1·62	1·56
[1]Equivalent to lime	50·70	50·85	51·40	51 20
[2]Equivalent to magnesia	0·87	0·84	0·78	0·75

Sample 61 was taken about one mile east of Stanbridge station, on the road to Bedford.

Sample 63 consisted of material taken from various points along the ridge, over a distance of half a mile, on lots 13, 14, and 15, range VII, Stanbridge township.

Sample 64 was taken in an old quarry, owned by A. S. Walbridge, of Mystic, on lot 15, range VII, Stanbridge.

Sample 65 was taken on lot 21, range VI, Stanbridge.

The third group of samples taken in Missisquoi county consists of much less pure material. The samples were taken to the east of the two foregoing districts. The stone here is uniformly darker in colour than in the former areas, and is made up of alternating layers of very thin shale and limestone. It is considerably higher in magnesia, and although in some places the percentage of shale present is small, the rock is, for the most part, of little or no commercial value. Three samples, numbers 62, 70, and 73 were taken to indicate the nature of the stone.

Sample 62, taken on lot 13, range VI, Stanbridge township, contained 43·02 per cent insoluble mineral matter, 16·55 per cent lime, and 9·98 per cent magnesia.

Sample 70, taken on lot 7, range VI Stanbridge township, contained 30·54 per cent insoluble mineral matter, 39·50 per cent lime, and 1·73 per cent magnesia. On this same lot, but farther to the west, outcrops of a better grade of limestone were noticed.

Sample 73 was taken on lot 13, West Parish St. Armand township:—

—	73.
Insoluble mineral matter	8·82
Iron oxide—all expressed as ferric oxide	0·53
Alumina	0·29
Calcium carbonate[1]	80·35
Magnesium carbonate[2]	6·16
[1]Equivalent to lime	45·00
[2]Equivalent to magnesia	2·95

ROUVILLE COUNTY.

In the county of Rouville, two limestone exposures were sampled.

Two samples were taken from old quarries on the farm of H. Berard, on the south side of the Casimir road, one-half mile southeast of the main road running north from Farnham. Sample 66 is an average sample taken in the southernmost quarry, and sample 67 represents the material of the upper beds exposed in the north quarry. The lower beds in the quarry are similar to those of the south quarry. The limestone of the south quarry is very dark in colour. Calcite veins are abundant in both quarries. The upper stone of the north quarry is thinly bedded and hard:—

—	66.	67.
Insoluble mineral matter	13·00	10·16
Iron oxide—all expressed as ferric oxide	0·24	Trace.
Alumina	0·06	0·10
Calcium carbonate[1]	83·03	87·05
Magnesium carbonate[2]	2·77	2·40
[1]Equivalent to lime	46·50	48·75
[2]Equivalent to magnesia	1·33	1·15

The other locality sampled in Rouville county was on the farm of Antoine Menard, on the north side of the Papineau road. The beds are very thin and are interveined with calcite in many places. The dip is about 75 degrees to the west. An analysis of stone from this locality follows:—

—	78.
Insoluble mineral matter	10·44
Iron oxide—all expressed as ferric oxide	0·24
Alumina	0·10
Calcium carbonate[1]	86·07
Magnesium carbonate[2]	1·81
[1]Equivalent to lime	48·20
[2]Equivalent to magnesia	0·87

BAGOT COUNTY.

At La Carrière, situated about 4 miles southeast of St. Hyacinthe, there are a number of small quarries asd lime-kilns. These pits produce building stone, as well as stone for lime-burning.

The three following quarries were visited. On the north side of the road, a small pit is worked by Alfred Corneau, from which he takes stone for a small lime-kiln. Sample 76 was taken here.

Joseph Lapointe's quarry to the south of the road, produces building stone, and supplies stone to Benoit et Fils, for lime-burning. Sample 77 was taken from this quarry.

Adolph Barrow's building stone quarry is situated a short distance to the west of the preceding one. The stone is similar to that from the pit owned by Alfred Corneau.

Benoit et Fils operate two lime kilns at St. Dominique, a short distance southeast of LaCarriere. They purchase all the limestone used.

—	76.	77.
Insoluble mineral matter	1·84	1·00
Iron oxide—all expressed as ferric oxide	0·14	0·14
Alumina	0·08	0·02
Calcium carbonate[1]	96·07	96·43
Magnesium carbonate[2]	0·69	1·67
[1]Equivalent to lime	53·80	54·00
[2]Equivalent to magnesia	0·33	0·80

In the township of Upton, Bagot county, there are a number of exposures of fairly good limestones. Two outcrops were sampled.

About 2½ miles north of Upton, on lot 51, range XXI, there is a small pit by the road where prospecting work has been done on a showing of copper ore. The country rock is limestone, which is well exposed over a considerable area to the north of the pit. Sample 93 was taken from the limestone exposed in the prospect hole. Owing to the weathered condition of the stone and the difficulties of sampling, it was impossible to get truly representative material.

Sample 94 was taken on lot 49, range XX. Here, also, some prospecting has been done for copper.

The limestone forms a ridge about 20 feet high, and covers two acres or more.

Other ridges or "hogs-backs," are to be seen on the opposite side of the road.

—	93.	94.
Insoluble mineral matter	6·36	4·40
Iron oxide—all expressed as ferric oxide	0·59	0·71
Alumina	0·13	0·45
Calcium carbonate[1]	90·09	83·12
Magnesium carbonate[2]	1·38	10·07
[1]Equivalent to lime	50·45	46·55
[2]Equivalent to magnesia	0·66	4·82

On lot 34, range V, Acton township, Bagot county, there is a large exposure of light grey, fine grained limestone. It is owned by Eugene Leclerc, and in it are some small pits from which stone was taken for lime-burning a number of years ago. Sample 95 consists of stone taken in several of these pits. This property is situated about one mile north of Actonvale.

A specially selected sample, number 96, was taken in the old Actonvale copper mine, on lots 31 and 32, range III, Acton township, a short distance southeast of Actonvale. In taking the sample, an effort was made to avoid such pieces of the limestone as contained noticeable quantities of copper or other sulphides, the object being to obtain a sample representative of what would be waste rock from copper mining. Upon the large waste dumps about the mine are large quantities of broken limestone:—

—	95.	96.
Insoluble mineral matter	5·06	5·06
Iron oxide—all expressed as ferric oxide	0·43	0·37
Alumina	0·57	0·39
Calcium carbonate[1]	84·91	83·57
Magnesium carbonate[2]	8·86	10 16
[1]Equivalent to lime	47·55	46·80
[2]Equivalent to magnesia	4·24	4·86

DRUMMOND COUNTY.

Only one limestone quarry was visited in this county.

Sample 78 was taken in a small quarry on lot 14, range X, West Wickham township. This is owned by E. Lupien, who burns lime in a small kiln. The stone is much interveined with calcite, and contains some copper pyrites:—

—	78.
Insoluble mineral matter	6·08
Iron oxide—all expressed as ferric oxide	0·53
Alumina	1·37
Calcium carbonate[1]	76·25
Magnesium carbonate[2]	10·84
[1]Equivalent to lime	42·70
[2]Equivalent to magnesia	5·16

Along the St. Francis river, near Drummondville, there are a number of exposures of impure limestone. A sample taken 4 miles up-stream from Drummondville contained about 30 per cent of insoluble mineral matter.

DANVILLE AND VICINITY.

All the limestones seen in this neighbourhood were impure, with thin interbedding of slate, and often much interlaced with veinlets of quartz and calcite.

The three following analyses will serve to illustrate the composition of the limestones of the district:—

—	110.	111.	112.
Insoluble mineral matter	17·44	9·58	17·20
Iron oxide—all expressed as ferric oxide	1·10	0·85	1·07
Alumina	0·44	0·11	0·08
Calcium carbonate[1]	78·39	87·14	77·59
Magnesium carbonate[2]	1·52	1·90	2·65
[1]Equivalent to lime	43·90	48·80	43·45
[2]Equivalent to magnesia	0·73	0·91	1 27

Sample 110 was taken on lot 23, range I, Warwick township, Arthabaska county. Sample 111 was taken on lot 18, range I, Shipton township, Richmond county. This sample was somewhat weathered, and is therefore probably slightly higher in insoluble matter than it should be. It was difficult to obtain a sample, as the old pits were all filled in with soil. At one time lime was burned here for local use. Sample 112 was taken on lot 17, range VII, Tingwick township, Arthabaska county. At one time lime was burned here for local use.

STUKELY TOWNSHIP.

The Dominion Marble Co., Ltd., is quarrying marble on lot 8, range II, South Stukely, Shefford county. The stone is of fine texture and handsomely marked, the various beds supplying marble of different combinations of colours.

The two following analyses are of samples of spalls and waste rock taken at this quarry. Sample 81A is of the white stone, and 81B of the coloured stone:—

—	81A.	81B.
Insoluble mineral matter	5·10	5·56
Iron oxide—all expressed as ferric oxide	1·86	0·56
Alumina	1·24	0·20
Calcium carbonate[1]	62·50	83·75
Magnesium carbonate[2]	28·51	9·94
[1]Equivalent to lime	35·00	46·90
[2]Equivalent to magnesia	13·64	4·76

This quarry was originally opened to supply stone for lime-burning. For some time no lime has been burned here.

In the village of South Stukely, near the station, quarries have been worked in the past, but are now idle.

On lot 13, range VII, North Stukely, Delphio Bauregard operates a quarry and lime-kiln. Sample 82 was taken in this quarry:—

—	82.
Insoluble mineral matter	1·20
Iron oxide—all expressed as ferric oxide	0·20
Alumina	Trace.
Calcium carbonate[1]	95·18
Magnesium carbonate[2]	3·05
[1] Equivalent to lime	53·30
[2] Equivalent to magnesia	1·46

KNOWLTON AND VICINITY.

Two old abandoned quarries were visited near Knowlton. The stone in both quarries is very dirty in appearance, and much fractured. Sample 80 was taken in the quarry on the farm of J. C. Patterson, lot 10, range XI, Brome township, and sample 83 at the quarry on lot 16, range XI, Brome township. Lime was burned at both of these localities many years ago, and is said to have been strong though dark in colour:—

—	80.	83.
Insoluble mineral matter	9·88	7.22
Iron oxide—all expressed as ferric oxide	3·86	1·00
Alumina	0·70	0·04
Calcium carbonate[1]	49·10	83·48
Magnesium carbonate[2]	36·07	4·18
[1] Equivalent to lime	27·05	46·75
[2] Equivalent to magnesia	17·26	2·00

LAKE MEMPHREMAGOG.

On the east side of Lake Memphremagog, there are innumerable exposures of slaty black limestones. Lime has been burned from time to time at various points near the shore, but of late years no use has been made of the stone. At Magoon point, a purer grade of limestone is reported. It was impossible to visit this during the past summer. Samples will be obtained later.

Near Sargents bay, on the west side of the lake, there are a few exposures of limestone which have been quarried in the past for the production of stone for lime-burning.

The following analyses are of samples taken in this district:—

—	84.	85.	86.	88.	89.
Insoluble mineral matter	10·14	13·44	6·60	11·44	9·78
Iron oxide—all expressed as ferric oxide	0·79	0·35	0·57	0·50	0·64
Alumina	4·15	0 26	0·11	0·38	0·52
Calcium carbonate[1]	50·09	83·30	90·35	81·78	84·28
Magnesium carbonate[2]	35·70	2·29	1 52	2·54	2·59
[1] Equivalent to lime	28·05	46·65	50·60	45·80	47·30
[2] Equivalent to magnesia	17·08	1·10	0·73	1·22	1·24

Sample 84 was taken on lot 12, range XIV, Magog township, Stanstead county.

Sample 85 was taken in an old quarry, on lot 27, range II, Stanstead township, Stanstead county.

Sample 86 was taken along the shore of the lake, near the site of an old lime-kiln, on lots 20 and 21, range I, Stanstead township, Stanstead county.

Sample 88 was taken in an old pit on lot 28, range X, Bolton township, Brome county.

Sample 89 was taken on the farm of S. A. Jones, lot 24 (?), range X, Potton township, Brome county.

SOUTHEASTERN COUNTIES.

In Stanstead county, east of Lake Memphremagog, and in Sherbrooke and Compton counties, the limestones encountered are all very highly arenaceous, and almost black in colour.

The following partial analyses are quoted merely to indicate the type of rock which occurs throughout this section:—

—	87.	91.	92.	97.
Insoluble mineral matter	37·28	47·12	50·00	54·16
Lime	31·00	25·30	24·55	20·86
Magnesia	2·40	2·86	1·53	2·70

Sample 87 was taken on lot 11, range V, Stanstead township, Stanstead county.

Sample 91, was taken on lot 7, range V, Ascot township, Sherbrooke county.

Sample 92 was taken on lot 6, range IV, Hatley township, Stanstead county.

Sample 97 was taken in the bed of a river on lot 5, range V, Barnston township, Stanstead county.

ALONG QUEBEC CENTRAL RAILWAY (SHERBROOKE TO D'ISRAELI).

Search was made for limestone for several miles on both sides of the Quebec Central railway. Most of the limestones within this area are very impure, and thin bedded. At Bishop Crossing, a highly arenaceous limestone is quarried for flagstone. The stone splits readily along the bedding plains, producing an even and very true surface. Flags are made up to 12 feet by 5 feet, and from 2 to 5 inches thick. Along the ridge which runs from Lime Ridge to Aylmer lake, there are occasional exposures of limestone of much better grade, several of which have been worked.

At Lime Ridge, in Dudswell township, Wolfe county, the Dominion Lime Co., Limited, operates a large quarry, which supplies stone to eleven lime-kilns. Five of these are modern gas-fired kilns, and the balance are fired with wood.

The stone is compact, and for the greater part, free from slate.

This is the only working quarry in the district:—

—	90.	98.	99.	100.	101.	102.	103.	104.	105.	106.	107.	108.	109.
Insoluble mineral matter	66·94	38·82	2·00	1·80	0·60	38·20	20·00	5·92	21·14	14·74	51·82	9·88	20·34
Iron oxide, all expressed as ferric oxide	....	......	0·21	0·21	0·10	......	......	0·35	......	1·28	......	0·45	......
Alumina	....	......	0·09	0·11	0·02	......	....	0·16	......	0·82	......	0·15	......
Calcium carbonate[1]	......	.....	95·71	96·87	98·75	......	......	91·52	......	52·23	......	87·50	......
Magnesium carbonate[2]	......	.....	1·19	1·34	0·85	......	......	1·81	......	29·26	.....	1·60	......
	......	.....	99·20	100·33	100·32	......	.....	99·76	....	98·33	......	99·58	......
[1] Equivalent to lime	11·90	29·10	53 60	54·25	55·30	32·00	31·15	51·25	40·10	29·25	17·20	49·00	41·35
[2] Equivalent to magnesia	1·92	3·78	0·57	0·64	0·41	1·56	11·66	0·87	2·29	14·00	4·36	0·77	2·18

Sample 90 was taken on lot 13, range VII, Stoke township, Richmond county, near Stoke Centre.

Sample 98 was taken by the roadside 2 miles southwest of Weedon in Weedon township, Wolfe county.

Sample 99 was taken in an old marble quarry on lot 21, range VII, Dudswell township, Wolfe county. The blocks of stone in the quarry show rather bad weathering.

Samples 100 and 101 were taken in the quarry of the Dominion Lime Co., Ltd. The former represents the material of the northeast working face of the pit, and the latter that of the southeast working face.

Sample 102 was taken from the pile of waste rock of Wm. Bentley's flagstone quarry, on lot 15, range V, Dudswell township.

Sample 103 was taken on lot 17, range III, Weedon township, along the road which leads from Weedon station to Weedon Mines.

Sample 104 was taken in a small quarry, which is at present idle, on lot 21, range VII, Weedon township. The stone which is somewhat shattered and interveined with calcite, was, a few years ago, used for lime-burning. There is some pyrite visible in this limestone.

Sample 105 was taken on Long point, Aylmer lake, in Garthby township, Wolfe county. It represents an impure thin bedded limestone of no apparent value.

Sample 106 was taken from a knoll of brecciated fine grained limestone, somewhat over 100 feet long and 60 feet in width, on lot 22, range V, Stratford township, Wolfe county.

Sample 107 represents a slaty limestone which occurs on a point in Lake St. Francis, on lot 22, range III, Lambton township, Frontenac county.

Sample 108 was taken in an old quarry owned by Francois Briere, situated on lot 26, range VII, Weedon township. The limestone occurs in fairly massive beds, with thin slate partings. This stone was at one time burned for lime, and is said to have produced a strong hydraulic lime.

Sample 109 was taken on lot 3, range C, Garthby township, Wolfe county.

EXTENSION OF WORK.

This investigation of the limestones of Quebec will be continued during 1915.

II.

INVESTIGATION OF MISCELLANEOUS NON-METALLIC MINERALS.

Hugh S. de Schmid.

During the season of 1914, I visited a number of localities in the provinces of Ontario, New Brunswick, and Nova Scotia, at which non-metallic minerals are being worked, or have been worked within recent years. The visits were made for the purpose of obtaining first-hand information as to the extent of the operations hitherto carried out upon the deposits of the various minerals; to investigate the methods of working and treating the material produced; and to determine the future economic possibilities of the deposits: such information, if circumstances warrant it, to be published in a series of short, individual bulletins.

The minerals investigated include the following: barytes, manganese, infusorial earth, scheelite, talc, fluorspar, and actinolite. In addition to securing data on the foregoing, visits were made to all the fertilizer works in Eastern Canada, for the purpose of obtaining information as to the nature, capacity, etc., of the various plants; these details being required for inclusion in the report on phosphate, now nearing completion. The feldspar district north of Kingston, Ont., was also visited, in order to bring up to date the information already collected on this industry, and to take note of any new developments since the last visit paid to this section, in 1912. Certain other feldspar deposits in the more or less immediate vicinity of Ottawa were visited, these having been either only recently discovered or exploited.

Of the minerals mentioned above, (not including feldspar), the only ones that are being worked actively at the present time were found to be talc, infusorial earth, and barytes. Although the present output and importance of any of the minerals mentioned is comparatively small, and hardly justifies the preparation of an individual bulletin, nevertheless the data secured has proved of the greatest assistance in enabling the Mines Branch to supply the latest information regarding the different industries to the numerous interested parties, both at home and abroad, who have addressed inquiries since the outbreak of the war concerning the possibility of obtaining from this country certain minerals, the supply of which has been curtailed, or cut off by the war. Particularly was this the case with barytes and infusorial earth, which, from the number of inquiries received, would seem to be in great demand, the former by domestic and the latter by British consumers.

Brief mention of the actual status of the above-mentioned industries is made below.

ACTINOLITE.

Mining of this mineral has not been carried on for several years past, and in 1914, only a small shipment of ground mineral from stock was made. The actinolite deposits are situated in Elzevir township, Hastings county, and Kaladar township, Lennox county, Ontario, and are owned by the Actinolite Mining Company, of Bloomfield, N.J.

Actinolite, which is a green, fibrous mineral, is used as a cheap substitute for asbestos, for insulating boilers and steam pipes; also, when finely ground, in plaster. About 10 per cent of the mineral mined in Elzevir township is stated to be sufficiently fibrous to be employed in boiler covering.

BARYTES.

Barytes exists in large amount in the vicinity of Lake Ainslie, Cape Breton. This is the only section in Nova Scotia where the mineral has been found in large quantities, though small outcrops or float have been recorded at several points in the province; and mining has been conducted near Five Islands, Colchester county. In former years, comparatively large quantities of crude mineral were exported to the United States (1,700 tons in 1905). A smaller amount was shipped to grinding mills at Halifax, which supplied to domestic paint works.

Latterly, the export trade in crude mineral has dwindled, and very little mining has been done. Barytes, Ltd., who control the greater number of the Lake Ainslie deposits, have, during the past few years, been engaged in perfecting a refining process, whereby the small, but, nevertheless, significant amount of impurities in the ore can be eliminated. These impurities consist of calcium carbonate, manganese oxide, silica, and fluorite. Toward the end of 1914, the Company announced that the difficulties had been largely overcome, and that it was hoped shortly to place on the market a product in every way equal to the imported, refined barytes, which, hitherto, had been obtained chiefly from Germany. The Company have a mill and refining plant on the east side of Lake Ainslie, within a short distance of the Peter Campbell property, from which the greater part of the mineral mined in recent years has been taken.

From the Johnson mine, south of the Barytes Ltd., properties, Messrs. Brandram-Henderson, paint manufacturers, have, for a number of years past, taken out small quantities of barytes for use in their own works. The mineral was shipped to Halifax, and there ground at the Company's mill, on Northwest Arm.

The Lake Ainslie barytes occurs on well-defined veins, which attain a width of as much as 16 feet, and are found in zones along the lofty ridge which overlooks the east shore of the lake. The total amount of ore contained in these veins is very large, and is sufficient to supply the domestic consumption for many years. Now that a method of eliminating the impurities has been devised, it may be hoped that development of the deposits will be undertaken on a larger scale.

In New Brunswick, a small production was reported in the eighties from near Gouldville.

In former years (between 1885 and 1895) a considerable tonnage of barytes was obtained from McKellar island, Lake Superior, where the mineral occurs in a 50-foot vein. Calcite and quartz form a considerable portion of the vein-filling at this point, in consequence of which the ore had to be hand-picked. No mining has been conducted here for a number of years.

Barytes also occurs near Kingston, Ont., and at several other points in the province, but the veins do not possess any economic value.

In Quebec, a small deposit was worked in Hull township in 1900, a small tonnage being extracted. The vein would appear to be worked out.

Barytes is used in paint, putty and lithophone making, as a filler in rubber, and to a lesser extent in the textile, wall paper, tanning, and chemical industries.

The total consumption of barytes in Canada at the present time is given, approximately, as 3,500 tons per annum, six-sevenths of which is imported. Thirty-five firms use the mineral.

FLUORSPAR.

The only important deposits of this mineral so far discovered in Canada are those in the vicinity of Madoc, Ontario, and these are relatively of small size. A 4-foot vein of fluorspar, mixed with chalcopyrite, has long been known near Cape Rouge, in the Cheticamp district, Cape Breton, but no attempt has been made to exploit the occurrence.

The Madoc deposits lie on lot 1, concession IV, of Madoc township, and on lot 10, concession XIV, of Huntingdon. Intermittent mining has taken place at these localities during the past ten years, and a few hundred tons of mineral are reported to have been taken out. The veins are, however, narrow, and the deposits do not possess any great economic value.

Mr. S. Wellington, of Madoc, controls the above properties.

Twenty-five firms in Canada use fluorspar, the amount of consumption being 10,500 tons of imported, and 40 tons of domestic mineral.

INFUSORIAL EARTH OR TRIPOLI.

Large bodies of this material exist at many points in Nova Scotia and New Brunswick, the substance representing recent deposits formed on lake bottoms, and being of an earthy nature as compared with the more compacted material of Tertiary age, known as tripolite, found in other parts of the world.

All of the worked deposits have been rendered accessible by the draining of lakes in which the earth had been found to exist, and it is quite likely that numbers of lakes in the above-mentioned provinces will be found, upon draining, to contain the material. Hitherto, however, the demand for the earth has not been great enough to encourage any active search for new deposits, and mining has been confined in recent years to two localities, both in Nova Scotia.

The more important of these is Silica lake (formerly known as Bass River lake), in Colchester county, about 16 miles from Londonderry, and 12 from Thompson—the shipping point on the Intercolonial railway. The initial work on this deposit was begun over twenty years ago, and practically the whole of the lake bottom has now been worked over and the earth removed. The area of the depression is about twelve acres. In recent years the deposit has been worked by the Oxford Tripolite Company, who employ about twenty hands, and prepare six grades of product. The crude tripoli is dried, and treated on the spot in a mill of 10-ton capacity per diem, the prepared goods being exported to the United States. It is stated that the Company has control of a nearby lake, in which tripoli is known to exist, and which they intend to work when the present deposit becomes exhausted.

The other locality at which infusorial earth has been worked in recent years is near Munro Point, St. Ann's, Cape Breton. The Premier Tripolite Company, of New York, are the present lessees of this deposit, which was worked formerly by the Victoria Tripoli Company. No extraction work has, however, been carried out for a number of years past, though small shipments of crude material have been made from stock from time to time. A small mill for treating the earth exists on the property, but has not been in operation for the last ten years. The area of the drained lake is stated to be about twelve acres, and only a relatively small portion of the available material has been taken out.

An important deposit of tripoli exists in New Brunswick at Fitzgerald lake, about 8 miles east of St. John. There, about 50 acres of tripoli-bearing lake bottom have been rendered accessible by draining operations, the average thickness of the bed being stated to be 10 feet. The deposit has been known for many years, but no attempt at development was made until 1909, when the Boston and St. John Tripolite Company was formed to exploit the occurrence. This Company leased (and continues to lease) the property from the owner, Mr. Wm. Murdoch, of St. John, and in the above year extracted a small quantity of earth, which was air-dried and experimentally treated in a small mill. The operations were soon discontinued, however, and the plant is now in a dilapidated condition. The material appears to be of good grade, and the deposit contains a very large amount of earth, which could be conveniently extracted, and hauled by a good road to St. John for shipment.

In Ontario, there is record of infusorial earth having been found in the Muskoka region near Bala, but no material appears to have been mined.

Tripoli is chiefly used as an abrasive in polishing powders, pastes, and liquids, and in what is known as "grease brick." It is also employed as a filler in rubber goods and woods, as insulating material for steam pipes, boilers, etc., in filters and as an absorbent for nitro-glycerine in dynamite manufacture. There are, in addition, a number of minor uses, and the material is coming more and more into use in a number of industries.

The treatment the crude earth has to undergo is practically the same in all cases, namely, a preliminary drying in kilns; grinding between buhrstones, and final reduction between rolls—though varying degrees of fineness are required for the different trades.

Fourteen firms in Canada use the treated tripoli powder, the total consumption being less than 100 tons, while the number using grease brick is 145, the amount of this material used being about 100 tons. All of this consumption represents imported mineral.

In spite of its many and varied uses, and the number of known deposits in the United States, infusorial earth is not produced in the latter country on a very large scale. The production in 1913 was only 6,500 tons, valued at $70,000—the output coming from eight states, the chief producer being California. The imports are not large, being valued in 1913 at only $28,000. In view of this, and despite the proved existence of large deposits of the material in the Maritime Provinces, and the probable existence of others, the industry is not likely, in the immediate future, to assume any important proportions.

Analyses of Canadian infusorial earth have lately been conducted by N. L. Turner, of the Mines Branch, on samples obtained by the writer last season at the three Maritime localities mentioned above. The results showed:—

—	1.	2.	3.
Silica	74·98	72·10	81·30
Alumina	3·81		
Ferrous iron	0·64	0·51	0·38
Ferric iron	0·72		
Lime	0·54		
Magnesia	0·36		
Soda	0·65		
Potash	0·25		
Water below 110° C	5·74	6·10	5·16
Water above 110° C	9·56	10·70	9·34
Organic	2·72	6·30	0·82

1. Fitzgerald Lake, St. John county, N.B.
2. Premier Tripolite Company's property, St. Ann's bay, Victoria county, C.B.
3. Oxford Tripoli Company's property, Silica lake, Colchester county, N.S.

Only partial analyses were made in the case of Nos. 2 and 3.

MANGANESE.

~~Manganese is known to occur in the Dominion only in the Provinces of Nova Scotia and New Brunswick.~~ Between 1880 and 1890, a considerable tonnage of high-grade pyrolusite was produced annually, the shipments averaging 1,500 tons. Most of this output was derived from the Tennycape, Walton, and Cheverie deposits in Nova Scotia, and from Markhamville in Kings county, New Brunswick. The mineral occurs here in pocketty aggregates of very pure ore, but the individual pockets are of limited extent and mining is rendered difficult in consequence. No mining has been carried on in this section for a number of years past.

Several deposits of a similar nature are known at various places in the same provinces, and recent reports state that the old Isabella mine, near Loch Lomond, in Richmond county, Cape Breton, has lately been re-opened by the Dominion Iron and Steel Company.

The most important manganese-bearing section in the country is that near New Ross, in Lunenburg county. There, two pyrolusite-manganite lodes enclosed in granite have been worked, one to a depth of 150 feet, and the large amount of manganese float that has been found in the neighbourhood of the mines suggests the probability that other similar veins exist in the district.

The original discovery in this area resulted in the formation of the New Ross Manganese Company, which opened up the most southerly of the known veins and extracted a small tonnage. A large lode was located later (in 1907) about one-fourth mile to the northward of the foregoing, and has been worked (from 1910 to 1912) to a depth of 150 feet by the Nova Scotia Manganese Company. At this depth, levels have been run 140 feet west, and 53 feet east of the shaft, and the existence of a considerable ore-body has been proved. Only about 500 tons of ore is stated to have been extracted, most of which still remains at the mine. The quantity in sight is estimated at about 5,000 tons. Work on the property ceased a couple of years ago, various factors combining to put a stop to operations; one of the chief being the distance the ore has to be hauled (20 miles to Windsor and 29 miles to Chester Basin) to a shipping point, and the lack of a good road. The Company has erected a large mill building at the mine, and partially equipped it with dry-concentrating machinery, which yields three sizes of product. The building is also designed to accommodate wet-concentrating machinery, which, however, has not yet been installed.

Pyrolusite or manganese dioxide, is used in considerable quantities in electric dry batteries; as a colourizer and decolourizer of glass, porcelain, bricks, and enamels; and as a dryer in varnish manufacture. It is also used, but to a decreasing extent, in the manufacture of oxygen, and it is employed in the chemical trade in the preparation of various manganese salts. Pyrolusite contains, theoretically, 60 to 63 per cent of manganese; but ores running as low as 35 per cent are considered "commercial" for the steel trade. The high grade mineral is not much used as a source of the manganese employed in steel manufacture, as the lower grade ore can be obtained more cheaply, and answers the purpose sufficiently well. Market quotations for ore for this purpose are usually for 40–49 per cent mineral.

The New Ross pyrolusite contains about 58 per cent metallic manganese, and 85–90 per cent MnO_2. This degree of purity is the average of most Canadian manganese ores. The mineral is, manifestly, more suitable for the arts than for steel manufacture.

The domestic consumption of high grade pyrolusite is insignificant (less than 20 tons), and consequently the home market has not offered much inducement for any active development of the Maritime deposits. About 1,300 tons of imported lower grade is used, the greater portion of which goes to the dry battery and glass makers. The opportunity for the owners of Canadian deposits to benefit by the cutting off, by the war, of Russian and Indian manganese supplies to the American market has been nullified by the placing of manganese and manganese ores on the prohibited exports list. There would, however, appear to be no reason why the high grade domestic ore cannot take the place of the lower grade imported mineral, for use in the battery, glass, and varnish trades.

TALC.

There are two talc producers in Canada, both in Hastings county, Ontario, at Madoc and Eldorado, respectively, and the greater part of their output is milled locally. Mines and mills were in active operation at the end of 1914, and the year 1913 saw a record output of over 12,000 tons. Both the above deposits are said to contain plenty of talc in sight.

The earlier exploited of the two deposits is the Henderson, on lot 14, concession XIV, township of Huntingdon. Here, the talc occurs in a series of overlapping, more or less upright, lenses, the greatest width of the talc body being about 60 feet. A depth of 250 feet has been reached in the workings, and the mineral is extracted by the square set system and caving. Most of the output is sent to the mill at Madoc, operated by Geo. H. Gillespie and Company; and a small quantity is shipped crude to the United States. Five grades of product are prepared at the above mill, which employs fifteen hands.

The Eldorado deposit—on lots 20 and 21, concessions IV and V, of Madoc township—lies a few miles north of the foregoing, and was opened up in 1911 by the Canadian Talc and Silica Company (now Eldorite, Ltd.). Two shafts have been sunk, 100 and 150 feet deep, respectively. The talc, here, contains rather a large admixture of quartz, which occurs throughout the talc body in small lenses, and has to be cobbed out.

In 1912, a mill was erected, capable of handling 50 tons of product per diem, and has since been in continuous operation.

The same Company has also carried out some development work on lot 15, concession XIV, of Huntingdon, adjacent to the Henderson mine, but has not operated there since 1913.

In addition to the above-mentioned occurrences, talc bodies are found in the province of Quebec, Brome county, on lot 26, range II; lot 24, range VI; and lot 24, range VII, of Bolton township; and on lot 28, range V, of Potton township. A small shipment was made from the second named, in 1871, but most of the material is stated to be dark coloured, and mixed with magnesite.

Talc is used in papermaking; in toilet powders and soaps; for dressing textile fabrics; as a filler in rubber goods, and in enamel paints, composition flooring, etc. Massive talc, or soapstone. is employed cut into various shapes and sizes for stove linings, acid tanks, switchboards, wash tubs and other purposes.

The mineral is used by 170 firms in Canada, the consumption representing over 4,000 tons of domestic, and 750 tons of imported goods.

TUNGSTEN.

Hübnerite float has been found at several localities in Nova Scotia, amongst others near Northeast Margaree, in Inverness county. Wolframite is recorded from various of the gold mines in British Columbia; and Dr. Walker, of Toronto University, has found it, also, in New Brunswick. These occurrences, however, are of little or no economic value, and have never been worked.

More attention has been paid to the mineral scheelite (calcium tungstate), which exists in the form of float at a number of localities in Nova Scotia. It has been found, also, in Ontario, Quebec, and British Columbia, though the latter occurrences are of no economic importance.

In Nova Scotia the most important scheelite locality is Moose river, in Halifax county; the mineral has been found, also, at the Caribou gold mines, north of Moose river; at the Molega gold mines, in Queens county; and near New Ross, in Lunenburg county.

The Moose River occurrence is the only one that has received any serious attention, and the venture, unfortunately, has resulted in failure. Development of the scheelite-arsenopyrite-quartz veins was commenced in 1910, and continued until 1913, by the Scheelite Mines, Ltd. A concentrating plant was erected, and in 1912 a shipment of 14 tons of scheelite concentrates, carrying 72 per cent tungstic acid, was made. The hopes that the scheelite content of the veins would persist in depth were, however, not realized, and all operations were suspended in 1913, owing to lack of ore. Although surface indications were regarded as quite promising, undue importance was certainly attached to the occurrence, which was also the case with the Molega and New Ross discoveries. The latter is never likely to prove more than merely an interesting mineralogical association of tin, tungsten, and other minerals in very small quantity, and the prominence given to it in various reports and technical journals, etc., is to be regretted, since it has given the impression that the above minerals occur, possibly, in economic quantities, which is not the case.

There is no probability that tungsten will be found in paying quantities in the areas mentioned above, nor can it be regarded as likely that economic deposits of tungsten minerals will be discovered within the Dominion.

Tungsten is used in hardening steel and for electric light filaments, while tungstic acid is utilized in weighting silk and fireproofing textile fabrics. The domestic consumption is negligible.

III.

INVESTIGATION OF THE SAND AREAS OF THE PROVINCE OF QUEBEC.

L. Heber Cole.

During the field season of 1914, the writer, with Mr. J. Ross Taylor as assistant, was engaged in the study of the sands and sandstones of the province of Quebec, with a view to determining their suitability for use in the building and manufacturing industries. In this investigation special search was made for sands suitable for glass manufacture and for foundry purposes.

The field work was carried out as follows: the sand areas to be investigated were first traversed hurriedly, by driving and walking, in order to map out the various boundaries. These boundaries were, generally, located easily and with sufficient accuracy, from the main and cross roads. Wherever the roads were far apart, the boundary was determined by means of a compass and pacing traverse; and where the boundary was not clearly defined on the surface, a series of test-holes were drilled on a line at right angles to the supposed boundary, and from these borings the limits of the sand areas were determined. After the boundaries were located, all the sand pits were thoroughly examined and sampled, as also were any other exposures, such as railroad cuts, river banks, etc., which afforded a favourable opportunity for investigation. In addition to the above samples, others were taken at different parts of the areas by boring a 6-inch hole with an auger drill to a depth, wherever possible, of 20 feet. Five-pound samples were taken, except in the case of a possible moulding sand, when an 80-pound sample was obtained.

A rough analysis of the sand in the various areas was made in the field, by washing, to determine the amount of silt; and with a magnet to determine the percentage of magnetic material.

The district first investigated was that situated between the St. Lawrence and Ottawa rivers, and the eastern boundary of Ontario; after which the district north of the Ottawa and St. Lawrence rivers, between a point 7 miles west of Lachute and as far east as Grand Mère, was examined. An investigation was also made of the sands exposed on either bank of the St. Lawrence river between Montreal and Quebec, as well as of the sands from the bottom of the river, when obtainable.

None of the sands examined gave promise of being suitable for the manufacture of glass; and only three samples were obtained which gave indications of being adapted for foundry work. Several samples of crushed sandstone were obtained with a view to determining their suitability in the glass-making industry; the remainder were taken in order to test their value for building purposes.

Some 150 samples were obtained and shipped to Ottawa, where it is intended to subject them to a series of tests to determine the class of work for which they are best suited.

The investigation is to be continued during the season of 1915.

IV.

BITUMINOUS SANDS OF NORTHERN ALBERTA.

S. C. Ells.

The work of the past season was a continuation of that of the preceding year. In 1913, a brief reconnaissance of the deposits of bituminous sand was undertaken. As a result of that reconnaissance, the writer considered that indications warranted a practical test of the bituminous sand as a possible paving material. The selection and mining of a trial shipment constituted, therefore, the chief feature of the past season's field work. As in the previous year, the work was unfortunately handicapped by a short field season, a consideration which adversely affected the efficiency of the party.

In the selection of a trial shipment of bituminous sand for experimental purposes, very considerable care was required; more particularly in an entirely undeveloped and unproven field. This fact had been emphasized by the results of the reconnaissance of the previous year, and, in a report prepared at that time, various outstanding features were briefly alluded to[1].

In the preliminary reconnaissance work already referred to, wide variation in the grading of the mineral aggregate was clearly recognized. This variation characterized not only separate outcrops, but was also observed within comparatively narrow limits in individual outcrops. Similarly, it was early recognized that very considerable variation would be found in the percentage of the bitumen content. Unimpregnated partings of clays, lignitic particles, gravel, and other undesirable material, constituted another feature to be carefully considered.

During the field season of 1913, and over an area exceeding 750 square miles, upwards of 250 separate outcrops of bituminous sand had been noted. In view of the considerations stated above, a certain degree of care was required in the selection of the point, or points, from which material might best be taken for demonstration purposes.

At the outset, it was possible to eliminate a number of the recognized outcrops from further consideration. In so doing, the results of the analyses of samples secured in 1913, and obvious transportation difficulties in handling a trial shipment like that contemplated, served as a basis.

In mining a trial shipment, it was deemed desirable that the outcrop or outcrops selected should be such as might, later on, lend themselves to development on a commercial scale (Plates VI, VII).[2] Any results obtained through the use of material from unworkable deposits might obviously convey an entirely wrong impression as to the probable economic value of the deposits as a whole.

In undertaking the examination of those deposits which appeared to conform to the requirements determined upon, the overburden, when present, was first removed by pick and shovel, supplemented, at times, by the use of explosives (Plates I, II, III). Specially designed augers[3] (Plate IX) were then sunk to the required depth, in 12 to 14 foot lifts, and an accurate core sample thus obtained. The entire core was then placed in a rotary mixer, and thoroughly mixed. An 8- to 10-pound sample was then taken from the mixer, and gently warmed in a large iron pot. As the material became softened, it was further mixed by constant agitation with a large metal spoon. Finally, a sample of 150 to 250 grams was taken for analysis. In certain cases where, for various reasons, core samples could only be obtained with considerable difficulty, a fresh vertical section of the outcrop was exposed by the use of pick and shovel. Along this section, small samples were then taken at intervals of about 4 inches, and to a depth of about 3 inches. In this work, a small circular cheese scoop was used, with satisfactory results. In such cases, as with the auger cores, the various fragments were combined, mixed, and the small sample secured for final determination.

As the result of a series of tests made in the writer's laboratory in Ottawa, it had been found that bitumens extracted from samples of bituminous sand from various parts of the McMurray area did not materially differ in their chemical and physical

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[1] Preliminary Report on Bituminous Sands of Northern Alberta.

[2] In choosing the outcrops from which bituminous sand was eventually taken, it has been assumed that they are adapted to commercial development. Only careful and systematic prospecting with suitable equipment will, however, definitely determine their true value.

[3] For complete descriptions see Preliminary Report on Bituminous Sands of Northern Alberta.

characteristics. Consequently, the only tests made in the field comprised a careful grading of the mineral aggregate, together with a determination of the approximate percentage of the bitumen content. In this work, but little apparatus was required. The weighed samples were placed in tall copper beakers, covered with benzol, and agitated. Bitumen and solvent were then carefully decanted through filters; the process of adding solvent, and decanting, being repeated until only the clean mineral aggregate remained. The sand recovered on the filter papers, together with that still remaining in the beakers, was then dried and weighed, and the percentage of the bitumen content determined by calculation. Allowance was also made for the presence of mechanically combined moisture, the correction applied being the average result of careful tests of a number of samples previously determined in the Ottawa laboratory. The dried sand was then carefully graded through a complete set of standard sieves. A sand scale, checked by the use of an accurate balance, was used in all weighings.

In this manner some 72 samples were tested during the field season. The following results of samples taken from the more important outcrops furnish the most accurate information available at the present time, and probably represent fairly well the general character of the bituminous sands of the whole McMurray area:—

Number and Origin of Sample.	Miles from mouth.	Passing Mesh.										Percentage of bitumen content.
		200	100	80	50	40	30	20	10	Over size.	Clay lignite etc.	
No. 1. Horse creek	1·5	6	61	13	19	....	....	....	....	....	....	16
2. " "	1·5	3	60	14	22	....	....	....	....	....	....	16
3. " "	1·5	7	52	22	16	1	....	....	....	....	....	15
4. " "	2·5	5	41	12	40	1	....	....	....	....	....	14
5. " "	3·7	8	33	5	55	1	1	....	....	....	....	11
6. Athabaska river	....	9	55	6	22	1	1	....	2	2	....	16
7. East side ½ mile south of	....	7	11	3	43	16	10	5	2	....	....	14
8. McMurray	....	4·5	43·5	6	44	1	·5	....	....	....	....	15·5
9. Athabaska river, Howard claim	....	4	5	1	9	11	16	26	30	5	....	14
10. Athabaska river, Murphy claim	....	2	4	1	6	7	16	35	29	1	....	13
11. Athabaska river, 6·5 miles below Pierre au Calumet	....	2	24	9	60	4	2	....	....	....	....	12
12. Hangingstone creek	2·5	1·5	4	2	64	25	4	....	....	....	....	14·5
13. " "	2·7	6	13	2	72	2	3	....	....	....	....	15
14. " "	3·4	5	21	1	39	19	4	8	....	....	....	15
15. " "	3·9	5·5	24	5	61	1	·5	1	....	....	....	10
16. Clearwater river	1·5	3	7	3	57	8	9	6	5	....	....	15
17. Steepbank river	3·8	2·5	8	2	39	15	8	8	8	8	....	14
18. " "	4·3	7	4	1	12	10	17	27	22	....	....	15
19. " "	4·8	3·5	3	2	80·5	6·5	2	2	....	....	....	16
20. " "	5·5	3	9	1	33	31	14	6	1	....	....	14·5
21. " "	7·1	3	14	2	72	5	5	1	....	....	....	16
22. " "	7·5	2	11	5	78	4	2	1	....	....	....	17
23. " "	8·5	5	33	2	43	7	4	2	....	....	....	16
24. " "	10·5	3	8	2	25	16	20	16	9	....	....	14
25. " "	....	3	6	13	15	21	14	18	8	....	....	11
26. Muskeg river	7·5	7	10	1	27	20	16	10	6	....	....	8
27. McKay river	·6	1	20	3	67	5	....	....	....	....	2	14
28. " "	9·1	2	45	6	37	3	....	....	....	....	6	13
29. " "	11·0	5	55	13	16	6	....	....	....	....	5	15
30. " "	11·4	3	39	4	35	8	....	....	....	....	8	15
31. " "	12·9	6	53	8	8	2	....	....	....	....	19	14
32. " "	14·6	2	18	4	70	1	....	....	....	....	2	15
33. " "	17·8	2	21	4	55	15	2	....	....	....	....	14
34. " "	19·3	2	62	14	17	1	....	3	....	....	....	11
35. Moose river	3·5	4	21	41	15	8	6	4	1	....	....	11
36. " "	3·4	9	42	5	30	6	2	2	1	....	1	11
37. " "	5·6	10	77	5	6	1	....	....	....	....	....	12
38. " "	6·1	4	32	6	50	4	....	....	....	....	4	12
39. " "	6·1	12	57	7	19	1	2	....	....	....	....	13

From a scrutiny of the above table, the difficulty of obtaining a sand that will conform to standard specifications for sheet asphalt will at once be seen. It was, therefore, decided to combine material from two outcrops in such a proportion that a close approximation to the desired grading would be secured. Approximately, 57 tons of bituminous sand were then mined, sacked, and stored. (Plates II, VIII.)

It is hoped that during the winter and spring of 1915, this shipment will be transported to Edmonton, for the purpose of laying a small section of experimental pavement for demonstration purposes.

Finally, it may be added that the work of the past season has confirmed, in general, conclusions already stated in the writer's report on work of the previous year. In that report the following statement appeared:—

> ". . . In the McMurray district there is thus a very large body of bituminous sand, the prospecting and development of which will be confined to stream valleys. Only after careful exploration by means of adequate equipment can the true value of any deposit be affirmed. Nevertheless, owing to heavy overburden (Plate V) and lack of uniformity in the quality of the bituminous sand, it is probable that quite 80 per cent of the exposures may be eliminated from further consideration at the present time. Considerations affecting transportation will still further reduce the remaining number. Certain of the outcrops should, however, lend themselves to development on a commercial scale."

In considering the derivation of by-products from bituminous sands, the possibility of extracting nitrogen at once suggests itself, and the writer has been frequently asked whether the bitumen content might be considered as a possible source of ammonium. In Scotland, at the present time, the success of the oil shale industry depends largely on the chief by-product, namely, sulphate of ammonia. The ultimate composition of representative samples of Broxburn shales gives nitrogen from 0·54 to 0·94 per cent. This nitrogen is derived from organic matter in the shales, and when converted into ammonium corresponds to 57—59 pounds of ammonium sulphate per ton of shale.

The nitrogen contained in two samples of bitumen extracted from the Alberta bituminous sand was determined[1] to be 0·3 to 0·4 per cent. It should be remembered, however, that in the case of the Scotch shales the percentage of nitrogen as stated is based on one ton of shale as mined. In the case of the Alberta sands, the percentage of nitrogen is based on the extracted bitumen only. Assuming that the extracted bitumen represents 15 per cent by weight of the crude bituminous sand, it will be seen that the nitrogen that could be derived would thus be equivalent to 0·045 to 0·06 per cent of the crude bituminous sand. Such a meagre percentage of nitrogen renders its utilization entirely out of the question.

During the course of the season's work, fragments of iron ore float — up to 15 pounds in weight — were found at a number of points on Steepbank and Moose rivers. At a point on Steepbank river, 4·9 miles from the mouth, two small excavations, 40 feet apart, were made in the northeast bank. In each instance a thin capping of bituminous sand overlies a compacted bed, one to two feet in thickness, and made up of fragments of siderite up to 20 pounds in weight. These fragments are not waterworn nor pitted as would be the case with float that had been carried any distance. A bed of clay, one to four feet in thickness, underlies the iron ore, and itself rests upon well bedded Devonian limestones.

A representative sample of the iron ore analysed by Mr. H. A. Leverin gave:— iron, 35 per cent; insoluble, 18 per cent. So far as the writer's limited observation has gone, this deposit has no economic value.

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[1] Determination by E. Stansfield.

It may be added that clay ironstone, in the form of impure siderite, has a fairly wide distribution, in association with rocks of Cretaceous age, in the western provinces of Canada. In some instances the deposits appear to be due to a silting out of the fragments of ore from the softer rocks of the formation. In no instance, however, have beds of economic importance been discovered in this area.

Samples of mineral water were also secured at four points in the McMurray district. These samples were submitted to the Division of Chemistry for analysis,[1] with the following results:—

No. 1. Overflow from casing-head of No. 1 well, Athabasca Oils, Ltd., Athabaska river.

No. 2. Overflow from casing-head of "Salt of the Earth" well. Sunk by A. von Hammerstein, on west bank Athabaska river, 1 mile north of McKay.

No. 3. From largest spring at La Saline lake.

No. 4. Overflow from casing of well drilled by Fort McKay Oil and Asphalt Company, at La Saline (August, 1914).

RESULTS OF ANALYSES.

	No. 1.		No. 2.		No. .		No. 4.	
	Parts per million.	Grm. per Imp. gallon.	Parts per million.	Grm. per Imp. gallon.	Parts per million.	Grm. per Imp. gallon.	Parts per million.	Grm. per Imp. gallon.
Ca	1638	109·5	1347	832·0	1821	121·1	3354	204·1
Mg	385	25·7	585	36·1	571	38·0	1021	62·1
K	296	19·7	336	20·7	496	33·0	192	11·6
Na	22988	1537·6	76268	4720·0	21184	1409·0	84076	5117·7
HCO_3	469	31·3	372	22·9	530	35·0	36·0	2·1
CO_3	none.	none.	none.	none.	none.	none.	none.	none.
Cl	36188	2419·5	118636	7329·3	39792	2647·0	127960	7788·9
SO_4	4144	277·0	4920	304·0	4688	312·0	2956	179·9
Sp. Gr. at 15·5°C.	1·047		1·133		1·052		1·150	

On the conclusion of the season's work, the writer, accompanied by one man, returned to Edmonton, via Methye portage and Prince Albert, and an attempt was made to secure some definite information regarding other reported outlying deposits of bituminous sand. An assistant, Mr. C. R. Ritson, together with the remainder of the party, returned to Athabaska direct via the Athabaska river.

From time to time have appeared more or less unauthentic references to asphaltic deposits at or near the Upper Narrows on Buffalo lake, Sask., and in or near township 79, range 19, W. of the 3rd meridian. On both sides of the Narrows, small excavations were made by the writer, and former excavations were examined.

On the east side, only a few small fragments of bituminous sand float—none over two pounds in weight—were found. These fragments were of low grade, and evidently much altered by the action of water.

On the west side of the Narrows (Plate XI) what appeared to be low ledges of bituminous sand were found. A small amount of excavation showed these to be masses of float, the largest weighing, possibly, 5 to 8 tons. It is impossible to say whether the main body from which these masses were derived occurs near by, or whether the bituminous sand has been transported a considerable distance. The

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[1] Analyses by Mr. N. L. Turner.

character of the material is similar to that found at McMurray. Careful enquiry among natives and settlers between Methye portage and Ile à la Crosse failed to elicit any information regarding other local occurrences.

For the most part the country to the east and west of La Loche river, La Loche lake, and Buffalo lake, is low-lying; while the infrequent and limited sections exposed indicate the presence of a heavy blanket of glacial and post-glacial material. Everywhere there is a fairly heavy forest growth, consisting of poplar, birch, and spruce. To the west of Buffalo lake the ground rises gradually. Buffalo river, the largest tributary entering from the west, was ascended for some 28 or 30 miles, but no rock in place was seen. Under conditions such as the above, prospecting for bituminous sands will probably present considerable difficulty.

In ascending the Athabaska, Mr. Ritson made a hurried examination of an exposure of coal which outcrops through a distance of some 15 miles, on both sides of the river, above and below Grand Rapid. In passing down the Athabaska, in June, outcroppings of this seam, at a number of points, had been readily seen from the middle of the river.

According to Mr. Ritson, the seam lies just above the Grand Rapids sandstone, and varies in thickness from 3 to 15 feet. Owing to frequent and extensive clay and rock slides, a complete examination would necessitate considerable excavation.

It appears that the seam contains a large percentage of impurities, consisting principally of clay partings. Thin bands of fairly clean lignite from 1 to 2½ feet in thickness were, however, noted.

A sample taken from one of these narrower bands, and at a depth of 4 feet from the face, gave the following analysis[1]:

Moisture	3.2	per cent.
Ash	75.8	"
Volatile matter	13.8	"
Fixed carbon (by difference)	7.2	"

LABORATORY TESTS OF CLAY SAMPLES FROM MCMURRAY AREA.

Incidental to the investigation of the bituminous sands, small samples of clays were secured by the writer at a number of points in the McMurray area during the field season of 1914. In most instances the thickness and extent of individual beds could not be determined without an undue amount of boring and excavation. All the clays referred to, either immediately overlie the Devonian limestone, or are associated with the Dakota sands.

It is considered that the samples secured will indicate, fairly well, the general character of clays in that portion of the area referred to. At the same time it should be remembered that, in work of a purely reconnaissance nature, the samples taken represent only a small percentage of all deposits, and that prospecting of a more detailed nature may discover still other types of clays of economic value.

An excessive percentage of carbon is noted in the case of certain of the samples examined. Where the clay lies between the bituminous sand and the Devonian limestone, this contained carbon has been largely, if not altogether, derived from the overlying bituminous sand. It is probable that such contamination would materially decrease on working in from the outcrop.

In the following notes actual extent and thickness of overburden are not stated. To secure accurate data regarding this very important feature will require further detailed work in the case of each individual deposit. The question of transportation will also require careful consideration.

In considering a possible fuel supply, it may be stated that workable beds of coal have not, as yet, been found in this part of the province of Alberta. There is, how-

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[1] Analysis by E. Stansfield.

ever, a fairly large supply of birch and poplar along most of the streams. It appears possible that intelligent prospecting may discover fuel gas in commercial quantity.

All the laboratory work necessary for a full series of physical tests, in order to determine the industrial value of the clays, was done by the writer, under the direction of Mr. Joseph Keele, and comments on the results of the tests were written by him.

LOCATION, AND RESULTS OF TESTS OF CLAY SAMPLES.

Steepbank River.

Steepbank river enters the Athabaska from the east, 21·5 miles north of McMurray. Along both sides, frequent exposures of clays were observed throughout a distance of 17 miles from the mouth. Samples 302, 303, and 304 are from points 4·9, 4·2, and 2·3 miles, respectively, from the mouth. A small amount of excavation would uncover other outcrops in addition to those from which the above samples were taken.

The overburden along this stream will, in most instances, be very heavy.

Laboratory No. 302.—This is a grey, highly plastic, fine grained clay, requiring 28 per cent of water for tempering. It has good working qualities. The drying shrinkage is 8 per cent. It must be dried slowly to avoid cracking.

On burning to cone 010, a dense, steel-hard body is produced, having an absorption of 10 per cent, and fire shrinkage of 1·3 per cent. If burned to cone 06, the absorption is reduced to 4 per cent, but the fire shrinkage is too high, being 4·6 per cent.

Burning to higher temperatures produces bloating, unless the firing is done very slowly. The clay is intact at cone 3, and will probably stand a much higher temperature, but the presence of carbonaceous matter is a defect, and interferes with the development of a good product.

Laboratory No. 303.—This clay is light grey in colour, and rather calcareous. It requires 27 per cent of water for tempering; the working qualities are good; the wet body is fairly smooth and free from coarse grit. The clay can be dried as fast as desired after moulding, the drying shrinkage being 5·8 per cent. The following results were obtained on burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	25	Salmon
06	0	25	Pink
03	0	23	Buff
3	Fused.	....	....

This clay is suitable for the manufacture of common building brick, either by the stiff mud or soft mud process; but must be burned to cone 03 to secure the best results. It is a typical calcareous brick clay, which is used largely for the manufacture of clay products in many parts of Canada. The buff colour developed in burning is due to the presence of a high percentage of lime.

Laboratory No. 304.—This material evidently contains thin bands of limestone interbedded with the clay or shale. The limestone bands are not visible on the weathered outcrops, or in the talus at the foot of the bank, as they soften like the shale.

The numerous white particles seen in the red body of the material, after burning, are lime oxide. These particles will absorb moisture from the air, and, on swelling, break up the burned ware.

In the case of clay No. 303, the lime is in a very finely divided state, and consequently, harmless.

While this clay is not recommended for the manufacture of clay products, it may be useful for Portland cement, if some more limestone is added.

Muskeg River.

Muskeg river enters the Athabaska 31 miles north of McMurray. Samples 190, 305, 306, 308, and 309 were taken from points along the lower 4 miles of its course.

None of the beds from which samples were taken are exposed to a thickness that would warrant commercial development; and a considerable amount of exploration will be necessary to demonstrate their value. In certain instances, however, the thickness of overburden should not prove prohibitive, and transportation to the Athabaska presents no serious difficulties.

Laboratory No. 190.—From point on northwest shore of Muskeg river, between head of portage and mouth of river.

A light grey, very plastic clay, with good working and drying qualities. It burns to a cream coloured, dense, steel-hard body at cone 3, with a total shrinkage of 9 per cent, and softens when heated up to the temperature of cone 27. This is a good example of a stoneware clay, and is also a fire-clay. It is the most refractory clay at present known to occur in the province of Alberta.

Laboratory No. 305.—Light grey clay.

This clay has good plasticity and working qualities when tempered with 27 per cent of water. It is fairly smooth to the feel, and free from coarse grit. The shrinkage on drying is 8 per cent, and fast drying can be accomplished safely without cracking the ware.

The following results were obtained on burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	·7	11	Light red
06	4·0	4	Red
03	4·0	0	Dark red
3	Begins to soften.	....	....

This is a good, red burning clay, suitable for the manufacture of rough clay products, such as building brick and hollow block. The shrinkages are rather high, but this would be overcome by adding about 20 per cent of sand. This clay would also be useful for mixing with one of the higher grade clays in this vicinity for the manufacture of vitrified wares.

Laboratory No. 306.—This clay requires 37 per cent of water to bring it to a good working consistency. The effect of this large quantity of water is evident in the high drying shrinkage, which is 10 per cent.

A steel-hard, light red body is produced at cone 010, having an absorption of 12 per cent, and a fire shrinkage of 1·3 per cent.

When burned to a higher temperature, the colour is improved, but the fire shrinkage is too high. With the addition of 25 per cent of sand, this clay would be suitable for the manufacture of common brick.

Laboratory No. 308.—This is a red burning clay, similar to 306, but the shrinkages are not quite so high. When mixed with 25 per cent of sand and burned to cone 010, a good strong common brick can be made from it.

Laboratory No. 309.—This is another red burning clay, similar to 306 and 308, but the shrinkages in drying and burning are less than these.

It burns to a light red, steel-hard, dense body at cone 010, with a total shrinkage of 10 per cent. When mixed with about 25 per cent of sand, it could be used for common brick. It must be burned slowly on account of the carbon it contains. A test piece burned to cone 03 had a black core, and was bloated, owing to this cause.

McKay River.

The McKay river enters the Athabaska from the west, some 34 miles north of McMurray. Outcrops of clay were observed along the lower thirty miles of its course.

Samples 310, 311, and 312 were taken at points 11·2, 26·7, and 27·2 miles from the mouth.

Sample No. 311 represents a large deposit, the development of which should present no serious difficulty. Samples 310 and 312 represent deposits regarding the extent of which little can be stated, owing to slide and talus piles. In all three cases transportation to the Athabaska will present considerable difficulty.

Laboratory No. 310.—This clay requires 23 per cent of water to bring it to the best working consistency. It is very plastic, and smooth. The drying must be done slowly after moulding, to avoid cracking. The drying shrinkage is about 7 per cent. The results obtained in burning are as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	0	10	Buff.
06	1·4	8	"
03	3·0	3	"
1	3·4	2	Dark buff.
5	2·0	0	Grey.
15	Fused.		

This is one of the better grades of clay, with good working qualities, and shrinkages within commercial limits. It would be suitable for the manufacture of hard burned fireproofing buff face bricks, or sewer pipe. The drying qualities could be improved by the addition of a small percentage of ground-burned clay to the raw clay. It must be burned slowly.

Laboratory No. 311.—This clay requires 26 per cent of water for tempering. It has fairly good working properties, but the wet body is rather short on account of a considerable quantity of fine grained silt being present. It stands fast drying without cracking, after moulding.

Owing to its silty content, this clay has lower shrinkages than any of the red burning clays already described. It will make a good common red brick when burned to cone 010, but the colour and body are improved by burning to cone 06. It is overfired at cone 03.

Laboratory No. 312.—This is a low grade, red burning clay, which has several defects, such as cracking in drying and firing, and excessive shrinkages. It is useless for the manufacture of clay products.

Moose River.

The Moose river enters the Athabaska some 47 miles north of McMurray. Outcrops of clay were observed at intervals throughout the distance that this stream was ascended, namely 16 miles.

Samples 187, 191, 313, 314, 315, 316, 316A, and 317 were taken at points 6·8, 3·3, 6·75, 6·7, 6·6, 5·6, 1·3 and 2·2 miles respectively from the mouth. As elsewhere in the district, slide and talus obscured the greater part of each deposit. The largest single exposure was that from which sample 315 was taken. Here the clay has an exposed thickness of 16 feet, and an exposed length of 170 feet. What appears to be the same bed of clay re-appears some 700 feet below the outcrop from which sample 315 was taken.

Along the contact between the clay and overlying bituminous sand, fragments of pyrite float up to 15 pounds in weight, as well as pieces of carbonized wood, were found.

Laboratory No. 187.—Dark grey, nearly black clay, underlying bituminous sand.

This clay is very plastic, fine grained, and smooth. It works up rather stiff and slightly sticky. Dries very slowly, with a drying shrinkage of 6·5 per cent. This clay contains such a large percentage of asphaltic carbon, that it is very hard to burn without swelling, unless burned very slowly during the oxidation stage. The density of body, due to the extreme fineness of grain, interferes with the expulsion of carbon, so that the oxidizing process of this clay is tedious.

The clay burns to a light red colour at the lower temperatures, and to a buff or grey at higher. It vitrifies about cone 5, and is fused at cone 20.

This clay is of the stoneware type, but the carbon it contains is a detriment.

Laboratory No. 191.—From Moose river, interbedded between bituminous sand and Devonian limestone.

Dark grey, very plastic, smooth, fine grained clay of the stoneware type. Burns to a salmon coloured dense body at cone 3, with rather high shrinkage, and fuses at cone 18.

Laboratory No. 313.—This clay only required 14 per cent of water for tempering, owing to the presence of a large percentage of rather fine grained quartz sand. The plasticity and working qualities were low for this reason.

The drying shrinkage was only 3 per cent.

The following results were obtained on burning:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	0	8	Salmon.
06	0	8	Buff.
03	0	8	"
5	0	7	"
14	Begins to soften.		Grey.
18	Fused.		

As this clay is too sandy to use alone, a mixture was made by adding 50 per cent of a fat clay (315) from a near by locality. This gave a body with properties intermediate between the two extremes of a highly plastic clay with large shrinkage, and a lean clay with low shrinkage, so that the results obtained in working and burning were good. The air shrinkage was about 5 per cent. A steel-hard, practically non-absorbent body was produced at cone 1.

This mixture would probably be suitable for sewer pipe, or electrical conduits.

Laboratory No. 314.—This is a soft grey clay, with good plasticity and working qualities. Wares moulded from it will stand fast drying without checking.

The drying shrinkage is 6 per cent.

The following data were obtained on burning:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	0	12	Salmon.
06	1·0	9	"
03	2·3	5	"
1	3·4	1	Buff.
5	4·6	0	Grey.
9	Intact.		
14	Softens.		

This is a good material, the shrinkages are low, and it gives no trouble on burning. It would be useful for the manufacture of face brick, fireproofing, electrical conduits or sewer pipe.

Laboratory No. 315.—This is a soft grey clay, very plastic and smooth when tempered with water. It is rather stiff and hard to work, but its working qualities could be improved by the addition of some ground calcined clay, or 'grog' as it is termed in the clay-working industry.

The clay contains a certain amount of carbon, which will give trouble in burning unless this operation is done very slowly. It burns to a dense body at low temperatures, the colours being salmon to grey. It develops fire checks, and becomes brittle at higher temperatures.

Samples of 3-inch, round hollow tile were made from this clay and sent to a commercial sewer-pipe works for salt glazing.

Salt glazing test: This material came from the kiln with a uniform bright salt glaze of a rich light brown colour.

The body was vitrified but the shrinkage was rather high, showing the necessity for the addition of some coarse material.

The results of this test show that a fine salt glaze can be applied to this clay at cone 3.

Laboratory No. 316.—This clay requires 21 per cent of water to bring it to a working consistency. The plasticity is good, and the clay is smooth to the feel.

It must be dried slowly after moulding, as checking may occur if the drying is forced.

The drying shrinkage is 6 per cent, and the following results were obtained on burning:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	1·3	9	Salmon.
06	2·6	7	"
03	3·7	2	"
1	4	0	Grey.
13	Fused.		

This clay behaves well at all stages of burning up to cone 1, when it becomes vitrified. When burned to cone 3, the test piece showed blistering on the surface and a honeycombed body, but this may be due to raising the temperature too fast, because the clay does not actually melt until cone 13 is reached.

Laboratory No. 316A.—This is a light brown silty clay, with low plasticity, and poor working qualities.

It burns to a porous red body at low temperatures, and melts about cone 3.

The only use this clay would have in the clay-working industry is the production of an indifferent common building brick.

Laboratory No. 317.—Light grey clay, with slightly reddish tinge, requiring only 17 per cent of water for tempering. It is rather stiff in working when wet; the plasticity is good, and the clay is very smooth. The drying qualities were not tested, but they are probably good, owing to the small amount of water required to bring it to a working condition.

The drying shrinkage is 5 per cent, and the following results were obtained on burning:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	0	10	Salmon.
06	0	10	"
03	1	7	Buff.
1	1	6	"
5	2	3	Grey.
9	4	Vitrified.	"
16	Fused.		

This is a stoneware clay suitable for the manufacture of pottery, crocks, jars, teapots, etc. It would require some experimental work to fit the bodies with suitable glazes, but it is probable that the usual Bristol and slip glazes used for stoneware articles would answer.

Some 3-inch round hollow tile was made on a hand press, and sent to a commercial sewer-pipe plant for a salt-glazing test.

Salt-glazing test: The results of the salt glaze tests on this clay show that the glaze cannot be successfully applied at cone 3, as that temperature is too low. The body showed no sign of vitrification, being still porous and rather soft.

It would require a temperature in the kiln of at least cone 5, or better, at cone 6, to produce a glaze on this clay. It will then show a glaze equal to number 315, but of lighter colour. The commercial kiln in which the tests were made did not give a higher temperature than cone 3, hence it was impossible to complete the test on this clay.

Laboratory No. 318.—Is from the west bank of the Athabaska river, about 1½ miles south of the Moose river. The clay bed has a thickness of at least 9 feet, and appears to extend for a considerable distance. The overburden includes from 10 to 15 feet of low-grade bituminous sand, but does not appear to be of prohibitive thickness.

This is fine grained, highly plastic, rather sticky clay, requiring 25 per cent of water to bring it to the best working consistency. It must be dried slowly after moulding, to avoid checking. The drying shrinkage is 7·5 per cent.

It burns to a salmon coloured, steel-hard body at cone 010.

This clay contains a certain amount of carbon, which is expelled with difficulty during burning, owing to the fineness of grain and density of body, so that swelling ensues at higher temperatures unless burned very slowly.

Laboratory Nos. 319 and 320.—Are from the point near which the southerly boundary of the Murphy bituminous sand claim meets the east shore of the Athabaska river. Owing to the slide and talus, the thickness of the clay could not readily be accurately determined, but appears to be quite 20 feet. At the points from which the samples were taken the overburden appears to consist of from 10 to 20 feet of low grade bituminous sand. What appear to be extensions of the same bed re-appear along the river at intervals for one-third of a mile to the south of the point where samples were secured.

Laboratory No. 319.—A light grey, highly plastic and smooth clay, with good working properties. It must be dried slowly, being liable to check, if dried too fast. The drying shrinkage is 5·5 per cent.

The following results were obtained on burning:—

Cone.	Fire Shrinkage.	Absorption.	Colour.
	%	%	
010	0	11	Salmon.
06	0	10	"
03	·6	8	Buff.
1	1·3	6	"
5	2	5	Grey.
9	4	Vitrified.	"
17	Fused.		

This is a typical stoneware clay, suitable for the manufacture of all classes of stoneware articles, and pottery.

It is not a fire-clay, but may be sufficiently refractory for stove linings, boiler-setting blocks, or other purposes where extremely high temperatures would not be used.

This is one of the best clays of the series; it closely resembles No. 317, which is almost as good. It is not so refractory as No. 190, which stands up at the highest temperature of any of these clays.

Laboratory No. 320.—A highly plastic rather sticky clay, when wetted, being stiff and hard to work. It requires to be dried slowly after moulding. The shrinkage on drying is 9 per cent, which is rather too great.

It burns to a dull salmon colour and steel-hard body at cone 010. Considerable trouble is experienced when burning this clay at higher temperatures, on account of the carbonaceous matter it contains. It fuses about cone 4. Owing to the carbon, high shrinkage, and low fusibility, this clay is not of much value.

Laboratory No. 321 is from the west bank of the Athabaska river, at a point about 1½ miles north of the mouth of the Calumet. It rests on Devonian limestone, but has no capping of bituminous sand. The exposed face is over 300 feet long, and upwards of 40 feet in thickness. The overburden is relatively light.

This is a light yellow, highly calcareous clay, with rather low plasticity, so that the wet body is short and crumbly in working.

It burns to a very porous, chalky, buff-coloured body at cone 03, on account of the high percentage of finely divided lime it contains. This clay has little or no value.

Laboratory No. 188.—From east bank of Athabaska river, one-third mile above McMurray, Alberta.

A dark grey clay, exceedingly plastic, and smooth, smelling strongly of asphalt when damp.

It burns to a light red colour at a low temperature, becoming grey when heated up to cone 5, or thereabouts.

It fuses at cone 16.

Owing to its fineness of grain, and to the fact that it contains a certain percentage of asphaltic carbon, this clay is very hard to burn. It could not be used unless a certain amount of it were calcined, ground, and added to the raw clay. This would improve its working, drying, and burning qualities.

Laboratory No. 189.—Mottled, light red clay, from north bank of Firebag river, one-fourth of a mile above first rapid.

This is a very plastic and rather sticky clay. It burns to a red vitrified body at cone 3, but the shrinkages are rather high. It fuses about cone 10. This clay may be suitable for the manufacture of sewer pipe.

Laboratory Nos. 188, 189, 190, and 191 are alike in many of their physical characteristics, and appear to occur in the same geological horizon—viz., underlying the tar sands, on the Athabaska river, and its tributaries. They are very fine grained sediments, and low in fluxing impurities, No. 190 being exceptionally so, hence they are more refractory than any of the Cretaceous clays from the southern part of the Province.

The samples were too small in size to allow of complete determinations concerning their working and drying qualities, but they appear to be free from the drying defects so common to the western Cretaceous clays.

These clays are of the stoneware type, being exceedingly plastic, and burning to a light-coloured dense body at cone 5, while they retain their shape without softening when fired to much higher temperatures. Their most serious defect is due to the presence of asphaltic carbon, which renders the safe burning of wares made from them a difficult process, Nos. 190 and 191 appear to be free from this impurity, as far as could be told from the small samples, and these clays would be valuable for many purposes.

Up to the present time the possible value of the clays of this part of the Province appears to have been quite overlooked by prospectors and others. The results of the above tests, are, therefore, of interest, since they furnish the first authoritative statement regarding the class of clays to be found in an entirely new area. Given adequate transportation facilities, these results should encourage careful and detailed prospecting for the higher grades of clays in the northern portion of Alberta.

FUSING POINTS OF PYROMETRIC CONES REFERRED TO IN THIS REPORT.

No. of Cone.	Degrees Fahrenheit.	Degrees Centigrade.
010	1742	950
06	1886	1030
03	1994	1090
1	2101	1150
3	2174	1190
5	2246	1230
9	2390	1310
13	2534	1390
14	2570	1410
15	2606	1430
16	2642	1450
17	2678	1470
20	2786	1530
25	2966	1630
26	3002	1650
27	3038	1670

BUILDING AND ORNAMENTAL STONES OF CANADA.

W. A. Parks.

The field work carried on in the eastern Provinces in connexion with this investigation was confined very largely to quarries in actual operation, and to localities already mentioned as possible producers of building or ornamental stone. The slight importance hitherto attained by the building stone industry in the Prairie Provinces makes the above basis of investigation inapplicable. Further, the growing population of the west, and the demand for building material, render necessary a presentation of the subject which will embrace all possible sources of supply. With this end in view, the field work of 1914 was planned to include all the types of stone known to occur within the Province of Manitoba. It is manifest that all recorded exposures could not be visited—the shores of Lake Winnipeg alone would consume a field season, on such a basis; but it was thought advisable to visit all quarries without regard to the object for which they are operated, and to obtain material for testing from each of the geological formations exposed in the Province.

The above basis of investigation having been approved by the director, I left Toronto on June 1, and returned on August 22, having spent two months and three weeks on the work. In this time, the province of Manitoba was covered fairly well, although there are still a few places that it seems advisable to visit: the extension of the Hudson Bay railway should afford an opportunity to examine the rock cuts for a considerably greater distance to the north.

A building stone industry, *per se*, is carried on only at Tyndall, where three companies are actively engaged; but development work is being done by Mr. Joseph Bourgeault on a fine grained Silurian limestone near Broad Valley, on the Inwood branch of the Canadian Northern railway. It is proposed to market this stone under the name "manatobite" for purposes of fine building and even for decoration, as it is said to take a good polish. Other deposits to which attention has been directed as producers of building stone within the narrower meaning of the term are as follows:—

(1.) The sandstones at the base of the Trenton series exposed on the shores and islands of Lake Winnipeg. This stone is for the most part very soft and friable, but it has a remarkable tendency to harden on exposure.

(2.) Sandstones exposed in some of the ravines in the vicinity of Boissevain and Deloraine in the Turtle Mountain district. This stone is of fair quality, and has been used for building purposes.

(3.) Granite on the east side of Lake Winnipeg, particularly at Rabbit point, where claims have been staked. Fairly good reddish granite can be obtained here, but I observed none possessing the requisite features to lift in into the class of monumental granite.

(4.) A deposit of fine grained, bluish and whitish anhydrite, situated to the eastward of Gypsumville, in the northern part of the Province. The deposit appears to be of considerable size, and the stone is of fine appearance; but the application of anhydrite to purposes of decoration has not achieved much success.

The only serious production of building or ornamental stone is confined to the mottled Trenton limestone of Tyndall, already referred to. This stone occurs in heavy layers of uniform quality, although two types are recognized—the blue and the buff. The rock is quarried with facility; it can be easily worked, and its mottled aspect gives a characteristic appearance to the many fine buildings for which it has been used in

Winnipeg. This stone ranks high as a building material, and its fortunate occurrence near the city of Winnipeg makes up in large part for the dearth of high grade stone throughout the Province.

A large amount of stone is quarried in Manitoba for use in macadam and concrete; many of the quarries produce rubble incidentally, and in some cases building blocks are cut from the better layers. The more important of the quarries of this class are as follows:—

Corporation of the City of Winnipeg, Manitoba Quarries, Limited,	Upper Ordovician limestone at Stony mountain.
Manitoba Quarries, Limited, Winnipeg Supply and Fuel Co.,	Silurian limestones at Stonewall.
Manitoba Quarries, Limited,	Silurian limestones at Gunton.
Lake Winnipeg Shipping Co.,	Lower Trenton limestones at Big Island, Lake Winnipeg.
Lake Winnipeg Shipping Co.,	Gneiss on east side of Lake Winnipeg.
Canada Cement Co.,	Devonian limestone at Steeprock on Lake Manitoba.
Moosehorn Lime Co.,	Devonian limestone east of Moosehorn.
Bowman Coal and Supply Co.,	Devonian limestone at Oak Point, Lake Manitoba.

Trenton limestones are exposed at many points along the west shore of Lake Winnipeg. I observed none particularly suited for high grade building stone, but I was much impressed by the possibility of quarrying excellent flagstone.

The Devonian limestones of Lake Manitoba and Lake St. Martin appear to be very thin-bedded, and do not give much promise for the production of building blocks.

Silurian limestones are exposed at the north end of Lake Winnipegosis, at the Grand Rapids of the Saskatchewan, and on Cedar and Cross lakes. Some of this stone is heavily bedded, and would make excellent material for heavy engineering works, as its crushing strength is remarkably high. On the other hand it is hard and of a cavernous nature, which would seriously detract from its value as a building stone.

Many exposures of Devonian limestone occur on the shores and islands of Lake Winnipegosis. Considerable variation is to be observed in different localities both as to the quality of the stone and the nature of the bedding. While no stone eminently adapted to building purposes was observed, there is no doubt that possibilities of production exist at more than one locality.

Hard and reddish mottled Ordovician limestones occur along the line of the Hudson Bay railway, to the northward of Le Pas, and the same type of stone is encountered farther east in the vicinity of Fisher branch. This stone would make good rock-face work of rather unique appearance, but it is too hard and "plucky" for cut stone. Certain of the beds are mottled in red and grey, and possess sufficient hardness and fineness of grain to be susceptible of a good polish. They might be employed as marbles, but I fear that the ever-present tendency to plucking would militate against their use for this purpose.

The basal member of the Cretaceous series of this district—the Dakota sandstone—is exposed on the Red Deer river, and, according to Tyrrell, on the top of Kettle mountain, south of Swan lake. I have been unable to locate any outcrop presenting commercial possibilities.

Strata occur in Turtle mountain, in the south of the province, and include a basal sandstone, which makes a fair quality of building stone. It has been quarried for structural purposes near Boissevain and Deloraine.

ORE DRESSING AND METALLURGICAL DIVISION.

G. C. MACKENZIE,

Chief of Division.

I.

During 1914, the staff of this division has been augmented by the appointment of Mr. H. C. Mabee, to the position of chemist.

Messrs. W. B. Timm and C. S. Parsons continued to act in their positions as first and second assistant engineers, respectively.

In May, I returned from Nelson, B.C., where I had resided since October, 1913—while in charge of the zinc investigation for the Mines Branch.

During part of July and August, Mr. B. F. Haanel and I represented the Mines Branch in Hartford, Conn., during an experimental test run of the Johnson electric furnace. We were accompanied by Mr. C. S. Parsons, of this division, and Mr. H. A. Leverin, of the chemical division, who acted as assistants.

In October and November—as a member of the special committee to report on the condition of the iron industry in Canada—I made a lengthy tour of United States iron and steel plants, for the purpose of collecting information with respect to the use of beneficiated iron ores in that country. I also represented the Mines Branch at the annual meeting of the American Iron and Steel Institute, held at Birmingham, Ala., October 28 to 31, 1914.

Construction on the roaster building for the Ore Dressing Laboratories was started in April, and completed in July. Installation of the Wilfley roaster and equipment did not commence until November, owing to the delay of the manufacturers of the furnace in making shipment.

The roaster building consists of a light steel and corrugated iron building, 60 feet long by 20 feet wide, situated about 20 feet from, and at right angles to, the main testing laboratory.

The installations in this building will consist of an 8-foot Wilfley roaster, specially adapted for testing purposes, and a Dwight and Lloyd duplex sintering pan, mounted on trunnions.

The roaster and fans for the ore roaster and sintering pan will be driven by means of a 35-horse power stationary engine.

Additional installations have been made to the equipment of the Ore Dressing Laboratory, consisting of the following:—

One Plumb pneumatic jig, standard size.
One Plumb pneumatic jig, laboratory size.
One small, belt-driven air compressor, for supplying compressed air to the above.
Two James automatic ore jigs, mounted in tandem.
One laboratory apparatus for cyanide agitation tests.
One laboratory apparatus for minerals separation flotation.

The following ores have been tested, and reports made thereon, during the calendar year 1914:—

LIST OF ORES TESTED, 1914.

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No. of Test.	Ore.	Locality.	Shipper.	Weight.	
				Tons.	lbs.
21	Iron, magnetite	Flower Station, K. & P. R. R., Ontario............	Thos. B. Caldwell, Esq., Lanark, Ont	......	280
22	Zinc, calamine...........	Hudson Bay mine, Deer Creek, West Kootenay, B.C..............	P. F. Horton, Esq., Salmo, B.C.......	......	200
23	Iron, magnetite-hematite...	Groundhog, Ont., Algoma district................	Algoma Central & H.B.R.R Sault Ste. Marie, Ont....	15	
24	Aluminium, bauxite concentrate	Northern Aluminum Co., Shawenegan Falls, Que..	Northern Aluminum Co., Shawenegan Falls, Que..	......	500
25	Chromium, chromite	Province of Quebec........	Geological Survey, Ottawa.	....	200
26	Zinc, zinc blende...........	Notre Dame Mine Co., of Portneuf, Que..... ...	David A. Poe, Esq., Montreal, Que...............	......	200
27	Iron, copper, magnetite, chalcopyrite	Vancouver Island, B.C....	R. R. Hedley, Esq., Vancouver, B.C	.....	12
28	Phosphorus, iron tailings ..	Moose mountain, Sellwood, Ont...	Moose Mountain, Ltd., Sellwood, Ont..........	...	5
29	Titanium, ilmenite........	Canadian Mining and Exploration Company, Toronto, Ont..............	W. S. Girard, Esq., Toronto, Ont...	.....	200
30	Zinc, zinc blende......... ...	New Canadian Metal Co., Riondel, B.C...........	S. S. Fowler, Esq., Riondel, B.C........	......	240
31	Sulphur, iron pyrites. ..	Northern Pyrites Co., North Pines, Ont.....	Robt. K. Painter, Esq., New York....	.....	1,000
32	Zinc-lead-copper, zinc blende, galena, chalcopyrite..	Laurentide Mining Co., Notre Dame des Anges, Portneuf co., Que.......	Stanislas J. Pointon, Esq., Notre Dame des Anges, Que...................	......	4
33	Iron, magnetic iron sand..	Natashkwan, Saguenay co., Que..............	Mines Branch, Ottawa ...	35	

TEST No. 21.

IRON ORE.

A small shipment of 280 pounds of iron ore was received from Mr. T. B. Caldwell, Lanark, Ont. The ore was taken from the stock pile, and was supposed to be an average sample. The deposit is located on lot 22, concession IV, township of Lavant, county of Lanark, Ontario, near Flower station, on the Kingston and Pembroke railway.

The ore consists of a fine grained magnetite, massive, through which is disseminated fine pyrites, hornblende, and calcite gangue.

The ore was crushed to pass through a 100-mesh Sturtevant screen. A head sample was obtained by passing it through a Jones riffled sampler. The remaining material was emptied into a push feeder and fed automatically to the Ullrich four-pole magnetic separator. Wet separation was employed. The current strength on the machine was 4·5 amperes. Six products were obtained: four of concentrate (one from each ring of the machine) and two of tailing. The various products were dried, and samples taken for analysis. From the results obtained the table given below was compiled:—

Head sample analysis—

Insoluble	10.35 per cent.
Iron	58.6 "
Phosphorus	.048 "
Sulphur	.248 "

MAGNETIC CONCENTRATION OF MAGNETITE FROM FLOWER STATION, K. AND P. R. R., ONT.

Product.	Weight.		Percentage of crude ore.	Averaged Analysis.				Combined weight.		Percentage of crude ore.	Calc. Average Analysis.			
	lb.	oz.		% Insoluble.	% Fe.	% P.	% S.	lb.	oz.		% Insoluble.	% Fe.	% P.	% S.
Concentrate from No. 1 Ring..............	86	14	33·05	8·75	64·7	·023	·211	235	3	89·48	9·34	64·2	·022	·219
Concentrate from No. 2 Ring..............	81	2	30·87	8·67	64·7	·019	·212							
Concentrate from No. 3 Ring..............	60	0	22·83	8·76	64·9	·022	·220							
Concentrate from No. 4 Ring..............	7	3	2·73	28·91	48·1	·042	·369							
Tailing from Rings........................	12	14	4·90	71·43	9·7	·175	1·00	27	10	10 51	73·39	9·2	·183	1·05
Tailing..................................	14	12	5·61	75 11	8·7	·190	1·10							
Totals and averages....................	262	13	99·99	....	...	.....	.. ...	262	13	99·99	16 07	58·45	·039	·306

The units of crude required per unit of concentrate:—

$$\frac{64\cdot2-9\cdot2}{58\cdot45-9\cdot2}=1\cdot16$$

The percentage of iron in the crude saved in the concentrate:—

$$\frac{100 \text{ by } 64\cdot2}{58\cdot45 \text{ by } 1\cdot16}=94\cdot69 \text{ per cent}$$

Units of tailing made per unit of concentrate 0·16.

The percentage of iron in the crude lost in the tailing:—

$$\frac{100 \text{ by } 9\cdot2 \text{ by } 0\cdot16}{58\cdot45 \text{ by } 1\cdot16}=2\cdot17 \text{ per cent}$$

Tons of concentrate made per ton of crude=0·895.

Calculations of iron saved from actual weights and analyses:—

$$\frac{235\cdot2 \text{ by } 64\cdot2 \text{ by } 100}{262\cdot8 \text{ by } 58\cdot45}=98\cdot3 \text{ per cent of the iron in the crude saved in the concentrate}$$

$$\frac{27\cdot6 \text{ by } 9\cdot2 \text{ by } 100}{262\cdot8 \text{ by } 58\cdot45}=1\cdot7 \text{ per cent of the iron in the crude lost in the tailing.}$$

From the above table it will be noticed that the concentrate from ring No. 4 shows an analysis of insoluble, 28·91 per cent; Fe., 48· per cent; P., ·042 per cent; S., ·369 per cent. By raising this ring, a concentrate could be obtained similar to that from the first three rings. Four important adjustments of the separator on which the results of the test largely depend are the amount of the feed water used; the rate of feed; the distance of the rings from the feed, and the strength of the current on the fields. There was not sufficient ore to make accurate adjustments and obtain the best results. A run of this ore using the Grondal wet magnetic separator would give a comparative test of the efficiency of the two machines.

Test No. 22.

ZINC ORE.

A shipment of 200 pounds of ore was received from Mr. P. F. Horton, of the Hudson Bay mine, Salmo, B.C. The ore was taken from the mine workings, 166 feet below the surface.

The ore is a zinc silicate; associated with it are small amounts of, possibly lead silicate and considerable limonite. Analysis of the ore shows it to contain silver and gold in small quantities. The minerals are very closely disseminated, making it very difficult to obtain a separation.

Experiments were conducted to effect a wet concentration by the use of hydraulic classifiers, jigs, and Wilfley tables. A small amount of the fine limonite was washed away, raising the zinc content five per cent; and decreasing the iron content by a similar amount. With this one exception, no concentration was obtainable, due to the closely disseminated character of the mineral constituents of the ore, and to no marked difference in their specific gravity.

Experiments were also conducted to effect a dry separation on the Huff electrostatic separator. The results obtained were not satisfactory.

Electrostatic Separation after Flash Roasting.

Seventy pounds of the ore were taken, and crushed in the laboratory jaw crusher, set at ½-inch opening. The material from the crusher was passed over a 10-mesh Sturtevant screen, the oversize fed to rolls, set at ¼-inch opening, and passed over the

10-mesh screen. The oversize from this second screening was returned to the rolls, set at $\frac{1}{16}$-inch opening, and passed over the 10-mesh screen. The crushed ore through 10-mesh was sampled by passing it through a Jones riffled sampler. During this operation, it was noticed that a concentration had taken place, the oversize on the 10-mesh screen appearing to be a high zinc product, low in iron. This point is of importance in the dressing of the ore.

The crushed ore through 10-mesh was divided into two halves. One portion was given a flash roast, and sized on Sturtevant 16, 20, 30, and 50-mesh screens. The sized products were treated separately on the Huff electrostatic single roll separator.

Head Analysis before Roasting: Zn, 34·16 per cent; Fe, 10·7 per cent; Ag, 1·2 oz.; Insoluble, 24·50 per cent.

HEAD.

Sized Products.	Weight.		Percentage of roasted ore	Analysis.		Contents.	
	lb.	oz.		% Zn.	% Fe.	lb. Zn.	lb. Fe.
− 10 + 16....	9	0	28·51	43·30	8·0	3·897	0·720
− 16 + 20....	3	12	11·88	40·44	9·2	1·516	0·318
− 20 + 30....	4	5	13·66	39·00	10·0	1·683	0·432
− 30 + 50....	3	14	12·28	36·41	12·5	1·411	0·484
− 50	10	10	33·66	29·97	16·2	3·184	1·721
Totals and averages..	31	9	99·99	37·04	11·64	11·691	3·675

Loss in weight by roasting is, approximately, 3 pounds.

Analysis of roasted ore shows an increase of: Zn, 3 per cent; Fe, 1 per cent.

ZINC PRODUCT.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents.	
	lb.	oz.		% Zn.	% Fe.	lb. Zn.	lb. Fe.
− 10 + 16....	8	0	88·89	44·06	6·7	3·525	0·536
− 16 + 20....	3	0	80·00	43·06	7·3	1·292	0·219
− 20 + 30....	2	6	55·07	44·26	5·7	1·051	0·135
− 30 + 50....	2	10	67·74	40·44	8·3	1·134	0·218
− 50	8	14	83·53	29·58	15·8	2·625	1·402
Totals and averages..	24	14	78·81	38·70	10·1	9·627	2·510

Average analysis of zinc product: Zinc.. ...... 38·70 per cent.
Iron.. ...... 10·1 "
Recovery of zinc values in crude ore........... 82·3 "

IRON PRODUCT.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents.	
	lb.	oz.		% Zn.	% Fe.	lb. Zn.	lb. Fe.
− 10 + 16....	1	0	11·11	32·18	16·8	0·322	0·168
− 16 + 20....	0	12	20·00	29·78	19·0	0·233	0·143
− 20 + 30....	1	15	44 93	32·18	16·2	0·623	0·314
− 30 + 50....	1	4	32·26	25·96	22·7	0·325	0·284
− 50.........	1	12	16·47	24·96	22·3	0·437	0·390
Totals and averages..	6	11	21·19	29·01	19·4	1·940	1·299

Average analysis of iron product: Zinc.. .. .. .. 29·01 per cent.
Iron.. .. .. .. 19·4 "
Zinc values of crude ore in iron product.. .. .. .. 16·6 "

Magnetic Separation after Roasting in Reducing Atmosphere.

A portion of the ore through 10-mesh was given a reducing roast, and sized on a Sturtevant 40-mesh screen. The sized products were treated separately on the Ullrich magnetic separator.

Head Analysis before Roasting: Zn., 34.16 per cent; Fe., 10·7 per cent; Ag., 1·2 ounce; Insoluble, 24·56 per cent.

HEAD.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents.	
	lb.	oz.		% Zn.	% Fe.	lb. Zn.	lb. Fe.
+ 40..........	11	8	66·67	39·84	9·4	4·582	1·081
− 40..........	5	12	33·33	32·55	15·2	1·872	0·874
Totals and averages..	17	4	100·00	37·42	11·3	6·454	1·955

ZINC PRODUCT.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents.	
	lb.	oz.		% Zn.	% Fe.	lb. Zn.	lb. Fe.
+ 40.........	8	0	69·57	42·45	5·4	3·396	0·432
− 40........	3	0	52·18	36·20	7·0	1·086	0·210
Totals and averages..	11	0	63·77	40·75	5 8	4·482	0·642

Average analysis of zinc product: Zinc.. .. .. 40·75 per cent.
Iron.. .. .. .. 5·8 "
Recovery in zinc values in crude ore.. .. .. 69·4 "
Iron content of crude ore in zinc product.. .. .. .. 32·8 "

IRON PRODUCT.

Sized Products.	Weight.		Percentage of roasted ore.	Analysis.		Contents.	
	lb.	oz.		% Zn.	% Fe.	lb. Zn.	lb. Fe.
+ 40.........	3	8	30·43	33·80	15·8	1·183	0·553
− 40.........	2	12	47·82	26·16	12·4	0·719	0·341
Totals and averages..	6	4	36·23	30·43	14·3	1·902	0·894

Average analysis of iron product: Zinc........ 30·43 per cent.
Iron........ 14·3 "
Zinc content of crude ore in iron product ...... 29·5 "

From the tests conducted on this ore the following conclusions have been arrived at:—

First.—The mineral constituents of the ore being so intimately mixed, and the slight difference in their specific gravity, make it difficult to obtain a wet concentration by jigging and table concentration.

Second.—A concentration is obtained by sizing. It would probably not be advisable to make further separation of the sized products under 30-mesh.

Third.—By roasting, the water is driven off, the limonite is converted, in one case, into hematite, and in the other, into magnetite; hence the head samples of the roasted ores show an increase of approximately 3 per cent in zinc and 1 per cent in iron.

Fourth.—The greater portion of the iron content is contained in the material through 30-mesh. This proportion could probably be increased by roasting the lump ore and crushing afterwards. The particles of iron would not have the tendency to attach themselves to the zinc particles, which takes place in roasting the crushed material.

Fifth.—By careful manipulation and adjustment of the electrostatic separator, the separation of the material through 30-mesh could be improved upon. There was no marked difference in the appearance of the two products, and we were unable to have analyses made, as the tests were conducted to determine the grade of the products and adjust the separator accordingly.

Sixth.—Dry separation on this portion given the reducing roast was not adapted to this ore. A better separation could be obtained by wet magnetic separation. The fine zinc particles were drawn over with the iron. This would not occur to such an extent by wet separation, as was demonstrated by taking a portion of the iron product submerging it in water and pulling out the iron with a horseshoe magnet. A fine zinc product remained, representing approximately 50 per cent of the original portion experimented with in this manner.

Seventh.—A portion of the sized products was taken, submerged in water, and subjected to a violent agitation by a propeller. It was found that the iron content could be reduced to 10 per cent, with a considerable loss in zinc values, in washing off the iron.

Eighth.—A portion of the original shipment remains, on which a test will be made along the following lines, namely: the ore will be calcined to convert the iron into the ferric state, crushed to pass through 10-mesh, violently washed to free the iron from the zinc particles, and the entire product run through the wet magnetic separator.

TEST NO. 5.

Zinc Ore (Calamine) from Hudson Bay Mine, British Columbia.

This is a continuation of test No. 5, the results of which are contained in the Summary Report for 1913.

A portion of the ore was taken and crushed in the laboratory crusher and rolls to pass through a 4-mesh screen. The crushed ore was mixed with 5 per cent of its weight of powdered coal, and roasted to convert the non-magnetic iron oxide into the magnetic oxide. The roasted ore was washed to free the particles of iron and zinc adhering to each other, and the total product run through the Ullrich wet magnetic separator. The results obtained are tabulated below:—

MAGNETIC SEPARATION OF ROASTED ORE.

Current strength: 2 amperes at 60 volts. Distance of rings from feed plates = ¾ inch.

Product.	Weight pounds.	Percentage weight.	Analysis.				Contents.				Concentration.			
			per cent.			oz.	pounds.			oz	per cent.			
			Zn.	Fe.	Pb.	Ag.	Zn.	Fe.	Pb.	Ag.	Zn.	Fe.	Pb.	Ag.
Zinc	26·0	78·8	30·45	9·67	4·30	1·06	7·917	2·514	1·118	0138	90·0	57·4	57·9	95·2
Iron	2·8	8·5	17·00	30·66	6·45	0·50	0·476	0·859	0·181	·0007	5·4	19·6	9·4	4·8
Slime loss	4·2	12·7	9·57	23·88	15·05	....	0·402	1·003	0·632	....	4·6	23·0	32·7	
Heads	33 0	100·0	26·65	13·26	5·85	0·88	3·795	4·376	1·931	·0145	100·0	100·0	100·0	100·0

Tons of zinc concentrate per ton of crude=0·788.
Analysis of zinc concentrate=Zinc :—30·45 per cent.
" " Iron:— 9·67 "
" " Lead :— 4·30 "
" " Silver :—1·06 "

Recovery of zinc values of crude in zinc product.	=90.0	per cent.
Iron content of crude removed.	=42.6	"
Recovery of lead values of crude in zinc product.	=57.9	"
Recovery of silver values of crude in zinc product	=95.2	"

TEST No. 23.

THE CONCENTRATION OF LOW GRADE IRON ORES OF GROUNDHOG, DISTRICT OF ALGOMA, PROVINCE OF ONTARIO.

Introductory.

In the autumn of 1913, application was received by the Director of Mines Branch from Mr. John A. Dresser, manager of the Lands Department of the Algoma Central and Hudson Bay Railway Co., and of the Algoma Eastern Railway Co., asking for a series of tests on a shipment of iron ore from the Company's mining claims situated at Groundhog, in the District of Algoma, in the Province of Ontario.

As this ore represented a distinct class of which there are other similar occurrences in the province, the Mines Branch decided to make a series of tests on a carload of 15 tons of the ore, which was received in November, 1913.

The ore was taken from the surface of the deposit, and consisted of bands of magnetite, hematite, and jasper, the bands ranging from one-half inch in thickness down to a very small fraction of an inch. The shipment showed an average analysis of 35 per cent iron, with only traces of sulphur, phosphorus, and other impurities. It was therefore a question of raising the metallic content, and not one of the elimination of impurities.

On a 35 per cent Fe head analysis, it was found that the ore contained 26·5 per cent Fe as magnetite, and 8·5 per cent Fe as hematite, or 75·8 per cent of the iron content was in the form of magnetite, and 24·2 per cent was in the form of hematite. (This point is worked out in detail in the report.) Theoretically, the best possible extraction by magnetic concentration would be 75·8 of the iron content. This is supposing the magnetite and hematite particles to be free, which is the case with the ore, as these two minerals are in distinct bands. Should the magnetite and hematite particles occur closely associated with each other, it would be possible to obtain, theoretically, a higher extraction than 75·8 per cent of the iron content by magnetic concentration.

The banded structure of this deposit is shown clearly in the cross-section given below.

From this cross-section, drawn from a typical specimen, it will be noted that the magnetite occurs in some cases in bands almost pure, replacing the jasper, in others mixed with the jasper forming the band, and in other cases finely disseminated through the jasper band. The hematite occurs in very thin layers along the parting of the bands. Several other points are also noticeable: namely, coarse crushing will free the larger bands of magnetite from the gangue; but as these magnetite bands contain varying proportions of magnetite, a high concentration cannot be looked for. Coarse crushing will not free the thinner bands of magnetite, nor the hematite along the parting of the bands, as this hematite is, in most cases, firmly attached to one of the walls. All these points, which are demonstrated clearly in the concentration tests following, confirm the fact that, for a good recovery of the iron content in this ore, fine crushing or grinding is necessary. To what stage crushing and grinding should be carried is also demonstrated clearly in the concentration tests following.

Concentration.

The tests conducted were carried on under the following methods of procedure:—

(1) Coarse crushing, followed by dry magnetic concentration of the sized products; dry magnetic concentration of the re-crushed middlings from the coarser sizes; jig concentration of the dry separator middlings from the re-crushed middlings and from the finer sizes and table concentration of the fines.

(2) Coarse crushing, followed by jig concentration of the sized products.

(3) Coarse crushing, followed by fine crushing in rolls; dry magnetic separation followed by jig and table concentration of separator tailings.

The object of the first two tests was to determine whether a commercial and economic product could be obtained, suitable for blast furnace use, without fine grinding, which would necessitate briquetting or sintering. The latter two tests were conducted to determine the maximum recovery, and a comparison of results with the first two tests from which the feasibility of the various methods of concentration can be arrived at.

TEST No. 1.

Preliminary test by coarse crushing, sizing, dry magnetic concentration of sized products, dry magnetic concentration of re-crushed separator middlings from the coarser sizes, and jig concentration of separator middlings from re-crushed middlings, and from the finer sizes.

Approximately, 2 tons of the ore were taken and crushed in the jaw crusher set at 1-inch opening. From the jaw crusher the ore was elevated to the bins, from which it was fed automatically to a set of Sturtevant rolls, set at ½-inch opening. From the rolls it passed through a Vezin sampler set to cut out a sample of $\frac{1}{10}$ of the feed unto a Ferraris screen fitted with 1-inch and ¾-inch circular aperture screens. The oversize + 1 inch was re-crushed in the rolls, and passed over the screen until the entire lot, with the exception of the sample, passed through the 1-inch screen. From this operation the sizes — 1 inch + ¾ inch and — ¾ inch were obtained.

The Ferraris screen was fitted up with ½-inch circular punched and ¼-inch straight slot screens and the — ¾ inch material was passed over the screens, from which the sizes — ¾ inch + ½ inch, — ½ inch + ¼ inch and — ¼ inch were obtained. The screen frame was fitted up with ⅛ inch and $\frac{1}{16}$ inch diagonal slot screens, and the — ¼ inch material was passed over the screens, from which the sizes— ¼ inch + ⅛ inch, — ⅛ + $\frac{1}{16}$ inch, and — $\frac{1}{16}$ inch were obtained.

The following screen sizes were made for concentration on the dry magnetic separator:—

Screen.	Weight.	Percentage by weight.	Analysis.
Sizes.	Pounds.	Pounds.	% Fe.
−1″+¾″	570	19·8	35·05
−¾″+½″	772	26·8	33·75
−½″+¼″	579	20·1	34·40
−¼″+⅛″	404	14·0	35·00
−⅛″+$\frac{1}{16}$″	272	9·4	34·28
−$\frac{1}{16}$″	284	9·9	34·10
Totals	2,881	100·0	

Analysis of head sample from the Vezin sampler showed it to contain 35·10 per cent Fe.

The following deductions were made from the analyses of the screen sizes to determine the per cent Fe, as magnetite, and the per cent Fe, as hematite:—

Screen Sizes.	Weight.	Analysis.			Contents.		
		% Fe O.		% Fe_2O_3.	Fe O.		Fe_2O_3.
		% Fe.	% FeO.		Fe.	Fe O.	
$-1'' + \frac{3}{4}''$........	570	9·0	11·6	37·9	51·300	66·120	216·030
$-\frac{3}{4}'' + \frac{1}{2}''$........	772	8·8	11·3	35·1	67·936	87·236	270·972
$-\frac{1}{2}'' + \frac{1}{4}''$........	579	8·6	11·1	36·9	49·794	64·269	213·651
$-\frac{1}{4}'' + \frac{1}{8}''$........	404	8·6	11·1	37·7	34·744	44·844	152·308
$-\frac{1}{8}'' + \frac{1}{16}''$........	272	8·2	10·5	37·3	22·304	28·560	101·456
$-\frac{1}{16}''$............	284	8·5	10·9	36·6	24·140	30·956	103·944
Totals and averages...	2,881	8·685	11·176	36·736	250·218	321·985	1058·361

The atomic weight of Fe is taken at 55·9.

The atomic weight of O is taken at 16·0.

From the above table the average analysis shows the ore to contain 11·176 per cent Fe O and 36·736 per cent Fe_2O_3. Magnetite has a chemical composition of ($FeO.Fe_2O_3$), hematite has a chemical composition of Fe_2O_3. Therefore the 11·176 per cent FeO will require 24·839 per cent Fe_2O_3 leaving 11·879 per cent Fe_2O_3 as hematite. That is 8·685 per cent Fe + 17·378 per cent Fe = 26·063 per cent Fe occurs as magnetite and 8·311 per cent Fe occurs as hematite, giving a head analysis of 34·374 per cent Fe.

75·82 per cent of the iron content is in the form of magnetite.
24·18 " " " " " hematite.

From these deductions it will be seen that the maximum recovery of the iron content by magnetic separation, provided the particles of magnetite are entirely freed, is 75·82 per cent. The finer the ore is ground, the nearer the approach to this maximum recovery of the magnetite is obtained, but the greater the loss of hematite by sliming in the retreatment of the tailings from the magnetite separation. As the magnetite bands vary in their percentage of iron content, it is impossible to make a high grade magnetic product by coarse crushing, without losing a high percentage of the magnetite in the tailings. Fine grinding is necessary to free the hematite from the gangue; although too fine grinding permits a high loss of hematite values in slimes. These are points to be considered in the concentration of this class of ore.

Dry magnetic separation of the sized material, $1'' + \frac{3}{4}''$—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 30 " 110 "

Head sample,	Weight, 32 lb.	Analysis, 35·05 % Fe.
Concentrates,	" 93 lb.	" 48·90 % Fe.
Middlings,	" 288 lb.	" 32·70 % Fe.
Tailings,	" 51 lb.	" 20·90 % Fe.

Dry magnetic separator of the sized material—$\frac{3}{4}''$ + $\frac{1}{2}''$—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 30 " 110 "

Head sample,	Weight, 68 lb.	Analysis, 33·75 % Fe.
Concentrates,	" 160 lb.	" 48·70 % Fe.
Middlings,	" 445 lb.	" 31·15 % Fe.
Tailings,	" 87 lb.	" 21·50 % Fe.

Dry magnetic separation of the sized material, —$\frac{1}{2}''$ + $\frac{1}{4}''$—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 25 " 110 "

Head sample,	Weight, 4 lb.	Analysis, 34·40 % Fe.
Concentrates,	" 119 lb.	" 52·60 % Fe.
Middlings,	" 371 lb.	" 31·75 % Fe.
Tailings,	" 89 lb.	" 20·15 % Fe.

Run No. 2—Products mixed and run over separator—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 30 " 110 "

Concentrates,	Weight, 190 lb.	Analysis, 48·00 % Fe.
Middlings,	" 307 lb.	" 27·10 % Fe.
Tailings,	" 55 lb.	" 19·50 % Fe.

Dry magnetic separation of the sized material, —$\frac{1}{4}''$ + $\frac{1}{8}''$—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 20 " 110 "

Head sample,	Weight, 4 lb,	Analysis, 35·00 % Fe.
Concentrates,	" 75 lb.	" 54·90 % Fe.
Middlings,	" 238 lb.	" 33·20 % Fe.
Tailings,	" 75 lb.	" 20·90 % Fe.

Run No. 2—Products mixed and re-run over separator—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 25 " 110 "

Concentrates,	Weight, 121 lb.	Analysis, 51·40 % Fe.
Middlings,	" 206 lb.	" 28·35 % Fe.
Tailings,	" 43 lb.	" 20·35 % Fe.

Run No. 3—Products mixed and re-run over separator—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 30 " 110 "

Concentrates,	Weight, 145 lb.	Analysis, 49·64 % Fe.
Middlings,	" 163 lb.	" 26·86 % Fe.
Tailings,	" 40 lb.	" 20·04 % Fe.

Dry magnetic separation of the sized material—$\frac{1}{8}''$ + $\frac{1}{16}''$—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 15 " 110 "

Head sample,	Weight, 3 lb.	Analysis, 34·28 % Fe.
Concentrates,	" 37 lb.	" 57·22 % Fe.
Middlings,	" 140 lb.	" 37·58 % Fe.
Tailings,	" 86 lb.	" 23·40 % Fe.

Run No. 2.—Products mixed and re-run over separator—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 20 " 110 "

Concentrates,	Weight, 58 lb.	Analysis, 54·70 % Fe.
Middlings,	" 122 lb.	" 32·60 % Fe.
Tailings,	" 56 lb.	" 21·00 % Fe.

Run No. 3.—Products mixed and re-run over separator—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 25 " 110 "

Concentrates,	Weight, 87 lb.	Analysis, 52·2 % Fe.
Middlings,	" 104 lb.	" 28·6 % Fe.
Tailings,	" 42 lb.	" 19·0 % Fe.

Run No. 4.—Products mixed and re-run over separator—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 30 " 110 "

Concentrates,	Weight, 94 lb.	Analysis, 50·8 % Fe.
Middlings,	" 91 lb.	" 27·0 % Fe.
Tailings,	" 36 lb.	" 18·5 % Fe.

Dry magnetic separation of sized material, — $\frac{1}{16}$″—

This size was not run over the separator in conducting the preliminary test, but in the final test the following products were obtained, from which the separation can be figured:—

Current strength on rectifying magnets, 6 amperes at 110 volts.
" " drum " 20 " 110 "

Rate of feed, 1·875 tons per hour.

Head sample,	Weight, 67·5 lb.	Analysis, 35·67 % Fe.
Concentrates,	" 258·0 lb.	" 53·13 % Fe.
Tailings,	" 326·5 lb.	" 23·75 % Fe.

In the operations of the separator, the suction fan in connexion with the machine drew out 97 pounds of dust; the greater proportion of which was deposited in the dust collector.

Dry magnetic separation of re-crushed middlings.

The dry separator middlings — 1″ + $\frac{3}{4}$″ and — $\frac{3}{4}$″ + $\frac{1}{2}$″ were elevated to the ore bins from which they were fed to the rolls set at $\frac{1}{8}$″ opening. From the rolls the re-crushed middlings passed through the Vezin sampler unto the Ferraris screen fitted with $\frac{1}{4}$″ straight slot and $\frac{1}{8}$″ diagonal slot aperture screens. The dry separator middlings — $\frac{1}{2}$″ + $\frac{1}{4}$″ were elevated to the ore bins from which they were fed to the rolls set at $\frac{1}{16}$″ opening. From the rolls the re-crushed middlings passed through the Vezin sampler unto the Ferraris screen. A sample of 124 pounds was cut out by the Vezin sampler representing the average of the re-crushed middlings. The oversize from the $\frac{1}{4}$″ screen was passed through the rolls until all the material passed through the $\frac{1}{4}$″ screen apertures.

The screen frame was fitted up with $\frac{1}{8}$″ and $\frac{1}{16}$″ diagonal slot aperture screens, and the material passed over the screens from which the sizes — $\frac{1}{4}$″+$\frac{1}{8}$″, — $\frac{1}{8}$″+$\frac{1}{16}$″, and — $\frac{1}{16}$″ were obtained.

Head sample,		Weight, 124 lb.	Analysis, 32·1 % Fe.
Size	— $\frac{1}{4}$″ + $\frac{1}{8}$″.	Weight, 390 lb.	Analysis, 30·2 Fe.
Size	— $\frac{1}{8}$″ + $\frac{1}{16}$″.	Weight, 252 lb.	Analysis, 30·7 % Fe.
Size	— $\frac{1}{16}$″.	Weight, 206 lb.	Analysis, 31·5 % Fe.

Dry magnetic separation of re-crushed middlings. Size —$\frac{1}{4}$" + $\frac{1}{8}$"—

Current strength on rectifying magnets,	6 amperes at	110 volts.
" " drum	" 20	" 110 "

Head sample,	Weight,	... lb.	Analysis,	30·2 % Fe.
Concentrates,	"	27 lb.	"	52·6 % Fe.
Tailings,	"	256 lb.	"	34·4 % Fe.
Tailings,	"	108 lb.	"	21·7 % Fe.

The middlings from this run were re-passed over the separator, with the amperage on drum magnets increased to 30.

Concentrates obtained,	64 lb.	Analysis,	44·0 % Fe.
Tailings "	185 lb.	"	30·0 % Fe.

Dry magnetic separation of re-crushed middlings. Size —$\frac{1}{8}$" + $\frac{1}{16}$"—

Current strength on rectifying magnets,	6 amperes at	110 volts.
" " drum	" 20	" 110 "

Head sample,	Weight,	... lb.	Analysis,	30·7 % Fe.
Concentrates,	"	46 lb.	"	51·3 % Fe.
Middlings,	"	108 lb.	"	32·5 % Fe.
Tailings,	"	92 lb.	"	19·5 % Fe.

The middlings from this run were re-passed over the separator, with the amperage on the drum magnets increased to 30.

Concentrates obtained,	35 lb.	Analysis,	40·9 % Fe.
Tailings	70 lb.	"	29·1 % Fe.

The results obtained from the second concentration of the middlings show that this operation is not practical, so that the products were re-mixed to form the middlings from the first operation.

Dry magnetic separation of re-crushed middlings. Size —$\frac{1}{16}$"—

This size was not run over the separator in conducting the preliminary test, but in the final test the following products were obtained from which the separation can be figured:—

Current strength on rectifying magnets,	5 amperes at	110 volts.
" drum	" 23	" 110 "

Head sample,	Weight,	.. lb.	Analysis,	33·43 % Fe.
Concentrates,	"	64 lb.	"	50·95 % Fe.
Tailings,	"	99 lb.	"	24·45 % Fe.

JIG CONCENTRATION OF DRY MAGNETIC SEPARATOR MIDDLINGS.

Size, —$\frac{1}{4}$-inch + $\frac{1}{16}$-inch. Weight, 337 pounds—

The separator middlings from this size and from the re-crushed middlings of the coarser sizes, were mixed, sampled, and 40 pounds taken for a jig test on the laboratory Richard's pulsator jig.

Head sample,	Weight,	.. lb.	Analysis,	28·7 % Fe.
Tailings obtained,	"	30 lb.	"	21·9 % Fe.
Concentrates obtained,	"	10 lb.	"	51·7 % Fe.

Size, —$\frac{1}{8}$-inch + $\frac{1}{16}$-inch. Weight, 156 lb.—

The separator middlings from this size and from the re-crushed middlings of the coarser sizes were mixed, sampled, and 36 pounds taken for a jig test on the laboratory Richard's pulsator jig.

Head sample,	Weight,	.. lb.	Analysis,	27·3 % Fe.
Concentrates obtained,	"	9 lb.	"	51·6 % Fe.
Tailings "	"	27 lb.	"	19·4 % Fe.

Size, —$\frac{1}{16}$-inch. No test work was done on the separator tailings from this size in conducting the preliminary test, but in the final test these tailings were sized, the coarser sizes were jigged, and the fines treated on tables.

JIG CONCENTRATION OF DRY MAGNETIC SEPARATOR TAILINGS.

The separator tailings from the coarser sizes, —1-inch + $\frac{3}{4}$-inch; —$\frac{3}{4}$-inch + $\frac{1}{2}$-inch and —$\frac{1}{2}$-inch + $\frac{1}{4}$ inch were crushed in rolls set at $\frac{1}{16}$-inch opening and sized on Ferraris screens $\frac{1}{8}$-inch and $\frac{1}{16}$-inch. To the sizes obtained, were added the separator tailings, — $\frac{1}{4}$ + $\frac{1}{8}$-inch; — $\frac{1}{8}$-inch + $\frac{1}{16}$-inch and —$\frac{1}{16}$-inch. A portion of the sizes were taken for a jig test on the laboratory type Richard's pulsator jig.

Size, —$\frac{1}{4}$-inch + $\frac{1}{8}$-inch: 100 pounds were taken for a test on the laboratory jig.

Head sample,	Weight,	.. lb.	Analysis,	22·0 % Fe.
Concentrates obtained,	"	27 lb.	"	43·2 % Fe.
Tailings "	"	73 lb.	"	14·3 % Fe.

Size, —$\frac{1}{8}$-inch + $\frac{1}{16}$-inch: 71 pounds were taken for a test on the laboratory jig.

Head sample,	Weight,	.. lb.	Analysis,	20·2 % Fe.
Concentrates obtained,	"	20 lb.	"	36·5 % Fe.
Tailings "	"	51 lb.	"	13·7 % Fe.

Size, —$\frac{1}{16}$-inch: No further test work was done on this size. Analysis of tailing sample, 21·4 % Fe.

Analysis of Dry Magnetic Separator Concentrates, Middlings, and Tailings, from size —$\frac{1}{8}$-inch + $\frac{1}{16}$-inch to determine Magnetite and Hematite Contents.

Analysis of Concentrates: 18·0 % FeO; 52·7 % Fe_2O_3; 50·8 % Fe. The 18·0 % FeO requires 40·0 % Fe_2O_3 to form magnetite, 52·7 % Fe_2O_3 —40·0% Fe_2O_3 = 12·7 % Fe_2O_3 in form hematite. The oxides reduced to their metallic content give 13· % Fe as FeO, and 28·0 % Fe as Fe_2O_2 or 41·9 % Fe as magnetite and 8·9 % Fe as Fe_2O_3 in form of hematite, a total of 41·9 + 8·9 = 58·8 % Fe.

82·5 % of the iron content is in the form of magnetite.
17·5 % " " " hematite.

Analysis of Middlings: 57 % FeO; 32·3 % Fe_2O_3; 27·0 % Fe. The 5·7 % FeO requires 12·7 % Fe_2O_3 to form magnetite. 32·3 % Fe_2O_3 — 12·7 % Fe_2O_3 = 19·6 % Fe_2O_3 in form of hematite.

The oxides reduced to their metallic content give 4·4 % Fe as FeO and 8·9 % Fe as Fe_2O_3 or 13·3 % Fe as magnetite and 13·7 % Fe as Fe_2O_3 in form of hematite a total of 13·3 + 13·7 = 27·0 % Fe.

49·2 % of the iron content is in the form of magnetite.
50·7 % " " " hematite.

Analysis of Tailings: 2·4 % FeO; 23·7 % Fe_2O_3; 18·5 % Fe. The 2·4 % FeO requires 5·3 % Fe_2O_3 to form magnetite. 23·7 % Fe_2O_3 — 5·3 % Fe_2O_3 = 18·4 % Fe_2O_3 in form of hematite. The oxides reduced to their metallic content give 1·9 % Fe as FeO and 3·7 % Fe as Fe_2O_3 or 5·6 % Fe as magnetite and 12·9 % Fe as Fe_2O_3 in form of hematite, a total of 18·5 % Fe.

30·3 % of the iron content is in the form of magnetite.
69·7 % " " " hematite.

Table showing the distribution of magnetite and hematite in the products from the dry magnetic separation of the size, —⅛-inch + 1/16-inch

Concentration Products.	Weight.	Analysis.		Contents.		Percentages.				
		Magnetite FeO. Fe_2O_3.	Hematite Fe_2O_3.	Magnetite.	Hematite.	Magnetite of total Magnetite.	Hematite of total Hematite.	Magnetite of total Iron.	Hematite of total Iron.	Iron of total Iron.
	Pounds.	% Fe.	% Fe.	Pounds.	Pounds.					
Concentrates	94	41·9	8 9	39·386	8·366	73·6	32·8	49·9	10·6	60·5
Middlings	91	13·3	13·7	12·103	12·467	22·6	48·9	15·3	15·8	31·1
Tailings	36	5·6	12·9	2·016	4·644	3·8	18·3	2·5	5·9	8·4
Totals and averages	221	24·2	11·5	53·505	25·477	100·0	100·0	67·7	32·3	100·0

Run No. 2.—Final test by coarse crushing, sizing, dry magnetic concentration of the sized material, dry magnetic concentration of re-crushed separator middlings from the coarser sizes, jig concentration of the separator middlings from the re-crushed middlings and from the finer sizes and jig and table concentration of the middlings — 1/16-inch.

A total of 5,608 pounds of the ore were weighed out and crushed in the jaw crusher, set at 1-inch opening. The crushed ore was elevated by a bucket elevator to the ore bins. From the ore bins it was fed by an automatic push feeder through the rolls and Vezin sampler unto the Ferraris screen, fitted up with 1-inch and ¾-inch circular perforated screens. The head sample cut out by the sampler representing one-tenth of the feed was cut down by taking alternate shovelfuls. This sample gave an analysis of 34·00 per cent Fe.

The oversize + 1-inch was elevated to the ore bins, fed to the rolls set at ½-inch opening and passed over the screen until the entire lot passed through the 1-inch screen perforations. From the above operation two sizes were obtained, namely, — 1-inch + ¾-inch and — ¾-inch.

Size — 1″ + ¾″, was elevated to the bin, and run over the Gröndal dry magnetic separator, after first passing through a Vezin sampler, which cut out one-tenth of the feed.

Weight of size — 1″ + ¾″, 1,383 lb.
Weight of sample, 149·5 lb.
Current strength on rectifying magnets, 7 amperes at 110 volts.
" " drum " 26·5 " 110 "
Rate of travel of belt, 339 feet per minute.
Concentrations obtained, Weight, 148·0 lb.
Middlings " " 839·0 "
Tailings " " 207·5 "
In each case a sample of one-tenth was cut out for analysis
Head sample.—Weight, 149·5 lb. Analysis, 34·79 % Fe.
Concentrates sample, Weight, 14·8 lb. Analysis, 45·66% Fe.
Middlings " " 83·0 lb. " 34·89% Fe.
Tailings " " 20·7 lb. " 24·92% Fe.

The separation on this size was not good, so it was decided to crush finer. The concentration products were mixed together, and with the undersize of the ¾-inch screen were elevated and passed over the screen set of ¾-inch and ½-inch circular perforations, giving sizes + ¾″ — ¾″ + ½″ and — ½″. A sample was cut out by the automatic sampler, representing one-tenth of the feed as head sample of the run.

Weight of feed, 5,165 pounds.
Weight of sample, 516·5 pounds.

Sample was cut down to 123 pounds and the remainder added to the run. The oversize + ¾″ was crushed in rolls set at ¼-inch opening and passed over the screen set, until the whole passed through the ¾-inch screen perforations.

Dry magnetic separation of size — ¾″ + ½″.

Weight, 1,378 pounds.
Current strength on rectifying magnets, 4 amperes, 110 volts.
" " drum " 25 " 110 "
Rate of travel of belt, 339 feet per minute.
Results obtained not satisfactory.

Run No. 2.—Concentration products from run No. 1 were mixed and passed over separator again.

Current strength on rectifying magnets, 3·5 amperes, 110 volts.
" " drum " 29 " 110 "
Rate of travel of belt, 339 feet per minute.
Concentrates obtained, 253 lb.
Middlings " 844 lb.
Tailings " 147 lb.
Head sample, 134 lb. Analysis, 34·25 % Fe.
Concentrate sample, 13·5 lb. " 47·05 % Fe.
Middlings " 21·0 lb. " 32·35 % Fe.
Tailings " 4·5 lb. " 23·55 % Fe.

Run No. 3.—Weight, 1,205 pounds—

The concentration products from run No. 2 were mixed and passed again over the separator.

Current strength on rectifying magnets, 6 amperes, 110 volts.
" " drum " 30 " 110 "
Rate of travel of belt, 339 feet per minute.
Time of run, 13 minutes; rate of feed, 2·82 tons per hour.
Concentrates obtained, 250 lb.
Middlings " 898 lb.
Tailings " 57 lb.
Concentrates sample, 12·5 lb. Analysis, 48·85 % Fe.
Middlings " 15·5 lb. " 32·14 % Fe.
Tailing " 18·0 lb. " 22·83 % Fe.

The undersize from the ½-inch screen was screened on the ¼-inch screen (straight slot perforations) and the ⅛-inch and $\frac{1}{16}$-inch screens (diagonal slot perforations). This screening gave the following sizes:—

— ½″ + ¼″, 1,009 pounds.
— ¼″ + ⅛″, 1015 "
— ⅛″ + $\frac{1}{16}$″, 444 "
— $\frac{1}{16}$″, 749 "

Dry magnetic separation of size—½" + ¼"—

Weight, 1,009 lb.
Current strength on rectifying magnets, 3·5 amperes, 110 volts.
" " drum " 25 " 110 "
Belt travel, 339 feet per minute. Time of run, 30 minutes.
Concentrates obtained, 178 lb.
Middlings " 601 lb.
Tailings " 124 lb.
Head sample, 94 lb. Analysis, 34·20 % Fe.
Concentrate sample, 7 lb. " 48·55 % Fe.
Middling " 8 lb. " 31·10 % Fe.
Tailing " 5 lb. " 24·32 % Fe.

Run No. 2.—Weight, 883 pounds.

The concentration products from run No. 1 were mixed, and passed over the separator.

Current strength on rectifying magnets, 6 amperes, 110 volts.
" " drum " 25 " 110 "
Belt travel, 339 feet per minute. Time of run, 10 minutes.
Concentrates obtained, 161 lb.
Middlings " 676 lb.
Tailings " 50 lb.
Concentrate sample, 6 lb. Analysis, 50·64 % Fe.
Middling " 4 lb. " 31·89 % Fe.
Tailing " 5 lb. " 21·44 % Fe.

Dry magnetic separation of size—¾" + ⅛"—

Weight, 10·15 pounds.
Current strength on rectifying magnets, 5 amperes, 110 volts.
" " drum " 25 " 110 "
Belt travel, 339 feet per minute.
Concentrates obtained, 245 lb.
Middlings " 524 lb.
Tailings " 140 lb.
Head sample, 106 lb. Analysis, 34·28 % Fe.
Concentrate sample, 7·5 lb. " 49·93 % Fe.
Middling " 9·5 lb. " 30·05 % Fe.
Tailing " 8·0 lb. " 21·60 % Fe.

Dry magnetic separation of size—⅛" + 1/16"—

Weight, 444 lb.
Current strength on rectifying magnets, 5 amperes, 110 volts.
" " drum " 25 " 110 "
Belt travel, 339 feet per minute. Time of run, 7 minutes.
Concentrates obtained, 258 lb.
Middlings " 184·0 lb.
Tailings " 74·5 lb.
Head sample, 38·5 lb. Analysis, 35·00 % Fe.
Concentrate sample, 6·5 lb. " 50·25 % Fe.
Middlings " 8·0 lb. " 28·88 % Fe.
Tailing " 7·5 lb. " 21·05 % Fe.

Dry magnetic separation of size, 1/16"—

Weight, 749 lb.
Current strength on rectifying magnets, 6 amperes, 110 volts.
" " drum " 20 " 110 "

Belt travel, 311 feet per minute. Time of run, 12 minutes.
Concentrates obtained, 258 lb.
Tailings “ 326·5 lb.
Dust loss “ 97·5 lb.
Head sample, 67·5 lb. Analysis, 35·67 % Fe.
Concentrate sample, 4·0 lb. “ 53·13 % Fe.
Tailing “ 4·5 lb. “ 23·75 % Fe.

Jig concentrates of dry separator middlings — ¼" + ⅛"—

Concentrates from No. 1 spout, 132 lb.
“ “ No. 2 spout, 23 lb.
Tailings 354 lb.
Concentrate, No. 1 sample, 4 lb. Analysis, 48·75 % Fe.
Concentrate, “ 2 “ 3 lb. “ 45·22 % Fe.
Tailing 5·5 lb. “ 22·98 % Fe.

Run No. 2.—Products from run No. 1 were mixed and re-run—

Concentrate, 100 lb. Analysis, 53·31 % Fe.
Tailings, 396 lb. “ 24·67 % Fe.

Jig concentration of dry separator middlings, — ⅛" + $\frac{1}{16}$"—

Concentrate from No. 1 spout, 49 lb.
Concentrate “ No. 2 “ 14 lb.
Tailings, 118 lb.
Concentrate No. 1 sample, 3·5 lb. Analysis, 50·94 %.
Concentrate No. 2 sample, 4·5 lb. “ 43·10 %
Tailings 4·5 lb. “ 20·35 %.

Jig and table concentration of dry separator tailings, —$\frac{1}{16}$"—

The tailings were sized on 16- and 40-mesh screens.

Size + 16-mesh (0·0445" aperture)—
Weight, 128·25 lb.
Sample weight, 2 lb. Analysis, 25·25 % Fe.
Jig concentrates obtained, 21 lb. Analysis, 52·25 % Fe.
Jig tailings obtained, 105 lb. Analysis, 19·86 % Fe.

Size — 16 + 40 mesh (— 0·0445" + 0·0150")—
Weight, 99 lb.
Sample weight, 1·5 lb. Analysis, 22·41 % Fe.
Wilfley concentrates obtained, 13·5 lb. Analysis, 50·00 % Fe.
Wilfley tailings obtained, 84 lb. Analysis, 17·98 % Fe.

Size — 40 mesh (— 0·0150" aperture)—
Weight, 29·5 lb.
Sample weight, 1 lb. Analysis, 23·15 % Fe.
Wilfley concentrates obtained, 4·5 lb. Analysis, 54·19 % Fe.
Wilfley tailings obtained, 24 lb. Analysis, 17·86 % Fe.

Dry Separation of re-crushed middlings from sizes — ¾" + ½" and ½" + ¼"—

Size — ¾" + ½". Weight, 882 lb.
Size — ½" + ¼". “ 672 lb.

Total 1,554 lb.

This material was crushed in rolls to pass the $\frac{1}{4}$-inch straight slot screen, and sized on $\frac{1}{8}$-inch and $\frac{1}{16}$-inch diagonal slot screen.

Size — $\frac{1}{4}''$ + $\frac{1}{8}''$,	8,999 lb.
Size — $\frac{1}{8}''$ + $\frac{1}{16}''$,	336·5 lb.
Size — $\frac{1}{16}''$,	201 lb.
Loss, - - - -	117·5 lb.
Total,	1,554 lb.

Dry magnetic separation of size — $\frac{1}{4}''$ + $\frac{1}{8}''$—

Current strength on rectifying magnets, 6 amperes, 110 volts
" " drum " 25 " 110 "
Time of run, 10 minutes.

Head sample,	86 lb.	Analysis,	32·57 % Fe.
Concentrates,	106·5 lb.	"	48·20 % Fe.
Middlings,	645·0 lb.	"	30·70 % Fe.
Tailings,	52·0 lb.	"	21·20 % Fe.

Run No. 2.—Products from run No. 1 were mixed and re-run over separator—
Weight, 779 lb.

Concentrates obtained,	97 lb.	Analysis,	48·90 % Fe.
Middlings "	560 lb.	"	31·70 % Fe.
Tailings "	122 lb.	"	22·64 % Fe.

Dry magnetic separation of size — $\frac{1}{8}''$ + $\frac{1}{16}''$—

Current strength on rectifying magnets, 6 amperes, 110 volts.
" " drum " 23 " 110 "
Time of run, 3 minutes.

Head sample,	27 lb.	Analysis,	31·50 % Fe.
Concentrates,	75 lb.	"	47·02 % Fe.
Middlings,	192 lb.	"	27·72 % Fe.
Tailings,	35 lb.	"	21·00 % Fe.

Run No. 2.—Products from run No. 1 were mixed and re-run over separator—

Current strength on rectifying magnets, 5 amperes, 110 volts.
" " drum " 20 " 110 "

Concentrates obtained,	59 lb.	Analysis,	48·70 % Fe.
Middlings "	204 lb.	"	28·31 % Fe.
Tailings "	27·5 lb.	"	20·54 % Fe.

Dry magnetic separation of size — $\frac{1}{16}''$—

Current strength on rectifying magnets, 5 amperes, 110 volts.
" " drum " 23 " 110 "

Head sample,	13 lb.	Analysis,	33·43 % Fe.
Concentrates obtained,	64 lb.	"	50·95 % Fe.
Tailings "	99 lb.	"	24·45 % Fe.
Dust loss,	25 lb.		

Jig concentration of dry separator middlings from recrushed middlings. Size — $\frac{1}{4}''$ + $\frac{1}{8}''$—

Weight, 553 lb.

Concentrates obtained,	146·5 lb.	Analysis,	50·45 % Fe.
Tailings "	400 lb.	"	24·35 % Fe.
Loss in feeder,	6·5 lb.		

Jig concentration of dry separator middlings from recrushed middlings. Size — $\frac{1}{8}$" + $\frac{1}{16}$"—

Weight, 200 lb.
Concentrates obtained, 45·5 lb.
Sample, 3·5 lb. Analysis, 48·80 % Fe.
Tailings obtained, 141 lb.
Sample, 2·5 lb. Analysis, 21·24 % Fe.
Loss in feeder, 13·5 lb.

Jig and table concentration of dry magnetic separator middlings from recrushed middlings. Size—$\frac{1}{16}$"—

Weight, 95 lb.
Sized on 16 and 40-mesh screens.
Size + 16 mesh (0·0445" aperture)—

Weight,	44·5 lb.	Analysis,	26·25 % Fe.
Jig concentrates,	6·25 lb.	"	52·25 % Fe.
Jig tailings,	37·25 lb.	"	19·86 % Fe.

Size — 16 + 40 mesh (— 0·0445 + 0·0150)—

Weight,	40·5 lb.	Analysis,	25·85 % Fe.
Wilfley concentrates,	10 lb.	"	50·00 % Fe.
Wilfley tailings,	29·5 lb.	"	18·00 % Fe.

Size — 40 mesh (— 0·0150" aperture)—

Weight,	10 lb.	Analysis,	26·46 % Fe.
Wilfley concentrates,	2·25 lb.	"	54·19 % Fe.
Wilfley tailings,	7·00 lb.	"	17·86 % Fe.

The following flow sheet and graphic illustration show the methods of procedure and the results obtained from the run.

Run No. 3—Coarse crushing, followed by jig concentration of the sized products.

A portion of the ore was taken, crushed in the jaw crusher set at 1-inch opening, elevated to the ore bin from which it was fed to the rolls set at $\frac{1}{2}$-inch opening. From the rolls it passed through the Vezin sampler unto the Ferraris screen fitted with 1-inch and $\frac{3}{4}$-inch circular perforated screens. The oversize was returned to the circuit until the entire lot passed the 1-inch screen.

The — $\frac{3}{4}$" size from the above operations was returned to the elevator and passed over the screen fitted with $\frac{1}{2}$-inch screen (circular perforations) and $\frac{1}{4}$-inch screen (straight slot perforations).

The — $\frac{1}{4}$" size was returned to the elevator and passed over the screen fitted with $\frac{1}{8}$-inch and $\frac{1}{16}$-inch diagonal slot screens.

The following screen sizes were obtained:—

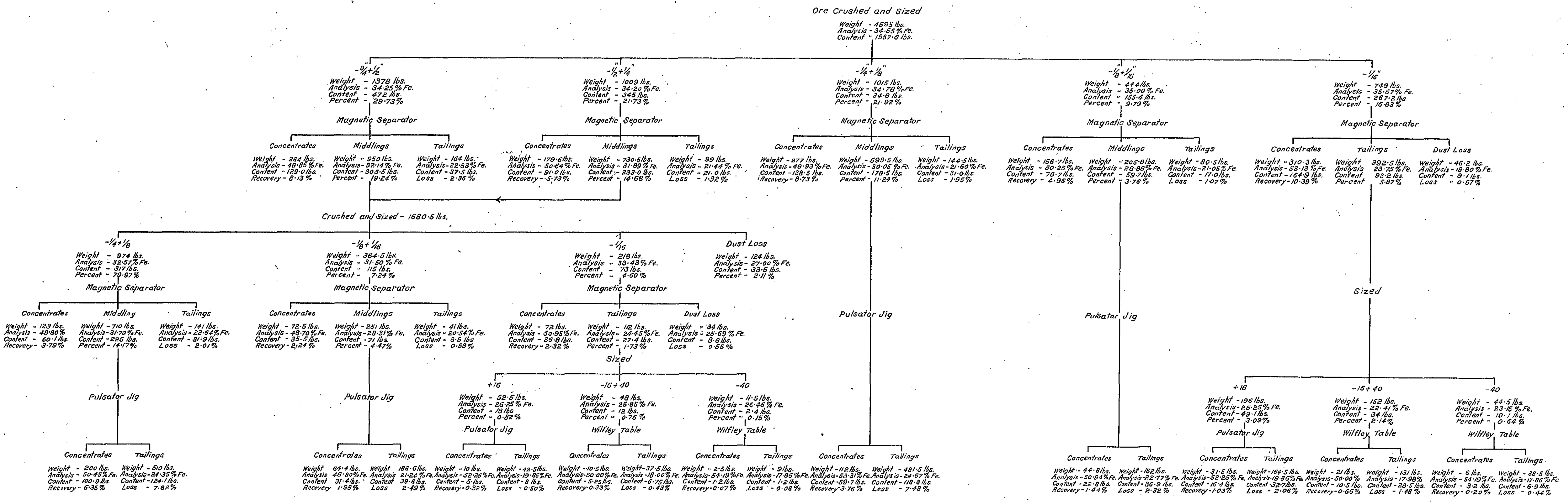
Size.	Weight.	Analysis.
	lb.	Per cent Fe.
— 1 + $\frac{3}{4}$	2,613	32·04
— $\frac{3}{4}$ + $\frac{1}{2}$	1,739	35·07
— $\frac{1}{2}$ + $\frac{1}{4}$	1.218	35·71
— $\frac{1}{4}$ + $\frac{1}{8}$	1,105	36·06
— $\frac{1}{8}$ + $\frac{1}{16}$	853	35 72
— $\frac{1}{16}$	912	35·02

FLOW SHEET

BANDED IRON ORE

DRY MAGNETIC SEPARATION, JIG AND TABLE CONCENTRATION

TEST NO. 23



SUMMARY Nº1 - Total Weight of Concentrates ..... 1957·7 pounds.
Tons of Concentrates per ton of Crude .. 0·426
Calculated Analysis of Concentrates ... 50·62 % Fe.
Recovery of Iron Content in Concentrates - 62·4 %

Total Weight of Tailings ...... 2637·3 pounds
Tons of Tailings per ton of Crude .. 0·574
Calculated Analysis of Tailings .. 22·63 % Fe.
Loss of Iron Content in Tailings .. 37·6 %

SUMMARY Nº2 - Total Weight of Concentrates ..... 1876·2 pounds.
Tons of Concentrates per ton of Crude .. 0·4083
Calculated Analysis of Concentrates ... 50·60 % Fe.
Recovery of Iron Content in Concentrates - 59·8 %

Total Weight of Tailings .... 2718·8 pounds.
Tons of Tailing per ton of Crude .. 0·5917
Calculated Analysis of Tailings ... 23·48 % Fe.
Loss of Iron Content in Tailings ... 40·2 %

Note - In Summary Nº2, the Jig and Table Concentration on the fines -1/16" is omitted. This is also omitted in the Graphic Flow Sheet following.

Fig. 2

GRAPHIC METHOD OF ILLUSTRATING RECOVERY OF IRON CONTENT

BANDED IRON ORE

DRY MAGNETIC SEPARATION AND JIG CONCENTRATION OF SEPARATOR MIDDLINGS

TEST No. 23

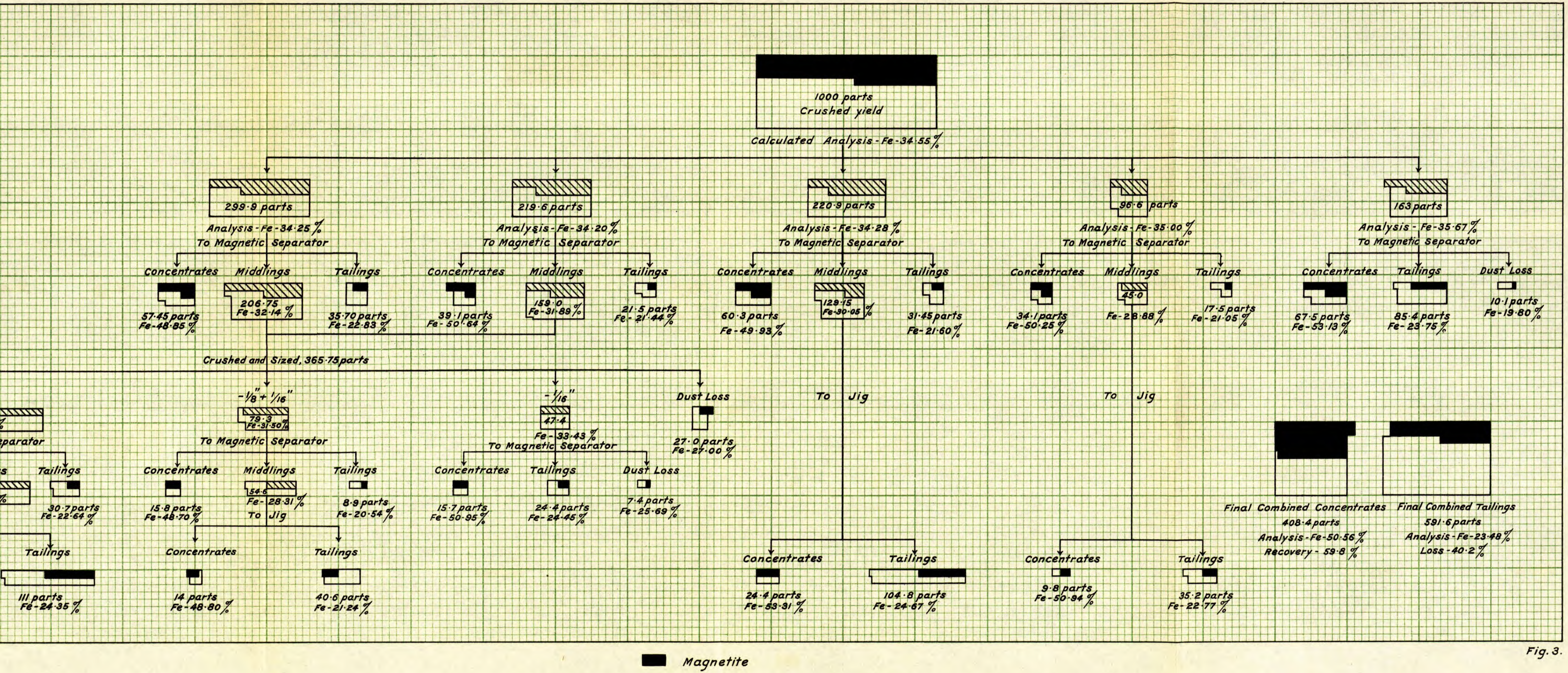
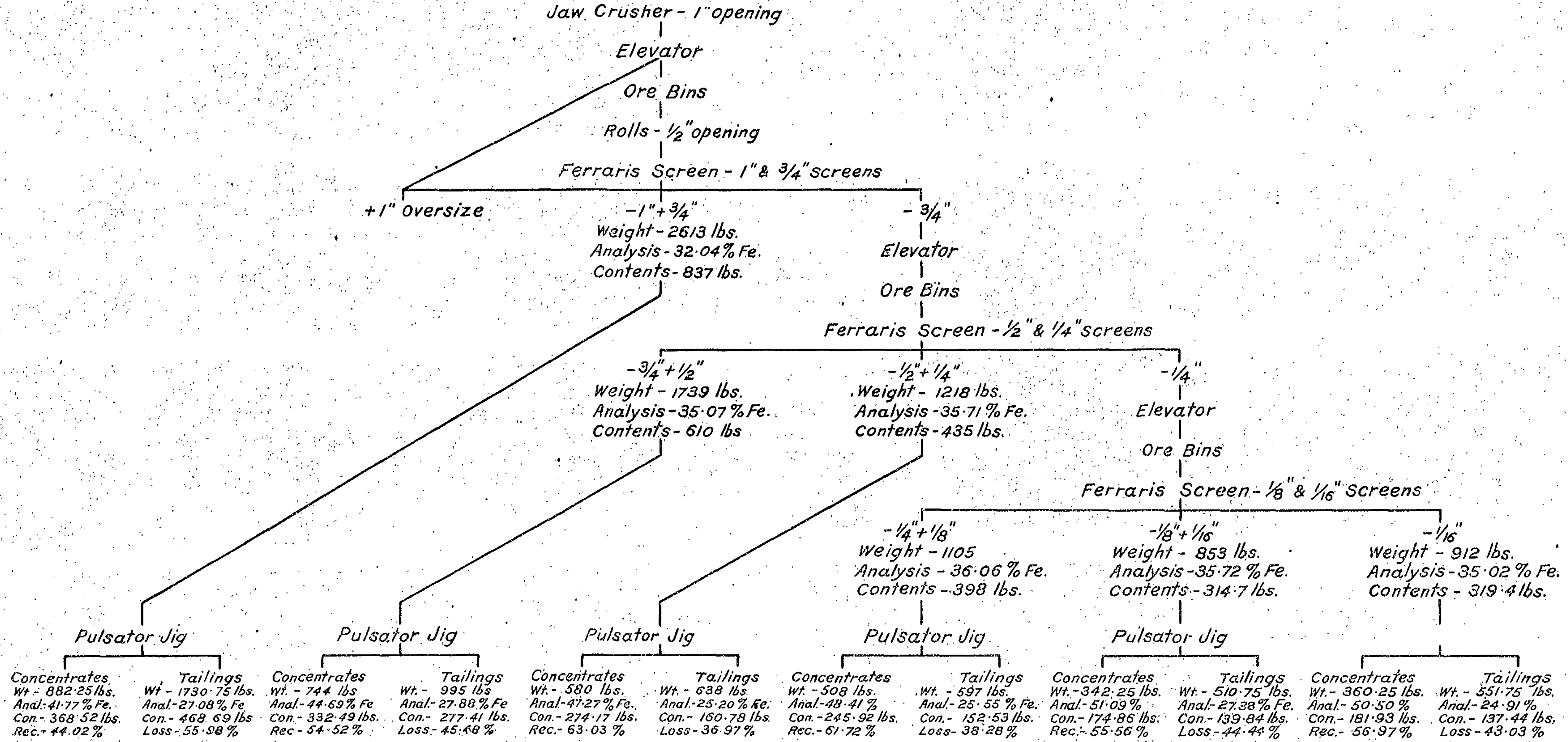


Fig. 3.



Averaged Analysis of Concentration Products
Crude Ore ____ 34·53 % Fe.
Concentrates ___ 46·12 % Fe.
Tailings _____ 26·61 % Fe.

Total Recovery of Iron Content _____ 54·14 %
Total Loss of Iron Content ________ 45·86 %
Tons of Concentrate per ton of Crude ___ 0·405
Tons of Crude per ton of Concentrate __ 2·47

FIG. 1.—Flow sheet, banded iron ore, jig concentration tests.

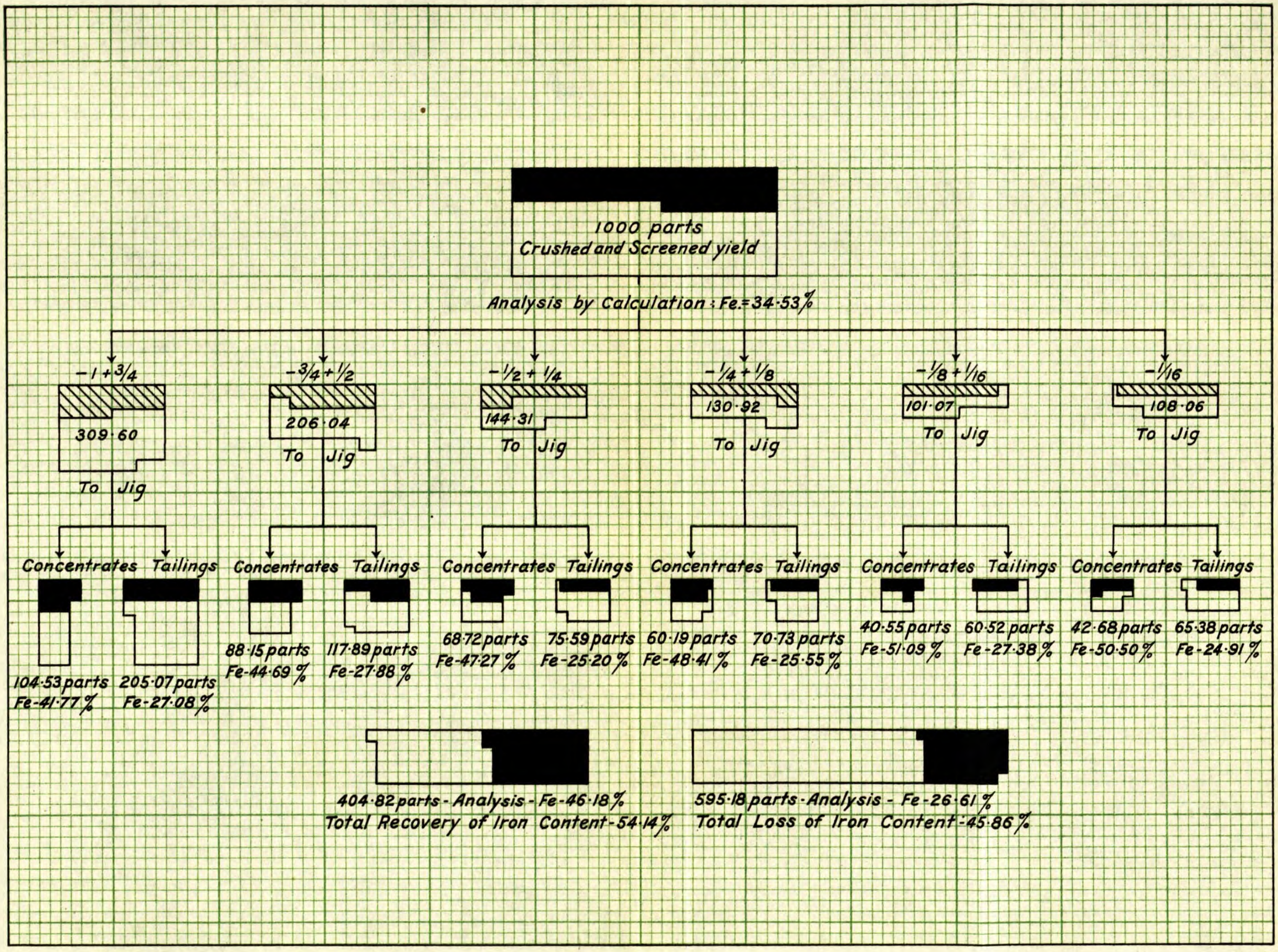
4

GRAPHIC METHOD OF ILLUSTRATING RECOVERY OF IRON CONTENT

BANDED IRON ORE

JIG CONCENTRATION

TEST No. 23



■ Magnetite

Fig. 5.

Size — 1″ + ¾″. Weight, 2,613 lb.
Weight to jig, 454 lb.
Concentrate obtained, 118 lb. Analysis, 41·77 % Fe.
Tailings, " 336 lb. " 27·08 % Fe.

Size — ¾″ + ½″. Weight, 1,739 lb.
Weight to jig, 528 lb.
Concentrate obtained, 223 lb. Analysis, 44·69 % Fe.
Tailings, " 305 lb. " 27·88 % Fe.

Size — ½″ + ¼″. Weight, 1218 lb.
Weight to jig, 1091 lb.
Concentrate obtained, 531 lb. Analysis, 47·27 % Fe.
Tailings " 560 lb. " 25·20 % Fe.

Size — ¼″ + ⅛″. Weight, 1105 lb.
Weight to jig, 1035 lb.
Concentrate obtained, 504 lb. Analysis, 48·41 % Fe.
Tailings " 531 lb. " 25·55 % Fe.

Size — ⅛″ + $\frac{1}{16}$. Weight, 853 lb.
Weight to jig 725 lb.
Concentrates obtained, 297 lb. Analysis, 51·09 % Fe.
Tailings " 428 lb. " 27·38 % Fe.

Size — $\frac{1}{16}$″. Weight, 912 lb.
Weight to jig, 790 lb.
Concentrates obtained, 312 lb. Analysis, 50·50 % Fe.
Tailings " 378 lb. " 24·91 % Fe.

A flow sheet showing the methods of procedure and the results of the test, and a graphic illustration showing the recovery of iron content, follows.

Run No. 4.—Coarse crushing, followed by fine crushing in rolls, dry magnetic separation followed by jig and table concentration of separator tailings.

A portion of the ore was taken and crushed in the jaw crusher and rolls to pass through the $\frac{1}{16}$-inch slot screen.

Weight to dry magnetic separator, 2,530 lb.
Current strength on rectifying magnets, 6 amperes, 105 volts.
" " " drum " 20 " 105 "
Belt travel, 339 feet per minute.
Concentrates obtained, 969·5 lb. Analysis, 53·95 % Fe.
Tailings " 1428·5 lb. " 24·78 % Fe.
Dust loss, 132·0 lb. " 19·85 % Fe.

The tailings were screened on the 16- and 40-mesh screens, giving the following sizes:—

Size.	Aperture.	Weight.	Analysis.
		lb.	Per cent Fe.
+ 16........	+ ·0445″	875	25·05
− 16 + 40........	− ·0445″ + ·0150″	368·5	24·50
− 40	− ·0150″	185	24·04

Size + 16 mesh was treated on the Richard's jig—
Concentrates obtained, 168·5 lb. Analysis, 50·72 % Fe.
Tailings " 706·5 lb. " 18·93 % Fe.

Size — 16 + 40 was treated on the Richard's jig—
Concentrates obtained, 69·25 lb. Analysis, 51·40 % Fe.
Tailings " 299·25 lb. " 18·27 % Fe.

Size — 40 was run over the Wilfley table—
Concentrates obtained, 31 lb. Analysis, 54·23 % Fe.
Tailings " 154 lb. " 17·93 % Fe.

A flow sheet showing the methods of procedure and the results obtained, and a graphic illustration showing the recovery of the iron content, follows.

Run No. 5.—Preliminary test by fine grinding in conical mill, followed by magnetic concentration in Gröndal double drum wet separator.

The concentration products from the jig test were mixed together, elevated to the ore bin, passed through a Vezin sampler, through a chute to the conical mill. The discharge end of the mill is connected with the Gröndal double drum wet separator by a step launder. A flood automatic sampler passes through the feed to the separator and cuts out a portion of the feed every 15 minutes. The current strength carried on the separator drum was 6 amperes, 110 volts. The concentrates from the separator were pumped by a 1-inch centrifugal pump to a settling tank. Samples of the concentrates and tailings were obtained by flood automatic samplers which cut out a sample every 15 minutes from the pump discharges.

The samples from the flood automatic samplers gave the following analysis:—

Feed to separator, 34·20 % Fe.
Concentrates, 63·41 % Fe.
Tailings, 20·99 % Fe.

The tailing analysis also showed that 1·06 % Fe existed as FeO and 19·93 % Fe as Fe_2O_3. The 1·06 % Fe requires 2·10 % Fe as Fe_2O_3 to form magnetite. 19·93 % — 2·10 % = 17·83 % Fe as hematite, i.e., had the total magnetite been recovered in the concentration of the grade 63·41 % Fe, the tailings would have shown 17·83 % Fe entirely as hematite. The tailings from the settling tank were dried and sampled. This sample gave an analysis of 21·73 % Fe showing that some specular hematite was lost as slimes in the taking of the sample.

Weight of concentrates 1,011 pounds.

From the amount of concentrates and the analysis of the feed and concentration products, the weight of feed and the weight of tailings are arrived at.

Heads, Weight X lb. Analysis, 34·20 % Fe.
Concentrates, Weight, 1,011 lb. Analysis, 63·41 % Fe.
Tailings, Weight, (X — 1,011) lb. Analysis, 21·73 % Fe.
34·20 X = (63·41 × 1011) + 21·73 (X — 1011).
3420 X = 6410751 + 2173 × 2196903.
1247 X = 4213848 [redacted]
X = 3379 lb.
X — 1011 = 2368 lb.

Heads, 3379 × 34·20 = 1155·62 lb. metallic iron.
Concentrates, 1011 × 63·41 = 641·08 " "
Tailings, 2368 × 21·73 = 514·54 " "

Recovery of iron content in concentrates—

$$\frac{641\cdot08 \times 100}{1155\cdot62} = 55\cdot48\ \%.$$

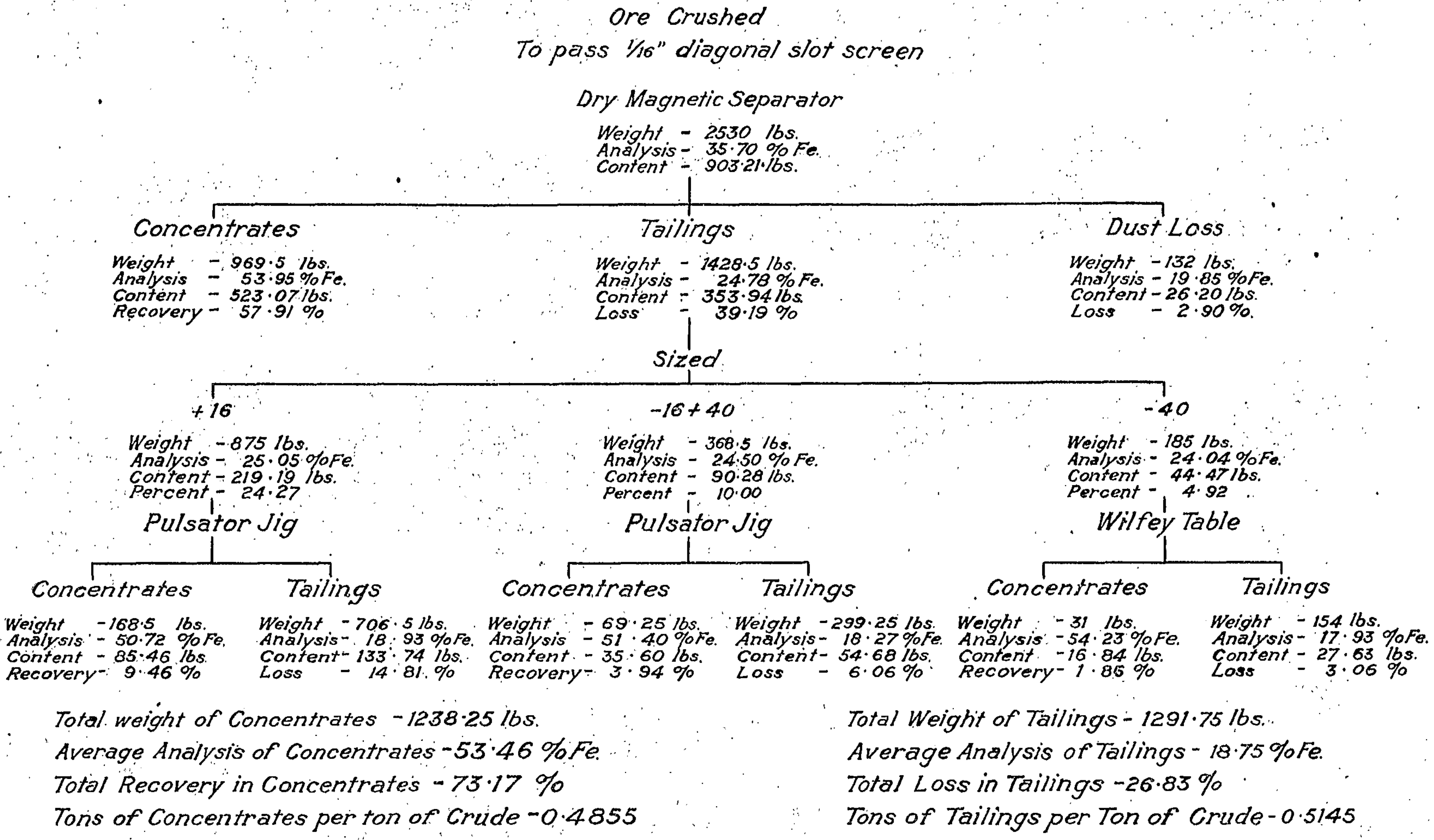


FIG. 6.—Flow sheet, banded iron ore, fine crushing. Dry magnetic separation, jig and table concentration tests. Test No. 23.

GRAPHIC METHOD OF ILLUSTRATING RECOVERY OF IRON CONTENT

BANDED IRON ORE

FINE CRUSHING, DRY MAGNETIC SEPARATION, JIG AND TABLE CONCENTRATION

TEST NO. 23

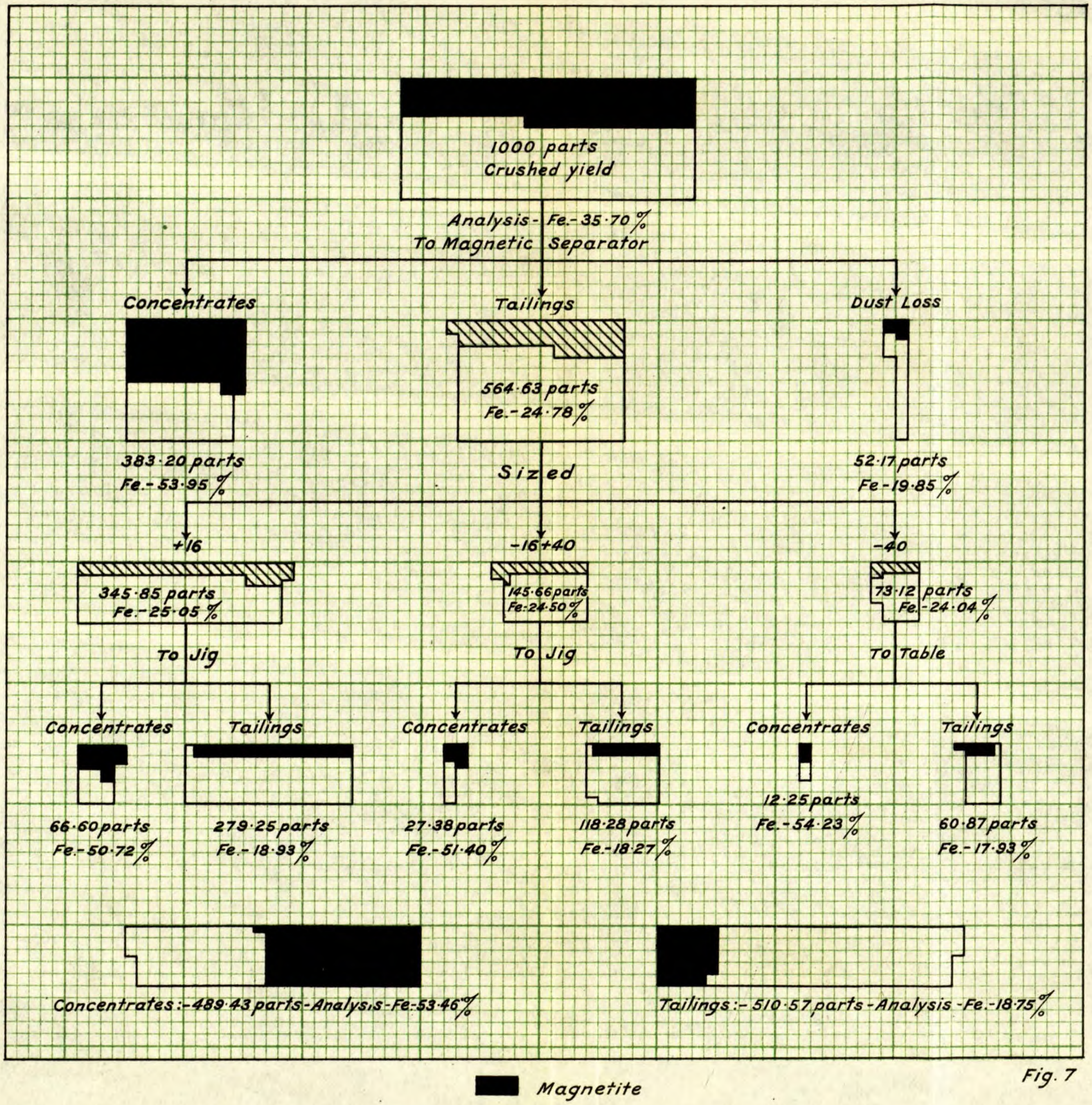


Fig. 7

Loss of iron content in tailings—

$$\frac{514{\cdot}54 \times 100}{1155{\cdot}62} = 44{\cdot}52\,\%.$$

Wet Magnetic Separation of Gröndal Tailings.

A portion of the tailings from the Gröndal wet magnetic separator was run through the Ullrich magnetic separator to obtain a separation of the hematite from the gangue. It was found that the gangue was nearly as magnetic as the hematite, as is shown by the analysis obtained:—

Head sample, 21·85 per cent
Concentrates, 25·20 "
Tailings, 19·72 "

Run No. 6.—Final test by coarse crushing, fine grinding, wet magnetic separation and table concentration of separator tailings.

Some 3,962 pounds of the ore were taken, crushed in the jaw crusher set at 1-inch opening and elevated to the ore bins. From the bins the crushed ore was fed by a push feeder to elevator No. 2, which discharged it to a Vezin sampler. From the sampler the ore passed through a chute to the conical mill. After fine grinding in the conical mill, it flowed through a step launder to the wet magnetic separator. A head sample was cut out by an automatic flood sampler which cut through the feed every fifteen minutes. From the separator the concentrates were conveyed to a 1-inch centrifugal pump, and discharged into a settling tank; the tailings were conveyed to a 2-inch centrifugal pump, and discharged into a settling tank. Samples of the concentrates and tailings were taken by automatic flood samplers which cut out a portion every fifteen minutes from the discharge of the pumps.

Analyses of samples—

Head sample, Fe — 35·89 %
Concentrates, Fe — 64·01 %
FeO — 27·31 % or 21·24 % Fe.
Fe_2O_3 — 61·10 % or 42·77 % Fe.
SiO — 10·58 %
S — 0·004%
P — 0·025%
Mn. — 0·014%

Tailings, Fe — 22·63 per cent.
Clean up of conical mill, Fe — 43·47 per cent.

Screen analyses of conical mill discharge—

Size.	Aperture.	Weight.	Percentages.	Analysis.
		grms	p.c.	
+ 20.....	+ 0·025	1·5	0·065	46·46
− 20 + 30.....	+ 0·0166	3·4	0·148	33·00
− 30 + 40	+ 0·0125	10·0	0·433	28·00
− 40 + 50.....	+ 0·01	15·5	0·673	24·66
− 50 + 60	+ 0·0083	41·5	1·802	26·62
− 60 + 70.....	+ 0·0071	57·5	2·497	27·62
− 70 + 80.....	+ 0·0062	36·0	1·563	28·61
− 80 + 90.....	+ 0·0055	70·5	3·061	33·60
− 90 + 100	+ 0·005	23·5	1·020	33·50
− 100 + 120	+ 0·0042	105·5	4·581	39·18
− 120 + 150.....	+ 0·0032	127·5	5·536	41·77
− 150 + 200.....	+ 0·0025	223·0	9·683	42·07
− 200	− 0·0025	1587·6	68·936	35·89
Totals.....	....	2303·0 grms.	99·998	36·19

NOTE.—Size + 20-mesh probably contained small fragments of the iron balls, hence the high analysis.

Time of run—

Test started at 11.30 a.m.
Bin empty at 3.30 p.m.
Mill run to 4.30 p.m.

Ball consumption for 8,044 pounds of ore—

Weight.	Before crushing.	After crushing.	Loss.
	lb.	lb.	lb.
4"	1,500	1,477	23
3"	500	487	13
2"	250	247	3
Totals	2,250	2,211	39

Power consumption on magnets—

Current strength on magnets—

Drum No. 1, 5 to 6 amperes, 100 to 110 volts.
Drum No. 2, 5 to 6 amperes, 100 to 110 volts.

Meter reading—

11.30 a.m., 163·5 k.w.h.
3.30 p.m., 168·0 k.w.h.
4.30 p.m., 169·0 k.w.h.

Water consumption—

Ball mill—	Time.	Reading.
Start	11.30 a.m.	243 cub. ft.
Bin empty	3.30 p.m.	356 "
"	4.00 p.m.	370 "
"	4.15 p.m.	380 "
"	4.25 p.m.	391 "
Stop	4.30 p.m.	396 "

Grondal separator—		
Start	11.30 a.m.	4,315 cub. ft.
Bin empty	3.30 p.m.	6,000 "
Stop mill	4.30 p.m.	6,400 "

Summary of Test—Calculations from weights and percentages obtained—

Weight of ore first taken, 3,962 lb.
Weight of concentrates, 1,263 lb.

Weight of ore left in ball mill, 243 lb. Approximately this amount was left in from preliminary run, so does not figure in calculations on this run.

Separator feed, X lb. Analysis, 35·89 per cent Fe.
Concentrates, 1263 lb. " 64·01 per cent Fe.
Tailings, (X — 1263 lb.) " 22·63 per cent Fe.

$35{\cdot}89\ X = (64{\cdot}01 \times 1263) + 22{\cdot}63\ (X - 1263).$

$3589\ X = 8084463 + 2263\ X - 2858169.$

$1326\ X = 5226294.$

$\therefore X = 3941$ lb.

$X - 1263 = 2678$ lb.

Separator feed, 3941 x 35·89 = 1414·43 lb. metallic iron.
Concentrates, 1263 x 64·01 = 808·44 lb. "
Tailings, 2678 x 22·63 = 606·03 lb.

Recovery of iron content in concentrates—

$$\frac{808\cdot44\times100}{1414\cdot43}=57\cdot16\text{ per cent.}$$

Loss of iron content in tailings—

$$\frac{606\cdot03\times100}{1414\cdot43}=42\cdot84\text{ per cent.}$$

From the analysis of the concentrate given above it is found that the total iron content is magnetite.

Table Concentration of Wet Magnetic Separator Tailings.

Run No. 1.—A portion of the tailings from the wet magnetic separator was run over the Deister concentrator to determine what kind of a separation could be made and also to determine the table adjustments necessary for this class of material. No weights were taken, but samples were taken of the products for analysis.

Feed to concentrator,	22·63 per cent Fe.
Concentrates,	60·20 per cent Fe.
Middlings,	43·39 per cent Fe.
Tailings,	14·18 per cent Fe.

Run No. 2.—The table was adjusted and fitted to make only two products.

Feed to concentrator,	413 lb.	Analysis,	22·63 per cent Fe.
Concentrates,	67 lb.	"	56·17 per cent Fe.
Tailings,	346 lb.	"	16·27 per cent Fe.

Recovery of iron content in concentrates—

$$\frac{67\times56\cdot17\times100}{413\times22\cdot63}=40\cdot3\text{ per cent.}$$

Loss of iron content in tailings—

$$\frac{346\times16\cdot17\times100}{413\times22\cdot63}=59\cdot8\text{ per cent.}$$

Run No. 3.—Further adjustments made to table.

Feed to concentrator,	101·5 lb.	Analysis.	22·63 per cent Fe.
Concentrates,	30·75 lb.	"	49·83 per cent Fe.
Tailings,	70·75 lb.	"	10·81 per cent Fe.

Recovery of iron content in concentrates—

$$\frac{30\cdot75\times49\cdot83\times100}{101\cdot50\times22\cdot63}=66\cdot7\text{ per cent.}$$

Loss of iron content in tailings—

$$\frac{70\cdot75\times10\cdot81\times100}{101\cdot50\times22\cdot63}=33\cdot3\text{ per cent.}$$

Run No. 4.—Further adjustment made to table.

Feed to concentrator,	258·00 lb.	Analysis,	22·63 per cent Fe.
Concentrates,	49·75 lb.	"	53·45 per cent Fe.
Tailings,	208·25 lb.	"	15·27 per cent Fe.

Recovery of iron content in concentrates—

$$\frac{49\cdot75\times53\cdot45\times100}{258\times22\cdot63}=45\cdot55\text{ per cent.}$$

Loss of iron content in tailings—

$$\frac{208\cdot25\times15\cdot27\times100}{258\times22\cdot63}=54\cdot45 \text{ per cent.}$$

The concentration tests on the Deister concentrator show that the higher the grade of concentrate the greater the loss of iron content in the tailing, and vice versa. Even in this finely divided state there remain particles of mixed hematite and gangue.

Summary of results—

Recovery of iron content in separator concentrates, 57·16 per cent.
Loss of iron content in separator tailings, 42·84 per cent.
Recovery of iron content in Deister concentrates, Run No. 2—
$42\cdot84\times40\cdot3=17\cdot26$ per cent.
i.e., 57·16 per cent of the iron content is recovered as magnetite.
17·26 " " " " " hematite.
74·42 " " " " total recovery.

Recovery of iron content in Deister concentrate, Run No. 3—
$42\cdot84\times66\cdot7=28\cdot57$ per cent.
i.e., 57·16 per cent of the iron content is recovered as magnetite.
28·57 " " " " " hematite.
85·73 " " " " total recovery.

Recovery of iron content in Deister concentrate, Run No. 4—
$42\cdot84\times45\cdot55=19\cdot51$ per cent.
i.e., 57·16 per cent of the iron content is recovered as magnetite.
19·51 " " " " " hematite.
76·67 " " " " total recovery.

Tons of magnetite (wet separator concentrate) per ton of crude—

$$\frac{0\cdot6315}{1\cdot9705}=\cdot32 \text{ of grade } 64\cdot01 \text{ per cent Fe.}$$

Tons of crude per ton of concentrate (magnetite)—

$$\frac{1\cdot00}{0\cdot32}=3\cdot125$$

Tons of hematite (Deister concentrates, Run No. 2) per ton of crude—

$$\frac{\cdot0335}{\cdot2065}\times\frac{1\cdot3990}{1\cdot9705}=\cdot11 \text{ of grade } 56\cdot17 \text{ per cent Fe.}$$

Tons of crude per ton of table concentrates (hematite)—

$$\frac{1\cdot00}{0\cdot11}=9\cdot1$$

Tons of hematite (Deister concentrates, Run No. 3) per ton of crude—

$$\frac{\cdot015375}{\cdot050750}\times\frac{1\cdot3990}{1\cdot9705}=\cdot2157 \text{ of grade } 49\cdot83 \text{ per cent Fe.}$$

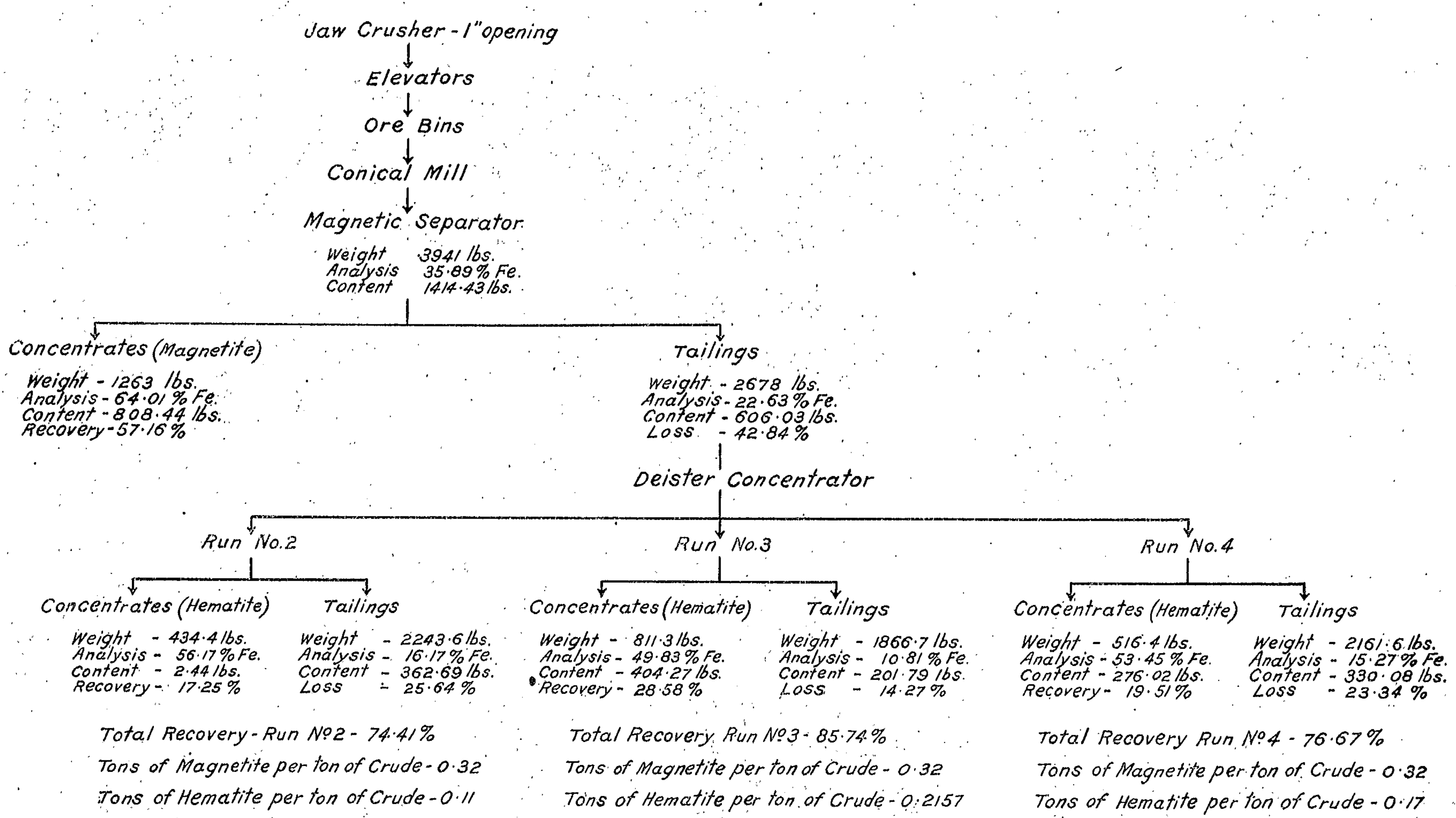


FIG. 8.—Flow sheet, banded iron ore. Wet magnetic separation and table concentration tests. Test No. 23.

GRAPHIC METHOD OF ILLUSTRATING RECOVERY OF IRON CONTENT

BANDED IRON ORE

WET MAGNETIC SEPARATION AND TABLE CONCENTRATION

TEST No. 23

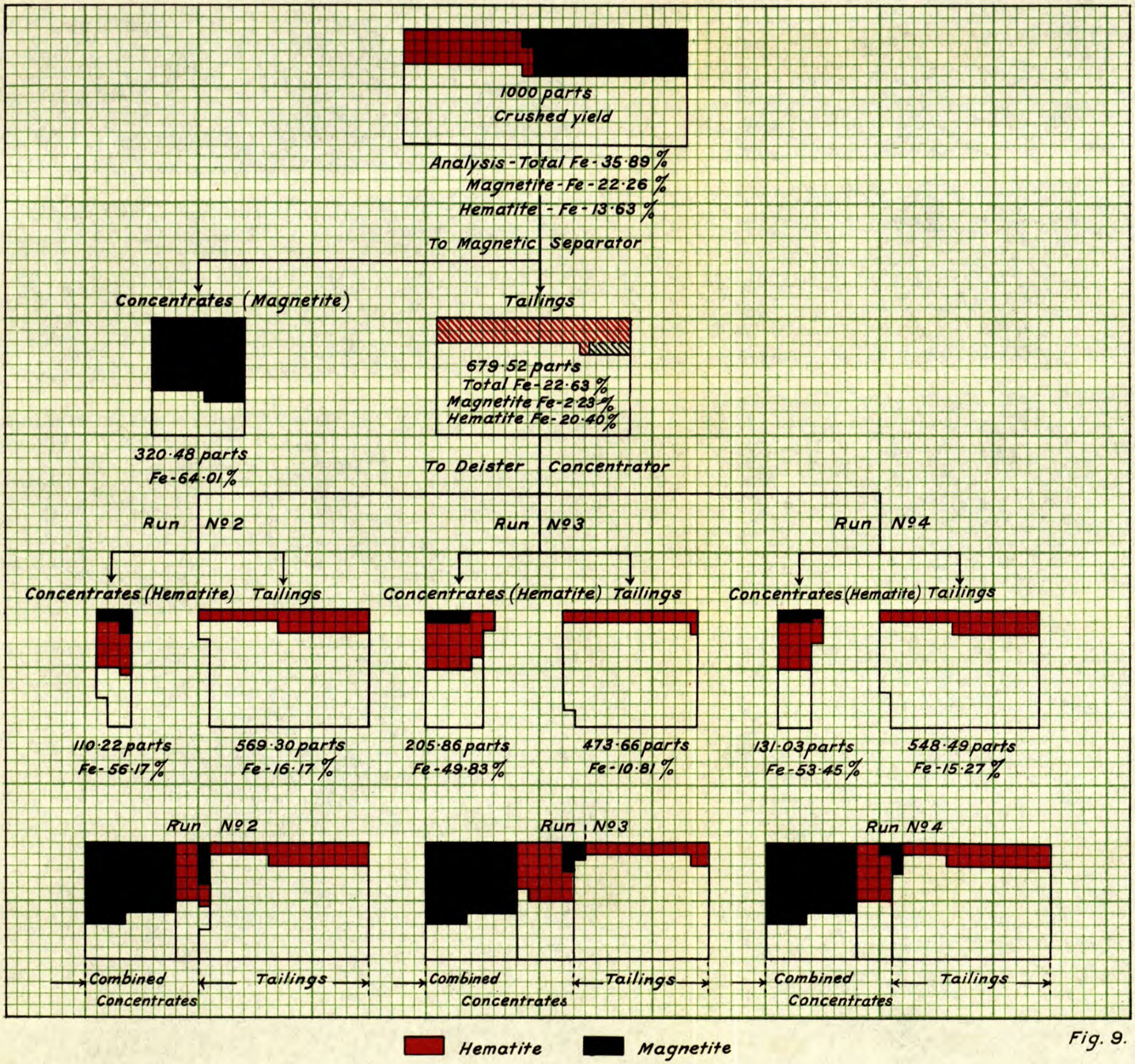


Fig. 9.

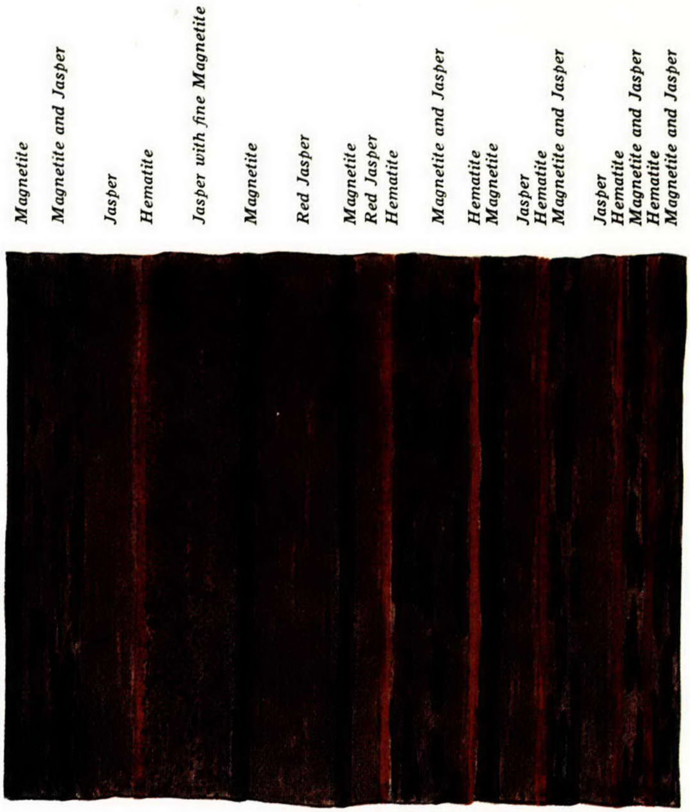


Fig. 10. Ideal section of banded iron ore, from Groundhog mine, Timiskaming district, Ont.

Tons of crude per ton of table concentrates (hematite)—

$$\frac{1\cdot0000}{0\cdot2157}=4\cdot6$$

Tons of hematite (Deister concentrates, Run No. 4) per ton of crude—

$$\frac{\cdot024875}{\cdot104125}\times\frac{1\cdot3990}{1\cdot9705}=\cdot17 \text{ of grade } 53\cdot45 \text{ per cent Fe.}$$

Tons of crude per ton of table concentrates (hematite)—

$$\frac{1\cdot00}{0\cdot17}=5\cdot9$$

A point of particular importance is the varying percentage of magnetite and hematite in the ore. The ore taken for run No. 1 showed an analysis of: Total Fe, 34·374 per cent; Fe as magnetite, 26·063 per cent; Fe as hematite, 8·311 per cent. The ore taken for run No. 6 showed an analysis of: Total Fe, 35·89 per cent; Fe as magnetite, 22·26 per cent; Fe as hematite, 13·63 per cent.

Had the former grade been taken for run No. 6, the test would have shown a marked increase in the recovery of the iron content as magnetite. The recovery shown in run No. 6, as 57·16 per cent, would have been 69·86 per cent, an increase of 12·70 per cent. The recovery of the iron content by table concentration would have been as follows:—

Run No. 2.—12·09 per cent.
Run No. 3.—20·10 "
Run No. 4.—13·71 "

A total recovery of—

Run No. 2.—As magnetite, 69·86 per cent.
" hematite, 12·09 "
Total, 81·95 "

Run No. 3.—As magnetite, 69·86 per cent.
" hematite, 20·10 "
Total, 89·96 "

Run No. 4.—As magnetite, 69·86 per cent.
" hematite, 13·71 "
Total, 83·57 "

The following flow sheet, and graphic illustration, show the methods of procedure, and the results obtained from the run.

TEST No. 24.

A shipment of three boxes containing 600 pounds of bauxite concentrate was received from the Northern Aluminum Company, Limited, Shawenegan Falls, Quebec.

The head sample of the feed to the machines showed it to contain 0·15 per cent metallic iron. It was supposed that the iron content was in the ferric state, and consisted of fine particles through the concentrate. The object of the test was to lower the iron content thus making a higher grade product for the manufacture of aluminum wire.

Tests were conducted on portions of concentrate on the following machines:—

The Ullrich magnetic separator.
The Huff electrostatic separator.
The Gröndal magnetic separator.

Run No. 1.—Ullrich magnetic separator—
Feed, dry.
Distance of feed from rings, 1 inch.
Current strength, 10 amperes at 110 volts.
Concentrate analysis, 0·14 per cent Fe.

Run No. 2.—Ullrich magnetic separator—
Feed, wet.
Distance of feed from rings, 1 inch.
Current strength, 10 amperes at 110 volts.
Concentrate analysis, 0·13 per cent Fe.

Run No. 3.—Ullrich magnetic separator—
Feed, wet.
Distance of feed from rings, ½ inch.
Current strength, 10 amperes at 110 volts.
Concentrate analysis, 0·13 per cent Fe.

Run No. 4.—Ullrich magnetic separator—
Feed, recalcined and new wet.
Distance of feed from rings, ½ inch.
Current strength, 10 amperes at 110 volts.
Concentrate analysis, 0·13 per cent Fe.

Run No. 5.—Huff electrostatic separator—
Feed, dry.
Distance of electrode from roll, 1½ inches.
Voltage on electrode, 27,000.
Concentrate analysis, 0·12 per cent Fe.
Tailing analysis, 0·12 per cent Fe.

Run No. 6.—Huff electrostatic separator—
Feed, dry.
Dist. electrode from roll, 1½ inches.
Voltage on electrode, 20,000.
Concentrate analysis, 0·13 per cent Fe.
Tailing analysis, 0·13 per cent Fe.

Run No. 7.—Gröndal magnetic separator—
Feed, wet.
Current strength, 6·5 amperes at 110 volts.
Concentrate analysis, 0·23 per cent Fe.

Conclusions.—The iron content in the bauxite concentrate does not exist as separate particles, nor does any of the particles contain greater proportions of it, but it is so intimately mixed through all the particles that a magnetic or electrostatic separation is impossible.

TEST No. 25.

Two hundred pounds of serpentine rock, carrying asbestos and chromite, was received from the Geological Survey, Ottawa.

Concentration tests were conducted on the laboratory Wilfley table to obtain a separation of the asbestos and chromite from the rock material.

The rock was crushed to pass through a 20-mesh screen by successive crushing and rolling; 4·625 pounds of asbestos fibre was caught on the 20-mesh screen.

The undersize, through 20-mesh, was sized on the following screen set, and the weights of each size noted:—

Size,	— 20 + 30.	Weight,	78·00 lb.
"	— 30 + 40.	"	22·50 "
"	— 40 + 50.	"	23·00 "
"	— 50 + 60.	"	11·75 "
"	— 60 + 80.	"	8·25 "
"	— 80 +100.	"	8·75 "
"	—100 +150.	"	9·50 "
"	—150.	"	19·00 "

Wilfley concentration of size — 20 + 30—

First concentrates	1·375	lb.
" middlings	12·250	"
" tailings	54·000	"
Second concentration from reconcentration of middlings	1·375	"
" middlings from reconcentration of middlings	2·750	"
" tailings " " "	8·000	"
Slime fibre from first and second concentration	0·500	"

Wilfley concentration of size — 30 + 40—

First concentrates	1·250	lb.
" middlings	5·375	"
" tailings	13·250	"
Second concentrates from reconcentration of middlings	0·3125	"
" middlings " " "	2·0000	"
" tailings " " "	3·0000	"
Slime fibre from first and second concentration	0·3125	"

Wilfley concentration of size — 40 + 50—

First concentrates	0·875	lb.
" middlings	3·000	"
" tailings	16·250	"
Second concentrates from reconcentration of middlings	0·1875	"
" middlings " " "	0·6875	"
" tailings " " "	2·0625	"
Slime fibre from first and second concentration	0·5625	"

Wilfley concentration of size — 50 + 60—

Concentration obtained	—0·4375	lb.
Middlings "	—1·5000	"
Tailings "	—7·5000	"
Slime fibre "	—0·3125	"

Wilfley concentration of size — 60 + 80—

Concentrates obtained	—0·2500	lb.
Middlings "	—0·8750	"
Tailings "	—5·0000	"
Slime fibre "	—0·3750	"

Wilfley concentration of size — 80 + 100—

Concentrates obtained	—0·344	lb.
Middlings "	—0·8125	"
Tailings "	—5·0000	"
Slime fibre "	—0·6875	"

Wilfley concentration of size — 100 + 150—
Concentrates obtained.................................. —0·3125 lb.
Middlings " .... —0·6250 "
Tailings " .... —4·5000 "
Slime fibre " .... —0·8750 "

Wilfley concentration of size — 150—
Concentrates obtained.................................. —0·5000 lb.
Middlings " .... —1·1250 "
Tailings " .... —7·0000 "
Slime fibre " .... —1·5000 "

TEST No. 26.

ZINC CONCENTRATES FROM NOTRE DAME MINE.

A small shipment of 200 pounds of zinc concentrate was received from Mr. David A. Poe. The concentrate is a table-and-jig product, analysis showing it to contain zinc, 26·07 per cent; iron, 26·22 per cent; copper, 0·33 per cent. Tests were run to obtain a zinc product high in zinc and low in iron content.

Run No. 1.—Magnetic separation followed by electrostatic separation of non-magnetic product.

Wet separation on the Ullrich magnetic separator was employed. A current strength of 5 amperes at 110 volts was used on the machine. The rings were set half an inch from the feed plates. The results of the operation are tabulated below:—

Products.	Weight.	Percentage by weight.	Analysis per cent.		Contents pounds.		Concentration. per cent.	
			Zn.	Fe.	Zn.	Fe.	Zn.	Fe.
	lb.—oz.							
Pyrrohite....................	43—0	26·7	7·22	48·90	3·105	21·027	7·40	49·82
Zinc..........................	118—0	73·3	32·94	17·95	38·869	21·181	92·60	50·18
Totals and averages...	161—0	100·0	26·07	26·22	41·974	42·208	100·00	100·00

The zinc product was divided into two portions; one was held to be given a magnetic roast, and separated magnetically, while the other was passed again through the separator, the current strength increased to 10 amperes at 110 volts, the rings remaining at half an inch from the feed plates. The following tabulated results were obtained:—

Product.	Weight.	Percentage by weight.	Analysis per cent.		Contents pounds.		Concentration per cent.	
			Zn.	Fe.	Zn.	Fe.	Zn.	Fe.
	lb.—oz.							
Magnetite................	16—12	11·5	31·19	23·01	2·105	1·553	11·04	14·30
Non-magnetite..........	51—12	88·5	32·79	17·99	16·969	9·310	88·96	85·00
Totals and averages...	58— 8	100·0	32·61	18·57	19·074	10·863	100·00	100·00

The above results are combined in the following table:—

Product.	Weight.	Percentage by weight.	Analysis per cent.		Contents pounds.		Concentration per cent.	
			Zn.	Fe.	Zn.	Fe.	Zn.	Fe.
	lb.—oz.							
1st Magnetic..	43—0	26·7	7·22	48·90	3·105	21·027	7·47	48·97
2nd "	13—9	8·4	31·19	23·01	4·231	3·122	10·17	7·27
Non "	104—7	64·9	32·79	17·99	34·243	18·787	82·36	43·76
Totals and averages....	161—0	100·0	25·82	26·48	41·579	42·936	100·00	100·00

The non-magnetic product was screened on an 8-mesh screen, and the oversize crushed to pass through 8-mesh. The material was sized, and the sized products treated separately on the Huff electrostatic separator. As considerable gangue material was noticeable, three products were made: a zinc product, an iron product, and a calcite product. The results of the separation are contained in the following table:—

HEAD.

Sized Product.	Weight.		Percentage of sized product.	Analysis.		Contents.		Voltage on Electrode for	
	lb.	oz.		Per Cent. Zn.	Per Cent. Fe.	lb. Zn.	lb. Fe.	Fe. Prod.	Calcite Prod.
− 8 +10	12	12	13·0	30·40	20·43	3·876	2·605	27·000	24·000
−10 +20	21	12	22·1	29·35	18·34	6·364	3·989	27·000	24·000
−20 +40	31	8	32·1	22·73	17·75	7·160	5·591	27·000	26·000
−40 +80	24	0	24·4	31·90	17·03	7·656	4·087	23·000	26·000
−80	8	4	8·4	29·40	16·43	2·426	1·355	24·000	17·000
Totals and averages..	98	4	100·0	27·97	17·94	27·482	17·627	.....	....

IRON PRODUCT.

Sized Product.	Weight.		Percentage of sized product.	Analysis.		Contents.		Percentage.	
	lb.	oz.		Per Cent. Zn.	Per Cent. Fe.	lb. Zn.	lb. Fe.	Zinc. Loss.	Fe. Recovery.
− 8 +10	3	4	3·31	24·79	28·37	0·806	0·922	2·935	5·225
−10 +20	6	8	6·62	18·25	29·63	1·186	1·926	4·320	10·910
−20 +40	4	12	4·83	11·93	34·52	0·559	1·640	2·033	9·30
−40 +80	2	9	2·608	20·85	30·29	0·534	0·776	1·945	4·40
−80	0	10	·632	30·05	27·39	0·188	0·171	·684	·970
Totals and averages..	17	11	18·004	18·50	30·71	3·273	5·435	11·917	30·805

ZINC PRODUCT.

Sized product.	Weight.		Percentage of sized product.	Analysis.		Contents.		Percentage.	
	lb.	oz.		Per Cent. Zn.	Per Cent. Fe.	lb. Zn.	lb. Fe.	Zinc Recovery.	Fe. in Zn. Prod.
− 8 +10	6	12	6·86	27·31	18·65	1·843	1·259	6·715	7·137
−10 +20	12	14	13·09	35·05	12·75	4·513	1·642	16·430	9·320
−20 +40	23	4	23·65	39·95	16·43	9·288	3·820	33·800	21·70
−40 +80	14	2	14·49	37·00	17·03	5·226	2·405	19·050	13·65
−80	5	0	5·08	34·75	17·95	1·838	0·898	6·685	5·10
Totals and averages..	62	0	63·17	36·63	16·17	22·708	10·024	82·68	58·90

CALCITE PRODUCT.

Sized product.	Weight.		Percentage of sized product.	Analysis.		Contents.		Percentage.	
	lb.	oz.		Per Cent. Zn.	Per Cent. Fe.	lb. Zn.	lb. Fe.	Zinc.	Fe.
− 8 +10	0	12	·7625	28·25	10·42	0·212	0·078	·771	·4425
−10 +20	0	12	·7625	18·80	5·10	0·142	0·038	·517	·2155
−20 +40	3	4	3·305	18·35	3·96	0·596	0·129	2·170	·7325
−40 +80	7	0	7·120	25·70	8 78	1·799	0·615	6·540	3·490
−80	3	2	3·170	21·85	11·96	0·683	0·373	2·482	2·115
Totals and averages..	14	14	15·12	23·07	8·29	3·432	1·233	12·48	6·9955

A summary of the above results is contained in the table given below:—

Products.	Weight.		Percentage by weight.	Analysis.		Contents—lb.		Concentration.	
	lb.	oz.		Per Cent. Zn.	Per Cent. Fe.	Zn.	Fe.	Per Cent. Zn.	Per Cent. Fe.
1st Magnetic	43	0	26·7	7·22	48·90	3·105	21·027	7·80	49 38
2nd "	13	9	8·4	31·19	23·01	4·231	3·122	10·62	7·33
Iron........	19	9	12·1	18·50	30·71	3·613	5·998	9·07	14·09
Calcite.......	16	6	10·2	23·07	8·29	3·783	1·360	9·50	3·19
Zinc........	68	8	42 6	36·63	16 17	25·096	11·078	63·01	26·01
Totals and averages..	161	0	100·0	24·73	26·45	39·828	42·585	100·00	100·00

Zinc Product—

42·6 % of crude concentrates.
Analysis: zinc, 36·63 %; iron, 16·17 %.
Recovery: 63·01 % of zinc values.
Iron removed from zinc product, 74% of iron values in crude concentrate.

Combined zinc and calcite product—

52·8 % of crude concentrate.

Calculated analysis, zinc, 34·02 %; iron, 14·65 %.

Recovery: 72·51 % of zinc values.
Iron removed from zinc and calcite products: 70·8 % of iron values in crude concentrate.

Run No. 2.—Magnetic separation followed by roasting and magnetic separation of roasted product.

As given above under run No. 1, the concentrate was first passed through the Ullrich magnetic separator. The current strength on the machine was 5 amperes at 110 volts and the rings were set half an inch from the feed plates. The following table shows the separation obtained:—

Product.	Weight.		Percentage by weight.	Analysis per cent.		Contents pounds.		Concentration per cent.	
	lb.	oz.		Zn.	Fe.	Zn.	Fe.	Zn.	Fe.
Magnetic..	43	0	26·7	7·22	48·90	3·105	21·027	7·40	49·82
Non-magnetic	118	0	73·3	32·94	17·95	38·869	21·181	92·60	50·18
Totals and averages..	161	0	100·0	26 07	26·22	41·974	42·208	100·00	100·00

One portion of the zinc product was given a magnetic roast, and passed through the separator. The current strength was increased to 10 amperes at 110 volts, the rings remaining at half inch from the feed plates. The results obtained are given in the following table:—

Product.	Weight.		Percentage by weight.	Analysis per cent.		Contents pounds.		Concentration per cent.	
	lb.	oz.		Zn.	Fe.	Zn.	Fe.	Zn.	Fe.
Magnetic	9	0	28·4	17·95	38·38	1·616	3·454	14·38	59·45
Non-magnetic	22	12	71 6	42·31	10·36	9·626	2·356	85 62	40·55
Totals and averages..	31	12	100·0	35·41	18·30	11·242	5·810	100 00	100·00

The above results are combined in the following table:—

Product.	Weight		Percentage by weight.	Analysis per cent.		Contents pounds.		Concentration per cent.	
	lb.	oz.		Zn.	Fe.	Zn.	Fe.	Zn.	Fe.
1st Magnetic...........	43	0	26·7	7·22	48·90	3·105	21·027	7·40	51·14
2nd Magnetic..	31	2	19·3	17·95	38·38	5·587	11·946	13·31	29·05
Non-magnetic..........	78	10	48·8	42·31	10 36	33·266	8·146	79·29	19·81
Roasting loss, etc........	8	4	5·2	....	....	....	. ...	....	....
Totals and averages..	161	0	100·0	26·01	25·56	41·958	41·119	100·00	100·00

The final zinc product obtained represents 48·8 % by weight of the crude concentrate. Analysis: zinc, 42·31%; iron, 10·36%.

Recovery: 79·29 % of the zinc values.

Iron removed from zinc product: 80·19 % of iron values in crude concentrate.

TEST NO. 27.

MAGNETITE-CHALCOPYRITE ORE.

A small 12-pound sample of this ore was received from R. R. Hedley, of Vancouver, B.C. The ore is magnetite with chalcopyrite, finely disseminated, which necessitates fine grinding to free the particles.

The sample was crushed to pass through a 100-mesh screen, a sample taken for analysis, and the remaining portion divided into small lots for testing purposes.

One portion of the ore was run through the Gröndal laboratory type dry magnetic separator, but it was found that this machine did not work satisfactorily on the ore in such a finely divided state. The laboratory Gröndal wet magnetic separator was not adapted to the separation of the ore, as there was considerable loss of the copper values in slime being carried over with the magnetic product. The construction of the Ullrich wet magnetic separation was best adapted to the ore, as the magnetic product was pulled out by the rings, while the shaking feed had a tendency to submerge the slime particles which were carried off with the non-magnetic product. Although only a current strength of 2·5 amperes at 65 volts was carried on the machine, the intense field drew considerable of chalcopyrite particles along with the magnetic product.

A preliminary run of a portion of the ore through the Ullrich wet magnetic separator gave products with the following analysis:—

Magnetic product:	Fe—67·93 %,	Cu—0·462 %,	S—1·438 %
Copper product:	Fe—24·78 %,	Cu—9·420 %,	S—........

The results obtained from the final run on a portion of the ore through the Ullrich magnetic separator are tabulated below:—

The analysis of the slime loss was figured by subtracting the sum of the combined metallic contents in the magnetic and copper products from that in the original heads.

Tons of magnetic products made per ton of crude: 0·875.

The units of crude required per unit of magnetic product: $\frac{100}{87\cdot5}=1\cdot14$

Percentage of iron in the crude saved in the magnetic product: 93·8.
Tons of magnetic product made per ton of crude: 0·875.

The units of crude required per unit of copper product: $\frac{100}{10.4} = 9.615$

Percentage of copper in the crude saved in the copper product: 48·7

STRENGTH of Current: 2·5 Amperes, 65 Volts.

Product.	Weight.		Percentage by weight.	Analysis per cent.			Contents pounds.			Concentration per cent.		
	lb.	oz.		Fe.	Cu.	S.	Fe.	Cu.	S.	Fe.	Cu.	S.
Magnetite..........	2	10	87·5	66·09	0·602	1·92	1·735	0·0158	0·0504	93·8	31·5	45·0
Copper.............	0	5	10·4	27·72	7·800	......	0·087	0·0244	.....	4·7	48·7	.....
Slime loss..........	0	1	2·1	28·80	15·040	......	0·018	0·0099	......	1·5	19·8	...
Heads.............	3	0	100·0	61·65	1·670	3·74	1·850	0·0501	0·1122	100·0	100·0	100·0

TEST No. 28.

HIGH PHOSPHORUS TAILINGS FROM MOOSE MOUNTAIN IRON MINE, SELLWOOD, ONTARIO.

A small sample of tailings from the concentration plant of the Moose Mountain, Limited, was received at the plant of the ore dressing laboratory.

Tests were conducted on this sample to obtain a product high in phosphorus content.

A portion of the sample was run through the Ullrich wet magnetic separator, and the non-magnetic product from the separator run over the small laboratory Wilfley table.

Ullrich separation—

Current strength: 10 amperes, 110 volts.
Distance of rings from feed: ½-inch.
Analysis of head sample: 0·197 per cent P.
Analysis of magnetic product: 0·417 per cent P.
Weight of magnetic product: 9·1 per cent of crude.
Magnetic product contains 19·2 per cent of Phos. in heads.
Analysis of non-magnetic product: 0·175 per cent P.
Weight of non-magnetic product: 90·9 per cent of crude.
Non-magnetic product contains 80·8 per cent of Phos. in heads.

Wilfley concentration of Ullrich separator tailings—

Wilfley concentrates = 17·2 % by weight.
Analysis = 0·330 % P.
Concentrate contains = 33·2 % of Phos. in separator tailing.
Wilfley middlings = 35·5 % by weight.
Analysis = 0·112 % P.
Middling contains = 23·2 % of Phos. in separator tailing.
Wilfley tailings = 34·2 % by weight.
Analysis = 0·075 % P.
Tailings contain = 14·4 % of Phos. in separator tailing.
Wilfley slimes = 13·1 % by weight.
Analysis = 0·374 % P.
Slimes contain 28·6 % of Phos. in separator tailing.

SUMMARY.

Product.	Analysis per cent phosphorus.	Per cent phosphorus in products.
Separator concentrates	0·417	19·2
Wilfley concentrates	0·330	26·8
" middlings	0·112	18·7
" tailings	0·075	11·6
" slimes	0·374	23·1
Head sample	0·197	99·4

TEST No. 29.

A 200-pound shipment of ilmenite ore was received at the testing laboratory from Mr. Girard. Several concentration tests were conducted on this ore on application of Mr. G. C. Bateman of the Canadian Mining and Exploration Company.

Run No. 1.—One bag of the ore was taken and crushed to pass a 10-mesh screen (·075-inch aperture). A sample was obtained for analysis by passing the material through Jones riffled sampler.

This sample gave an analysis of—

Fe	33·65	per cent.
TiO_2	33·60	"
SiO_2	6·72	"
$CaCO_3$	5·48	"
$MgCO_3$	7·30	"

The material through 10-mesh was then sized on 20-mesh (·034-inch aperture) and on 40-mesh (·015-inch aperture) screens resulting in the following sizes:—

— ·075″ + ·034″—

Weight, 29·00 lb.

Analysis, Fe	34·45	per cent.
TiO_2	33·31	"
Insol	6·64	"

— ·034″ + ·015″—

Weight, 14·25 lb.

Analysis, Fe	34·10	per cent.
TiO_2	33·89	"
Insol	6·75	"

— ·015″—

Weight, 17·25 lb.

Analysis, Fe	32·05	per cent.
TiO_2	32·81	"
Insol	6·78	"

Weights of sized products after sampling—

— ·075″ + ·034″	— 28·250 lb.
— ·034″ + ·015″	— 14·125 lb.
— ·015″	— 17·000 lb.

To the sized material was added 5 per cent by weight of powdered charcoal, and each size given a reducing roast to make the iron content more magnetic.

Dry Magnetic Separation on the Ullrich Separator

The sizes were passed separately.

The current strength on the magnets was 4·3 amperes at 110 volts.

The rings were set at half an inch from the feed plates.

No appreciable difference was noticed in the magnetic and non-magnetic products. The gangue material was evidently drawn up with the magnetic material while the non-magnetic products showed it to contain an equal amount of ilmenite particles as the magnetic products.

Wet Magnetic Separation on the Ullrich Separator.

Size, — ·075 inch + ·034 inch. Weight, 25·50 lb.

Current strength on the magnets, 4·3 amperes, 110 volts.

Rings set at ½ inch from the feed plates.

Magnetic product. Weight, 25·00 lb.

Analysis, Fe	31·65	per cent.
TiO_2	37·14	"
Insol.	7·41	"

Non-magnetic product. Weight, 0·50 lb.

No analysis was determined, as this product contained a considerable amount of charcoal.

Size, — ·034 + ·015. Weight, 12·00 lb.

Current strength on magnets, 4·3 amperes, 110 volts.

Rings set at ½ inch from the feed plates.

Magnetic product. Weight, 11·75 lb.

Analysis, Fe	33·75	per cent.
TiO_2	33·17	"
Insol.	6·63	"

Non-magnetic product. Weight, 0·25 lb.

No analysis was determined as this product contained a considerable amount of charcoal.

Size, — ·015. Weight, 15·00 lb.

Current strength on magnets, 4·3 amperes, 110 volts.

Rings set at ½ inch from the feed plates.

Magnetic product. Weight, 12·50 lb.

Analysis, Fe	33·00	per cent.
TiO_2	30·60	"
Insol.	9·84	"

Non-magnetic product. Weight, 1·25 lb.

No analysis was determined as this product contained a considerable amount of charcoal.

The above operation shows that no marked concentration has been made.

This may be due to the difficulty experienced in obtaining an even roast.

Electrostatic Separation of the Magnetic Products from the Ullrich Magnetic Separator.

Size, — ·075″ + ·034″—

Voltage on electrode, 25,000.

Distance of electrode from roll, 2 inches.

Passes, 2.

Analysis of concentrates, Fe	33·18	per cent.
TiO_2	34·00	"
Insol.	6·69	"

Size, — ·034″ + ·015″—
Voltage on electrode, 20,000.
Distance of electrode from roll, 2 inches.
Passes, 1.
Analysis of concentrates, Fe. . . . . 33·53 per cent.
TiO_2. . . . . 36·71 “
Insol. . . . . 6·80 “

Size, — ·015—
Voltage on electrode, 18,000.
Distance of electrode from roll, 2 inches.
Passes, 1.
Analysis of concentrates, Fe. . . . . 31·69 per cent.
TiO_2. . . . . 35·17 “
Insol. . . . . 8·38 “

This operation shows that with the finer sizes the TiO_2 content is raised 5 per cent, the insoluble content remaining about the same. This, however, is at the expense of losing a large percentage of the TiO_2 content in the tailings.

The concentrate obtained from the electrostatic separator of the size — ·015 was run over the laboratory dry magnetic separator. The analysis of the concentrate obtained was: Fe, 35·17%; TiO_2, 37·34%; and insoluble, 4·46%. Analysis of the tailing showed it to contain 9·72% insoluble. This concentration was obtained also at the expense of losing a large percentage of the TiO_2 content in the tailings.

Run No. 2.—One bag of the ore was taken and crushed in the jaw crusher and rolls, and re-ground in pebble jars. A sample was taken for analysis which showed it to contain:—

Iron. . . . . 33·03 per cent.
TiO_2. . . . . 29·82 “
Insol. . . . . 13·30 “

A screen analysis was also made to determine the state of fineness of the ore after re-grinding:—

Mesh.	Aperture.	Weight.	Percentage.	Accummulated.
+ 80	+ ·0062″	3·17 oz.	17·36	17·36
− 80 + 100	+ ·0050″	0·78 "	4·27	21·63
− 100 + 120	+ ·0042″	1·17 "	6·41	28·04
− 120 + 150	+ ·0032″	1·04 "	5·70	33·74
− 150 + 200	+ ·0025″	4·11 "	22·51	56·25
− 200	− ·0025″	7·99 "	43·76	43·76

Twenty-six pounds of the crushed ore were taken, to which were added 2 pounds of powdered charcoal, and the whole mixed thoroughly, and given a reducing roast.

A small sample of the roasted ore was run through the laboratory Gröndal wet magnetic separator. Only a small portion of the more finely divided material came over as concentrates. This was due to the weak field of the magnets, which is only adaptable to highly magnetic material.

The remainder of the roasted ore was run through the Ullrich wet magnetic separator.

Current strength on the magnets, 4·3 amperes, 110 volts.

Distance of rings from feed plates, ½ inch.

Concentrates obtained gave an analysis of:—Fe, 35·25 per cent; TiO_2, 33·53 per cent; insoluble, 9·65 per cent.

By this operation the content of the concentrate shows an increase over the content of the original ore of: Iron, 2·22 per cent; TiO_2, 3·71 per cent; insoluble, 3·65 per cent.

Run No. 3.—One bag of the ore was taken and crushed in the laboratory jaw crusher and rolls to pass through a 5-mesh (0·159″ aperture) screen. The material through 5-mesh was sized on 10, 20, 40, and 80-mesh. The following weights and analysis of the various sizes were obtained:—

Sizes.	Weight.	Analysis.		
		Per cent Fe.	Per cent TiO_2	Per cent Insoluble.
	Pounds.			
− 0·1590 + 0·0750	33·75	36·40	33·75	8·28
− 0·0750 + 0·0340	17·25	36·38	33·49	8·29
− 0·0340 + 0·0150	10·50	36·12	31·99	9·82
− 0·0150 + 0·0068	5·50	34·55	30·96	10·85
− 0·0068	8·50	33·05	28·89	12·88
Totals and averages....	75·50	35·85	32·70	9·20

Size, —5 + 10 mesh (—0·1590 + 0·0750)—

Weight, 33·75 pounds; weight of sample, 1·25 pounds. Concentrated on laboratory Richard's pulsator jig.

Jig Concentrates—

Weight, 28 lb.
Analysis, Fe.. .. .. 36·10 per cent.
TiO_2.. .. .. 33·82 "
Insol.. .. .. 8·52 "

Jig Tailings—

Weight, 4·5 lb.
Analysis, Fe.. .. .. 34·60 per cent.
TiO_2.. .. .. 31·56 "
Insol.. .. .. 12·11 "

Size, —10 + 20 mesh (—0·0750 + 0·0340)—

Weight, 17·25 pounds; weight of sample, 0·25 pounds.
Concentrated on laboratory Richard's pulsator jig.

Jig Concentrate—

Weight, 14·5 lb.
Analysis, Fe.. .. .. 36·91 per cent.
TiO_2.. .. .. 33·60 "
Insol.. .. .. 7·90 "

Jig Tailings—

Weight, 2·5 lb.
Analysis, Fe.. .. .. 33·43 per cent.
TiO_2.. .. .. 30·68 "
Insol.. .. .. 13·05 "

Size, —20+40 mesh (—0·0340+0·0150)—

Weight, 10·50 pounds; weight of sample, 3·50 pounds.
Concentrated on laboratory Richard's pulsator jig.

Jig Concentrate—

Weight, 5·75 lb.

Analysis, Fe	37·15 per cent.
TiO_2	33·53 "
Insol	8·06 "

Jig Tailings—

Weight, 1·25 lb.

Analysis, Fe	32·05 per cent.
TiO_2	24·67 "
Insol	17·13 "

Jig products mixed and reconcentrated on laboratory Wilfley table.

Wilfley Concentrate—

Weight, 2·50 lb.

Analysis, Fe	36·15 per cent.
TiO_2	33·39 "
Insol	9·02 "

Wilfley Tailings—

Weight, 0·50 lb.

Analysis, Fe	32·85 per cent.
TiO_2	27·02 "
Insol	14·87 "

Size, —40+80 mesh (—0·0150+0·0068)—

Weight, 5·50 lb.; weight of sample, 0·50 lb.
Concentrated on laboratory Wilfley table.

Wilfley Concentrates—

Weight, 3·375 lb.

Analysis, Fe	35·59 per cent.
TiO_2	33·97 "
Insol	9·11 "

Wilfley Tailings—

Weight, 1·625 lb.

Analysis, Fe	31·85 per cent.
TiO_2	28·35 "
Insol	14·97 "

Size, —80 mesh (—0·0068)—

Weight, 8·50 lb; weight of sample, 0·50 lb.
Only a portion of this size was run over the laboratory Wilfley table.

Wilfley Concentrates—

Weight, 1·125 lb.

Analysis, Fe	36·00 per cent.
TiO_2	33·88 "
Insol	8·79 "

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GRAPHIC METHOD OF ILLUSTRATING EXTRACTION

ZINC MIDDLINGS

RUN NO. 1, TEST NO. 30

🟨 Zinc 🟦 Lead ⬛ Iron

Fig. 11

2

GRAPHIC METHOD OF ILLUSTRATING EXTRACTION

ZINC MIDDLINGS

RUN NO. 2, TEST NO. 30

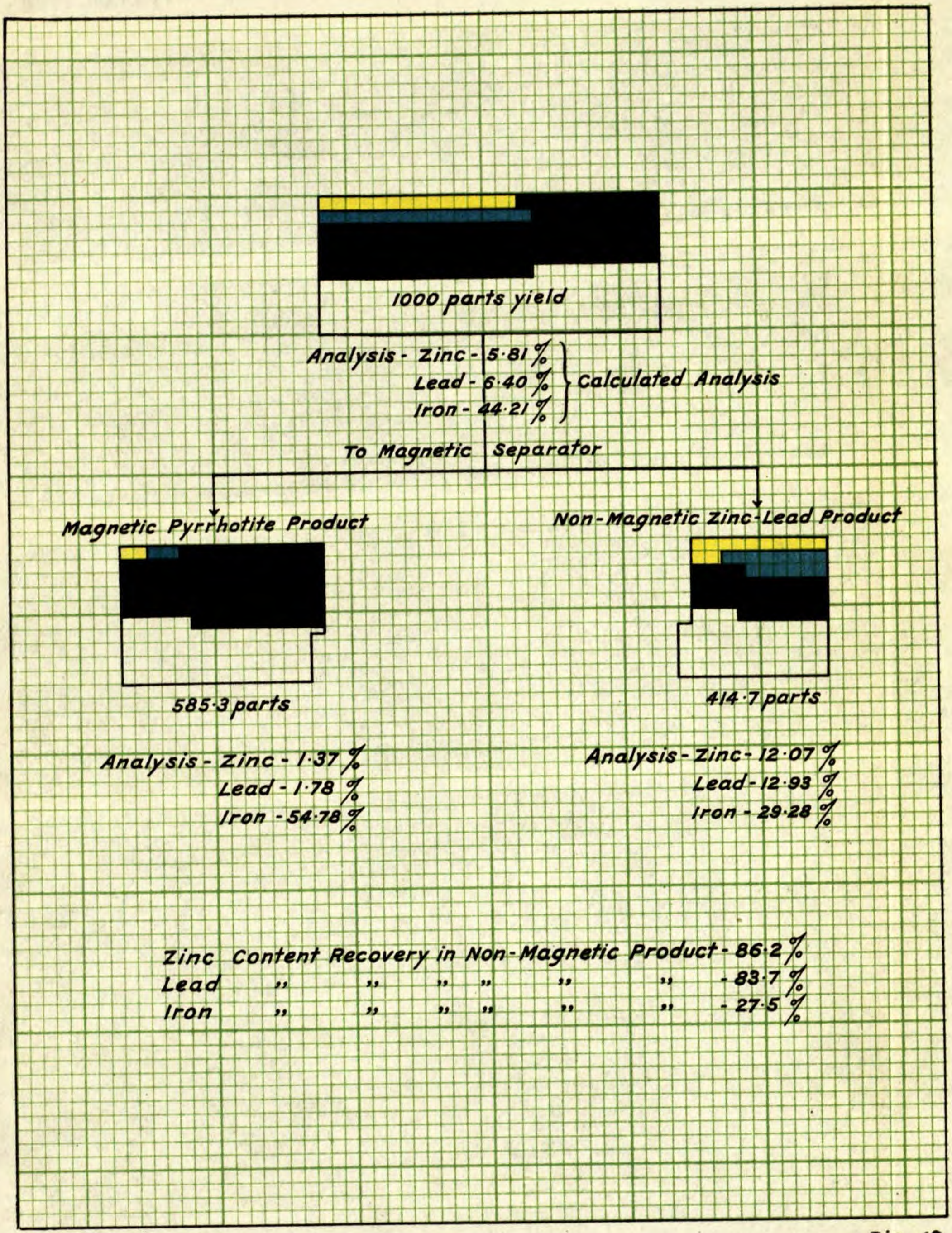


Fig. 12

🟨 Zinc 🟦 Lead ⬛ Iron

Wilfley Tailings—

Weight, 0·875 lb.

Analysis, Fe	31·55	per cent.
TiO_2	24·55	"
Insol	17·39	"

From the above treatment, the TiO_2 content of the concentrate obtained, shows an increase of 1 per cent over the content of the original ore, and the insoluble content has been decreased by a similar amount. On the coarser sizes + 20 mesh there is very little difference, but on the finer sizes — 20 mesh the TiO_2 content of the concentrate shows an increase of from 2 per cent to 4 per cent over the content of the original ore, and the insoluble content has been decreased by a similar amount.

The jig and table products were mixed together, re-sized, and the sizes treated separately on the electrostatic separator. No noticeable separation was seen to have taken place.

Test No. 30.

A shipment of 240 pounds of zinc middlings from the concentrating plant of the Blue Bell Mine, Riondel, B.C., was received at the ore testing laboratories.

The shipment was made by Mr. S. S. Fowler, general manager of the New Canadian Metal Co., Ltd., who asked for a test to be made on the Ullrich magnetic separator, in the wet way, with the object of removing as much clean pyrrhotite, and leaving as much lead and zinc as possible in the non-magnetic product.

A sample was obtained by means of the Jones riffled samplers. This sample showed an analysis of:—

Zinc	7·68	per cent.
Lead	6·47	"
Iron	44·82	"

Run No. 1.—The circular rings of the separator were adjusted in steps with the following distances from the shaking feed plates:—

Outer ring	¾″
Second ring	⅝″
Third ring	½″
Fourth ring	⅜″

A current strength of 6·6 amperes, 90 volts was used on the magnets.

The duration of the run was 6·5 minutes.

The weights and analysis of the concentration products were as follows:—

Magnetic (Pyrrhotite) Product. —		Non-Magnetic (Zinc, Lead) Product.	
Weight	130·375 lb.	Weight	92·0 lb.
Analysis—Zinc	1·79 per cent.	Analysis—Zinc	12·45 per cent.
Lead	1·83 "	Lead	12·58 "
Iron	54·92 "	Iron	33·38 "

Run No. 2.—Rings were left the same as run No. 1.

A current strength of 9·7 amperes, 97 volts was used on the magnets.

The duration of the run was 17 minutes.

The weights and analysis of the concentration products were as follows:—

Magnetic (Pyrrhotite) Product. —		Non-Magnetic (Zinc, Lead) Product.	
Weight	129·50 lb.	Weight	91·75 lb.
Analysis—Zinc	1·37 per cent.	Analysis—Zinc	12·07 per cent.
Lead	1·78 "	Lead	12·93 "
Iron	54·78 "	Iron	29·28 "

TEST No. 31.

A shipment of 1,000 pounds of pyrite ore was received at the ore testing laboratories from the Northern Pyrites Company's mine at North Pines, Ontario.

The ore represented a considerable tonnage of the second run of mine, and consisted of pyrite and pyrrhotite with magnetite in a siliceous gangue.

PRELIMINARY TESTS.

The ore was crushed in the jaw crusher set at 1 inch opening, screened on a 2-mesh screen 0·437-inch aperture. The oversize was crushed in the laboratory jaw crusher set at ¼-inch opening and screened on the 2-mesh screen. The following sizes were obtained by screening:—

Size.	Aperture.	Weight.	Analysis.
Mesh.	Inches.	Pounds.	% Sulphur.
− 2+ 3	−0·437	300·186	33·55
− 3+ 4	−0·279	122·750	33·68
− 4+ 6	−0·203	96·125	31·17
− 6+ 8	−0·132	141·250	30·43
− 8+12	−0·097	146·938	28·78
−12+20	−0·060	35·186	28·82
−20+30	−0·034	25·625	28·95
−30+50	−0·0198	20·875	30·30
−50	−0·0110	92·813	30·45

Dry Magnetic Separation of Screen Sizes.

Size, —2 + 3. Weight, 285 lb.
Current strength on belt magnets, 4 amperes, 105 volts.
“ “ drum “ 20 “ 105 “
Belt travel, 311 feet per minute.
Tailing vane raised 5 inches.
Concentrates obtained, 67·75 lb. Analysis, 41·98 % S.
Tailings “ 217·25 lb. “ 29·61 % S.

Size, —3 + 4. Weight, 117·75 lb.
Current strength on belt magnets, 4 amperes, 105 volts.
“ “ drum “ 20 “ 105 “
Belt travel, 311 feet per minute.
Tailing vane raised 5 inches.
Concentrate obtained, 31·00 lb. Analysis, 41·44 % S.
Tailings “ 86·75 lb. “ 29·91 % S.

Size, —4 + 6. Weight, 90·5 lb.
Current strength on belt magnets, 4·7 amperes, 105 volts.
“ “ drum “ 30 “ 105 “
Belt travel, 311 feet per minute.
Tailing vane raised 3 inches.
Concentrate obtained, 31·25 lb. Analysis, 40·03 % S.
Tailings “ 59·25 lb.

Size, — 6 + 8. Weight, 136 lb.

Current strength on belt magnets, 4 amperes, 105 volts.
" " drum " 20 " 105 "
Belt travel, 311 feet per minute.
Tailing vane raised 4 inches.
Concentrate obtained, 60·5 lb. Analysis, 38·78 % S.
Tailings " 75·5 lb. " 23·28 % S.

Size, — 8 + 12. Weight, 141·5 lb.

Current strength on belt magnets, 4 amperes, 100 volts.
" " drum " 20 " 100 "
Belt travel, 311 feet per minute.
Tailing vane raised 4 inches.
Concentrates obtained, 52·25 lb. Analysis, 40·25 % S.
Tailings " 89·25 lb. " 22·41 % S.

Size, — 12 + 20. Weight, 30·25 lb.

Current strength on belt magnets, 4 amperes, 98 volts.
" " drum " 17·5 " 98 "
Belt travel, 311 feet per minute.
Tailing vane raised 3½ inches.
Concentrates obtained, 13·5 lb. Analysis, 38·75 % S.
Tailings " 16·75 lb. " 20·54 % S.

Size, — 20 + 30. Weight, 21·5 lb.

Current strength on belt magnets, 4 amperes, 96 volts.
" " drum " 15 " 96 "
Belt travel, 311 feet per minute.
Tailing vane raised 3 inches.
Concentrates obtained, 11·0 lb. Analysis, 37·09 % S.
Tailings " 10·5 lb. " 19·90 % S.

Size, — 30 + 50. Weight, 16·375 lb.

Current strength on belt magnets, 4 amperes, 95 volts.
" " drum " 12·5 " 95 "
Belt travel, 311 feet per minute.
Tailing vane raised 2½ inches.
Concentrates obtained, 9·25 lb. Analysis, 38·70 % S.
Tailings " 7·125 lb. " 20·27 % S.

Size, — 50. Weight, 88·75 lb.

Separator did not work satisfactorily on the fines.

From the results obtained, and data collected on the above preliminary tests, it was found that a satisfactory separation could be made on the coarser sizes by the use of the dry magnetic separator, and that a separation could be made on the fines by magnetic separation, followed by table concentration, or vice versa.

FINAL TESTS.

In order to simplify the process, the sizes used in the preliminary tests were grouped, and the tailings from the coarser sizes were re-crushed and added to the next size.

Size — 2 + 6 (— 0·437 + 0·132). Weight, 468 lb.—
Current strength on rectifying magnets, 4 amperes, 105 volts.
" " " drum " 20 " 105 "
Belt travel, 311 feet per minute.
Tailing vane raised 5 inches,
Concentrates obtained, 127 lb. Analysis, 41·51 % S.
Tailings " 341 lb. " 29·29 % S.
Weights of samples taken: Concentrates, 7 lb. 1 oz.
Tailings 5 lb. 8 oz.

The tailings, less the weight of the sample, were crushed in rolls to pass the 6-mesh screen, and sized on the 20-mesh screen. The oversize was added to the sizes —6 + 8, —8 + 12, and —12 + 20 from the preliminary test.

Size, — 6 + 20 (— 0·132″ + 0·234″). Weight, 331·5 lb.—
Current strength on rectifying magnets, 4 amperes, 103 volts.
" " " drum " 20 " 103 "
Belt travel, 311 feet per minute.
Tailing vane raised 4 inches.
Concentrates obtained. 95·75 lb. Analysis, 40·05 % S.
Tailings " 235·75 lb. " 25·27 % S.
Weight of samples taken: Concentrates, 3 lb. 3 oz.
Tailings 3 lb. 12 oz.

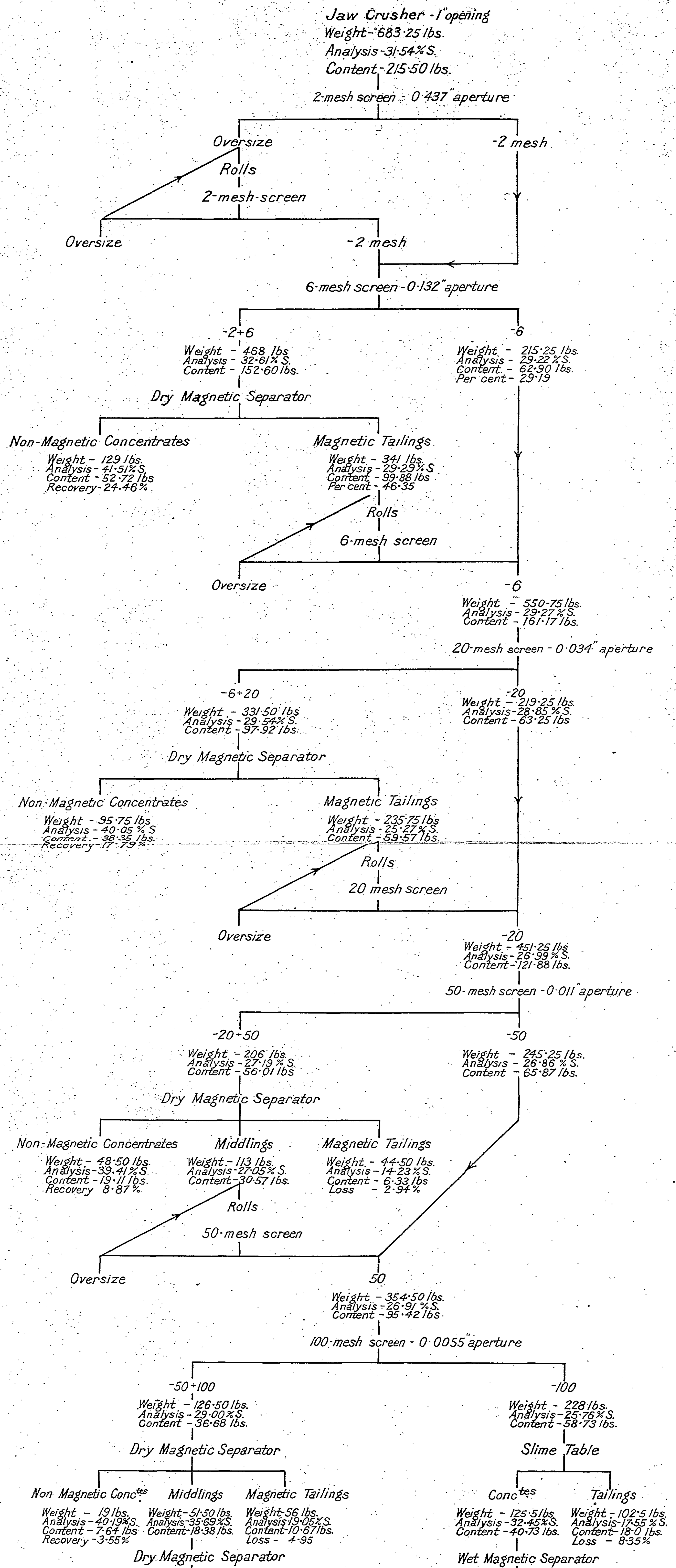
The tailings, less the weight of the sample, were crushed in rolls to pass the 20-mesh screen, and added to the re-crushed tailings from —2 + 6 size through 20-mesh. These were sized on the 50-mesh screen, and the oversize added to the sizes, —20 + 30 and —30 + 50 from the preliminary test.

Size, —20 + 50 (0·034 + 0·011). Weight, 206 lb.—
Current strength on rectifying magnets, 4 amperes, 103 volts.
" " " drum " 20 " 103 "
Belt travel, 311 feet per minute.
Tailing vane raised 3½ inches.
Concentrate vane in No. 7 notch.
Concentrates obtained, 48·50 lb. Analysis, 39·41 % S.
Middlings " 113·00 lb. " 27·05 % S.
Tailings " 44·50 lb. " 14·23 % S.
Weights of samples taken: Concentrates, 3 lb. 1 oz.
Middlings 3 lb. 12 oz.
Tailings 2 lb. 12 oz.

The middlings, less the weight of the sample, were crushed in rolls to pass the 50-mesh screen, and added to the re-crushed tailings from the former sizes through 50-mesh, and to the size —50 from the preliminary test. The products were mixed thoroughly, and screened on the 100-mesh screen.

Size, — 50 + 100 (— 0·011 + 0·055). Weight, 125·50 lb.
Current strength on rectifying magnets, 4 amperes, 108 volts.
" " " drum " 30 " 108 "
Belt travel, 311 feet per minute.
Tailing vane raised 3½ inches.
Concentrate vane in No. 5 notch.
Concentrates obtained, 19 lb. Analysis, 40·19 % S.

2


Jaw Crusher - 1" opening
Weight - 683·25 lbs.
Analysis - 31·54% S.
Content - 215·50 lbs.
2-mesh screen - 0·437" aperture
Oversize
-2 mesh
Rolls
2-mesh-screen
Oversize
-2 mesh
6-mesh screen - 0·132" aperture
-2+6
Weight - 468 lbs
Analysis - 32·61% S.
Content - 152·60 lbs.
-6
Weight - 215·25 lbs.
Analysis - 29·22 % S.
Content - 62·90 lbs.
Per cent - 29·19
Dry Magnetic Separator
Non-Magnetic Concentrates
Weight - 129 lbs.
Analysis - 41·51% S.
Content - 52·72 lbs
Recovery - 24·46%
Magnetic Tailings
Weight - 341 lbs.
Analysis - 29·29% S
Content - 99·88 lbs
Per cent - 46·35
Rolls
6-mesh screen
Oversize
-6
Weight - 550·75 lbs.
Analysis - 29·27 % S.
Content - 161·17 lbs.
20-mesh screen - 0·034" aperture
-6+20
Weight - 331·50 lbs
Analysis - 29·54% S.
Content - 97·92 lbs.
-20
Weight - 219·25 lbs.
Analysis - 28·85 % S.
Content - 63·25 lbs
Dry Magnetic Separator
Non-Magnetic Concentrates
Weight - 95·75 lbs
Analysis - 40·05 % S
Content - 38·35 lbs.
Recovery - 17·79%
Magnetic Tailings
Weight - 235·75 lbs
Analysis - 25·27 % S.
Content - 59·57 lbs.
Rolls
20 mesh screen
Oversize
-20
Weight - 451·25 lbs
Analysis - 26·99 % S.
Content - 121·88 lbs.
50-mesh screen - 0·011" aperture
-20+50
Weight - 206 lbs
Analysis - 27·19 % S.
Content - 56·01 lbs
-50
Weight - 245·25 lbs.
Analysis - 26·86 % S.
Content - 65·87 lbs.
Dry Magnetic Separator
Non-Magnetic Concentrates
Weight - 48·50 lbs.
Analysis - 39·41% S.
Content - 19·11 lbs.
Recovery 8·87%
Middlings
Weight - 113 lbs.
Analysis - 27·05% S.
Content - 30·57 lbs.
Magnetic Tailings
Weight - 44·50 lbs.
Analysis - 14·23% S.
Content - 6·33 lbs
Loss - 2·94%
Rolls
50-mesh screen
Oversize
50
Weight - 354·50 lbs.
Analysis - 26·91 % S.
Content - 95·42 lbs
100-mesh screen - 0·0055" aperture
-50+100
Weight - 126·50 lbs.
Analysis - 29·00% S.
Content - 36·68 lbs.
-100
Weight - 228 lbs.
Analysis - 25·76% S.
Content - 58·73 lbs.
Dry Magnetic Separator
Slime Table
Non Magnetic Conctes
Weight - 19 lbs.
Analysis - 40·19% S.
Content - 7·64 lbs
Recovery - 3·55%
Middlings
Weight - 51·50 lbs.
Analysis - 35·69% S.
Content - 18·38 lbs.
Magnetic Tailings
Weight - 56 lbs.
Analysis 19·05% S.
Content - 10·67 lbs.
Loss - 4·95
Conctes
Weight - 125·5 lbs.
Analysis - 32·45% S.
Content - 40·73 lbs.
Tailings
Weight - 102·5 lbs.
Analysis - 17·55 % S.
Content - 18·0 lbs.
Loss - 8·35%
Dry Magnetic Separator
Wet Magnetic Separator

1

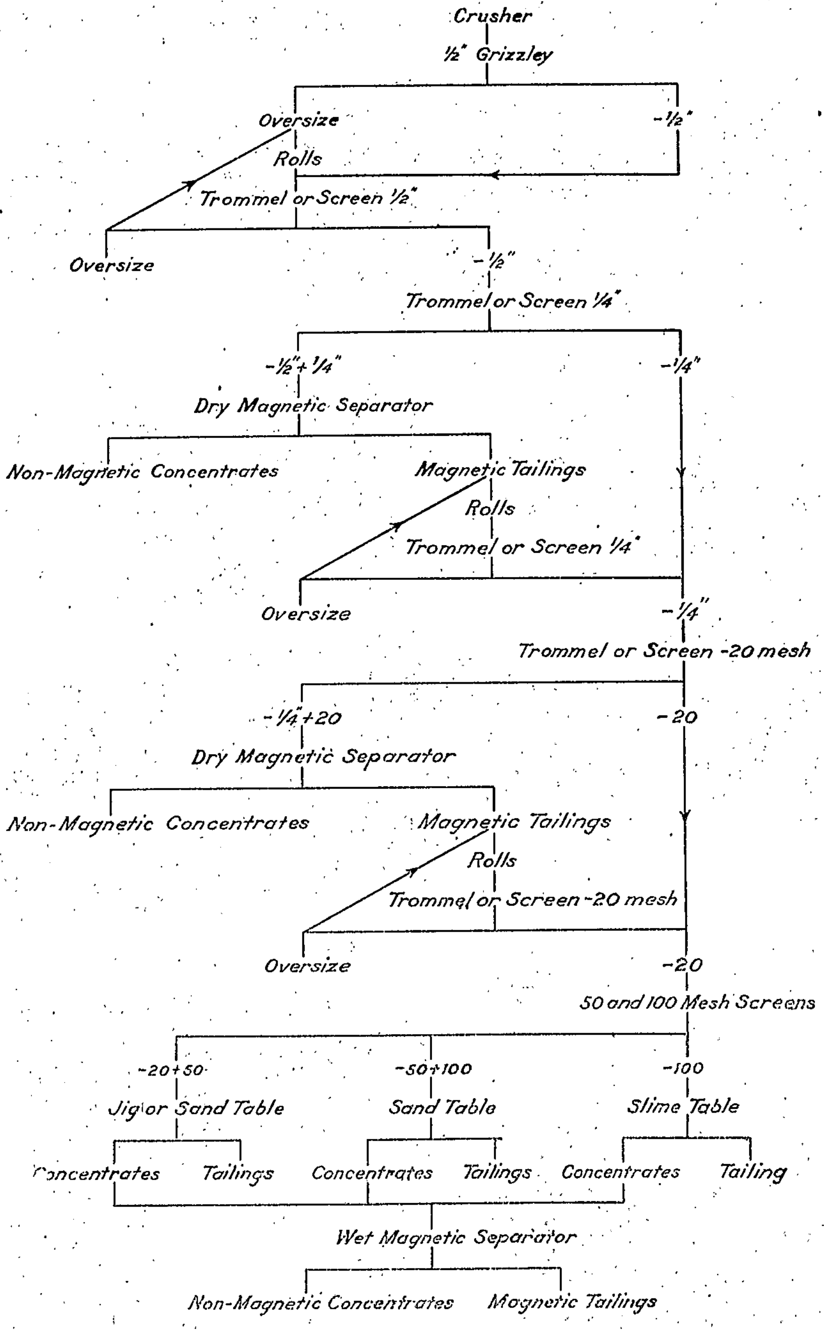
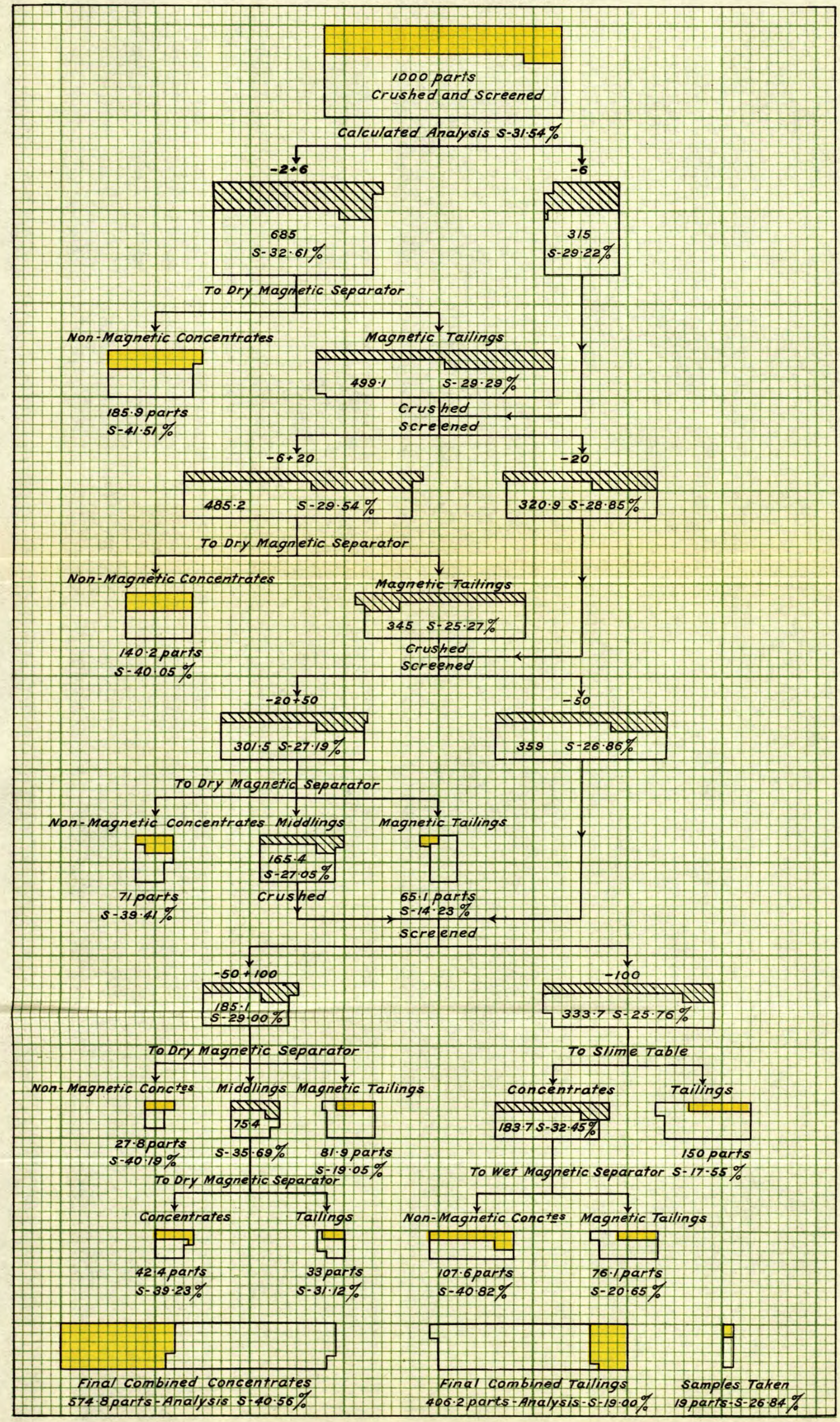


FIG. 14.—Flow sheet for concentration of pyrite ore. 2nd run of mine, Northern Pyrites Co., North Pines, Ont.

GRAPHIC METHOD OF ILLUSTRATING CONCENTRATION TESTS FOR THE RECOVERY OF SULPHUR FROM PYRITES ORE

TEST No. 31

NORTHERN PYRITES CO., NORTH PINES, ONT.



🟨 Sulphur

Fig. 15.

Middlings obtained, 51·5 lb.
Tailings " 56 lb. Analysis, 19·5% S.
The middlings were run over the separator with the tailing vane raised 3¼ inch.
Concentrates obtained, 29 lb. Analysis, 39·23 % S.
Tailings " 22·5 lb. " 31·12 % S.

Size—100, (—0·055). Weight 228 lb.—

A satisfactory separation could not be made by dry magnetic separation, so that table concentration on the Deister slime table followed by wet magnetic separation on the Ullrich magnetic separator was resorted to.

Deister concentrates obtained, 125·5 lb. Analysis, 32·45 % S.
Deister tailings " 102·5 lb. " 17·55 % S.

Concentrates were re-run on the Ullrich magnetic separator with a current strength of 10 amperes, 110 volts on the magnets.

Non-magnetic concentrates obtained, 73·5 lb. Analysis, 40·82 % S.
Magnetic tailings " 52·0 lb. " 20·65 % S.

The method of procedure, and the results obtained from the final run of the ore, are given in the following flow sheet. A graphic illustration showing the recovery from each operation, and the final total recovery of sulphur is also given.

TEST NO. 32.

A small sample of 4 pounds of zinc-lead-copper ore was received from Stanislas J. Pointon, Esq., of the Laurentide Mining Company, Notre Dame des Anges, county of Portneuf, Quebec.

Analysis of the sample showed it to contain:—

Zinc	21·30 per cent.
Lead	1·18 "
Copper	4·76 "
Insoluble	31·12 "
Silver	1·74 oz.

The sample was crushed to pass through 10-mesh and sized on the 16-, 20-, 30-, 40-, 60-, 80-, 100-, 150-, and 200-mesh screens. The sizes were run through the laboratory pneumatic jig, commencing at the coarser size, and following up with the finer sizes, without removing the jig bed. A fair separation was made on the sizes up to 100-mesh.

Analysis of the jig concentrate showed it to contain:—

Zinc	36·00 per cent.
Lead	1·08 "
Copper	6·97 "

Analysis of the jig tailing showed it to contain:—

Zinc	6·79 per cent.
Lead	0·26 "
Copper	1·44 "

The products from the above separation were mixed together and run over the laboratory Wilfley table. The concentrates from the Wilfley table were treated on the Huff electrostatic separator to obtain a separation of the copper values from the zinc values. It was found that the zinc particles, together with their iron content, were almost as conductive as the chalcopyrite particles. The separation was not satisfactory.

Further tests were not made, as there was such a small quantity of the material that it was impossible to do anything further with it.

From tests conducted on a similar ore, a possible concentration would be that of jig and table concentration, magnetic separation, and oil flotation of the table tailings.

TEST NO. 33.

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

Concentration Tests.

Two shipments of magnetic iron sands were received at the ore testing laboratories, from Natashkwan, Quebec. These samples were taken during the summers of 1912 and 1913.

The method of obtaining these samples has already been described in the Summary Report of 1913. To enable the following tests to be more easily understood, a brief description of the method of obtaining the samples is given.

The deposits of magnetic iron sand situated at the mouth of the Natashkwan river were surveyed and blocked off into squares with 500-feet sides. Five holes were drilled in each square; one at each of the four corners and one in the centre. The core from each of these drill holes was bagged separately, numbered, and shipped to Ottawa. While the above sand was being bagged, a field sample was taken of each 5 feet of the core. The magnetic iron content of this sample was determined in the field by a hand magnet and a set of balances.

To check the accuracy of the field sample, the bags containing the cores of each bore hole were sorted out and separated. The core from each bore hole was dried separately, and its dry weight and volume in cubic feet were obtained. It was then run over a Gröndal dry magnetic separator, and the products were weighed up and the results checked with those obtained from field samples.

The Field Samples of 1912 were Tested First.

As stated above, the core from each bore hole was dried, and the weight and volume of the sand obtained. They were then run separately over a Gröndal dry magnetic separator.

The combined weight of the concentrates obtained from all the samples was 1,024 pounds, and that of the tailings, 19822·05 pounds.

ANALYSIS of first Concentrate and first Tailing obtained from the Gröndal Dry Magnetic Separator.

——	Fe.	FeO	TiO_2	SiO_2	Au.
	per cent.	per cent.	per cent.	per cent.	
Crude	6·75	....	....	....	....
First concentrate	64·12	....	2·40	7·64	....
First tailing	3·79	1·89	2·30	82·37	none.

It is very difficult to obtain an average sample of the dry sand. The concentrates were sampled on the Jones riffled samplers to approximately 10 pounds. One-half was taken for a screen analysis, and the other half for the regular sample. The tailings were sampled through Vezin samplers, to an amount small enough to cut down in the riffled sampler. Screen sizing tests were made on the tailings; one on a small sample of 3124·97 grams, using a set of Tyler standard screens after Rittenger's scale, and a larger one on a sample weighing 1747·50 pounds, using the Keedy sizer.

Grinding and reconcentration of the first concentrate.

The first concentrate from the cobber was ground in a Hardinge 4 × 6-inch conical mill and fed to a Gröndal double drum wet magnetic separator.

A screen analysis was made on the tube mill discharge and also on the final concentrate and tailing from the separator.

ANALYSES of First Concentrate, Second Concentrate, and Tailing.

——	Fe.	FeO	TiO_2	SiO_2	S.	P.	Mn.	CaO	MgO
	%	%	%	%	%	%	%	%	%
First concentrate.......	64·12	....	2·40	7·64	....	....	....	....	....
Second concentrate......	69·39	......	1·52	2·08	trace	0·008	0·043	trace	trace
Second tailing........	26·50	5·52	7·57	56·14	......	....	....	....	....

Calculation of iron saved from second concentration—

$$\frac{69{\cdot}39 - 26{\cdot}55}{64.12 - 26{\cdot}55} = 1{\cdot}141$$ tons of first concentrate required per unit of second concentrate.

$$\frac{69{\cdot}39 \times 100}{64{\cdot}12 \times 1{\cdot}141} = 94{\cdot}8\ \%$$ of the iron saved.

Calculation of iron saved from analyses and actual weights.

Weight of first concentrate	1024	pounds.
" " second concentrate	902·1	"
" " " tailing	121·9	"

$$\frac{(902{\cdot}1 \times 69{\cdot}39)\ 100}{1024 \times 64{\cdot}12} = 95{\cdot}37.$$

SCREEN TEST OF FIRST CONCENTRATES: (Lot 1912) Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grm.	Direct per cent of total weight.	Cumulative per cent of weight.	Iron per cent.	Distribution of iron per cent of total.	Cumulative per cent of total iron.	Titanic acid per cent.	Distribution of acid per cent total.	Cumulative per cent of total titanic acid.
+ 20	·0328	0·47	0·73	0·73	12·31	1·42	1·42	2·13	0·71	0·71
− 20 + 28	·0232	2·87								
− 28 + 35	·0164	13·21								
− 35 + 48	·0116	65·49	2·89	3·62	21·47	·98	2·38	3,08	4·10	4·87
− 48 + 65	·0082	235·24	10·39	14·02	43·27	7·03	9 41	3·65	18·28	22·51
− 65 + 100	·0058	673·25	29·74	43·75	63·63	29·63	39·10	2·53	34·98	57·53
− 100 + 150	·0041	1173·42	51·81	95·50	69·37	56·23	95·36	1·65	39·73	97·30
− 150 + 200	·0029	74·80	3·31	98·80	69·68	3·60	99·35	1·23	1·89	99·17
− 200 +	....	25·30	1·12	....	61·82	1·08	... ...	1·72	·88	
Totals......	....	2264·05	99·99	....	....	99·99	....	....	....	....

NATASHKWAN IRON SANDS (1912).—Sizing Test using Tyler Standard Screens on Tailings from first concentration.

Mesh.	Aperture in inches.	Weight in grm.	Direct per cent.	Cumulative per cent.
+ 14	0·0460	26·93	0·86	0·86
− 14+ 20	0·0328	39·97	1·28	2·14
− 20+ 28	0·0232	101·21	3·24	5·38
− 28+ 35	0·0164	267·62	8·57	13·94
− 35+ 48	0·0116	1619·32	51·82	65·76
− 48+ 65	0·0082	675·85	21·63	87·41
− 65+100	0·0058	238·99	7·65	95·01
−100+150	0·0041	130·13	4·16	99·22
−150+200	0·0029	16·16	0·52	99·73
−200+ 8	8	8·79	0·28	
Totals............	....	3124·97	99·99	

NATASHKWAN IRON SANDS (1912).—Keedy Sizer Test on Tailings from first concentration.

Mesh.	Screen No.	Aperture inches.	Weight in pounds.	Direct per cent.	Cumulative per cent.
20	20 SW	·0410	37·00	2·12	2·12
24	24 SW	·0342	29·50	1·69	3·80
28	28 SW	·0282	42·50	2·43	6·24
34	34 SW	·0229	60·00	3·43	9·67
42	42 SW	·0183	86·00	4·92	14·59
50	50 SW	·0145	258·00	14·75	29·35
62	4 XX	·0116	504·50	28·87	58·25
74	6 XX	·0089	428·50	24·52	82·73
86	8 XX	·0068	97·50	5·58	88·30
109	10 XX	·0054	143 50	8·21	96·50
125	12 XX	·0041	38·00	2·17	98·70
150	15 XX	·0036	....	....	....
200	25 Std.	·0026	18·00	1·03	99·78
....	—25 Std.	....	4·50	0·26	....
Totals	....	....	1747·50	....	....

SCREEN TEST tube mill discharge grinding first concentrate: (Lot 1912) Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Per cent of total weight.	Cumulative per cent of total weight.	Per cent of iron.	Distribution of iron per cent of total.	Cumulative per cent of iron.	Per cent of titanic acid.	Distribution of titanic acid of total.	Cumulative per cent of titanic acid.
+ 28	·0232	0·34	·074	·074	60·24[1]	·07	·07	2·14	·065	·065
− 28+ 35	·0164	0·95								
− 35+ 48	·0116	0·70								
− 48+ 65	·0082	12·40	·46	·535	19·51	·14	·214	1·55	·31	·379
− 65+100	·0058	87·97	3·27	3·81	37·52	1·95	2·16	2·77	4·02	4·40
−100+150	·0041	750·75	27·94	31·75	62·30	27·64	29·78	2·34	28·94	49·87
−150+200	·0029	648·02	24·10	55·87	65·50	25·05	54·81	2·14	22·82	72·68
−200	....	1186·85	44·16	....	64·50	45·15	....	2·24	43·80	....
Totals ...	... .	2687·98	100·00	....	....	....	....	....	....	....

---

[1] NOTE.—This high iron is due to pieces of iron from the tube mill.

SCREEN TEST of second concentrate: (Lot 1912).—Showing distributions of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Direct per cent of total weight.	Cumulative per cent of 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 titanic acid.
− 48+ 65	·0072	2·27	0·23	0·23	55·64	2·40	2·40	2·83	5·77	5·77
− 65+100	·0042	27·29	2·73	2·956						
−100+150	·0026	259·44	25·95	28·90	67·62	25·66	28·04	1·73	31·10	26·93
−150+200	·0021	255·00	25·50	54·40	68·80	25·65	53·69	1·41	24·89	61·80
−200	....	456·00	45·60	....	69·45	46·28	....	1·21	38·23	....
Totals ...	....	1000·00	100·00	....	....	....	....	....	....	....

SCREEN TEST on second tailing: (Lot 1912). Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Direct per cent of total weight.	Cumulative per cent of total weight.	Per cent iron.	Direct per cent of total iron.	Cumulative per cent of total iron.	Per cent titanic acid.	Direct per cent of titanic acid.	Cumulative per cent of titanic acid.
+ 35	·0122	1·00	·10	·10	6·73	·305	·305	0 92	·15	·15
− 35+ 48	·0092	1·00	·10	·20						
− 48+ 65	·0072	10·00	1·00	1·20						
− 65+100	·0042	93·00	9·30	10·50	7·23	2·54	2 84	2·22	2·89	3·05
−100+150	·0026	242·00	24·20	34·70	18·17	16·56	19·40	8·84	23·22	26·23
−150+200	·0021	242·00	24·20	58·90	26·73	24·36	43·75	8·98	30·05	56·73
−200	....	411·00	41·10	....	36·33	56·23	....	7·51	43·27	....

TEST ON FIELD SAMPLES, 1913.

The field samples representing each bore hole were dried, and run separately over a Gröndal cobber, as in the first test on the 1912 samples.

The combined weight of concentrate obtained from the above samples was 2,021·75 pounds, and the tailing 27,882·67 pounds.

ANALYSIS of first concentrate and first tailing from the Gröndal dry magnetic separator:

—	Fe.	TiO_2	SiO_2	Au.
	Per cent.	Per cent.	Per cent.	Oz.
Crude	9·60	....	....	
First concentrate	64·61	2·36	6·35	
First tailing	5·61	2·69	84·58 insol.	None.

The concentrate was sampled on Jones riffled samplers, and a sizing test was made, using Tyler standard screens. The tailing was passed through a Vezin sampler, and then cut down on the riffler. A small lot of 5,605·929 grams was sized on the Tyler screens, and a lot weighing 1,313·5 pounds was sized in the Keedy ore sizer.

Grinding and reconcentration of first concentrate.

The first concentrate from the cobber was ground in a Hardinge 4-foot × 6-inch conical mill, and fed to the double drum Gröndal wet separator. A screen analysis was made of the tube mill discharge, of the final concentrate, and of the final tailing from the separator.

ANALYSIS of first concentrate, second concentrate, and second tailing:—

—	Fe.	FeO	TiO_2	SiO_2	S	P	Mn	CaO	MgO
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
First concentrate.. ...	64·61	....	2·36	6·35	....	....	....	....	
Second concentrate......	68·37	....	1·61	2·27	Trace.	·023	·19	·13	·145
Second tailing.... ...	28·95	....	9·17	46·50	....	....	....	....	

Calculation of iron saved from second concentration—

$$\frac{68{\cdot}37 - 28{\cdot}95}{64{\cdot}61 - 28{\cdot}95} = \frac{39{\cdot}42}{35{\cdot}66} = 1{\cdot}106 \text{ tons of first concentrate per unit of second concentrate.}$$

$$\frac{68{\cdot}37 \times 100}{64{\cdot}61 \times 1{\cdot}106} = 95{\cdot}60 \text{ per cent of iron saved.}$$

Calculation of iron saved from analyses and actual weights—

Weight of first concentrate..	2021·75 lb.
" second "	1849·64 "
" " tailing....................	172·11 "

$$\frac{1849{\cdot}64 \times 68{\cdot}37}{2021{\cdot}75 \times 64{\cdot}61} = \frac{1306{\cdot}25}{1264{\cdot}60} = 96{\cdot}75 \text{ per cent of the iron was saved.}$$

SCREEN TEST of first concentrate: (Lot 1913) Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Direct per cent of total weight.	Cumulative per cent of weight.	Iron per cent.	Distribution of iron per cent of total.	Cumulative per cent of total iron.	Titanic acid per cent.	Distribution of acid per cent of total.	Cumulative per cent of total titanic acid.
+ 35	·0164	14·175	0·42	0·42	14·85	0·10	0·10	2·27	0·42	0·42
− 35+ 48	·0116	53·865	1·61	2·03	24·26	0·61	0·71	3·26	2·30	2·72
− 48+ 65	·0082	608·108	18·22	20·25	55·29	15·62	16·33	3·08	24·66	27·38
− 65+100	·0058	1,870·533	56·03	76·28	67·16	58·35	74·68	2·27	55·88	83·26
−100+150	·0041	670·761	20·09	96·37	69·38	21·61	96·29	1·61	14·21	97·47
−150+200	·0029	85·475	2·56	98·93	68·42	2·71	99·00	1·41	1·58	99·05
−200	....	35·721	1·07	....	60·19	1·00	......	2·03	0·95	......
Totals......	....	3,338·638	100·00	....	64·49	100·00	....	2·28	100·00	....

NATASHKWAN MAGNETIC IRON SANDS (1913).

SIZING TEST, using Tyler Standard Screens on tailing from first concentration. (Lot 1913.)

Mesh.	Aperture in inches.	Weight in grammes.	Direct per cent.	Cumulative per cent.
+14	0·0460	51·5970	0·92	0·92
−14+20	0·0328	70·8750	1·27	2·19
−20+28	·0232	188·5275	3·36	5·55
−28+35	·0164	487·0530	8·69	14·24
−35+48	·0116	2965·1265	52·89	67·13
−48+65	·0082	1180·2105	21·05	88·18
−65+100	·0058	408·8070	7·29	95·47
−100+150	·0041	210·0735	3·75	99·22
−150+200	·0029	26.3655	0·47	99·69
−200	......	17·2935	0·31	......
		5605·9290	100·00	

NATASHKWAN MAGNETIC IRON SANDS, (1913).

KEEDY SIZER TEST on tailings from first concentration. (Lot 1913.)

Mesh.	Screen No.	Aperture.	Weight in pounds.	Direct per cent.	Cumulative per cent.
20	20 SW	·0410	29·5	2·25	2·25
24	24 SW	·0342	25·5	1·94	4·19
28	28 SW	·0282	35·5	2·701	6·88
34	34 SW	·0229	47·0	3·578	10·46
42	42 SW	·0183	70	5·328	15·80
50	50 SW	·0145	204·0	15·53	31·32
62	4 XX	·0116	349·0	26·57	57·82
74	6 XX	·0089	268·0	20·41	78·30
86	8 XX	·0068	128·0	9·75	87·90
109	10 XX	·0054	113·9	8·60	96·61
125	12 XX	·0041	26·5	2·02	98·63
150	15 XX	·0036	....	....	......
200	25 Std.	·0026	15·0	1·14	99·80
−200	−25 Std.	....	2·5	·19	
			1313·5	100·00	

SCREEN TEST tube mill discharge grinding first concentrate (Lot 1913). Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Per cent of total weight.	Cumulative per cent of total weight.	Per cent of iron.	Distribution of iron per cent of total.	Cumulative per cent of iron.	Per cent of titanic acid.	Distribution of titanic acid per cent of total.	Cumulative per cent of total titanic acid.
+48	·0092	6·24	·19	·19	8·16	·024	·024	1·06	·09	·09
−48+65	·0072	29·77	·92	1·11	19·35	·277	·302	2·53	1·06	1·16
−65+100	·0042	233·28	7·20	8·32	56·23	6·320	6·61	2·90	9·54	10·70
−100+150	·0026	826·17	25·49	33·79	64·95	25·400	32·45	1·98	23·14	33·85
−150+200	·0021	1,280·10	39·49	73·25	65·87	40·650	73·05	2·10	37·97	71·86
−200	... .	867·50	26·75	....	64·58	26·700	....	2·29	28·20	... .
		3,243·06								

SCREEN TEST on second concentrate (Lot 1913). Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Direct per cent of of total.	Accumulative per cent of weight.	Iron per cent.	Distribution of iron per cent of total.	Cumulated per cent of total iron.	Titanic acid per cent.	Distribution of acid.	Cumulated per cent of acid.
+ 48	·0116	1·5	·15	·15	30·85	0·31	0·31	2·75	1·26	1·26
− 48+ 65	·0082	5·5	·55	·70						
− 65+100	·0058	41·00	4·10	4·80	60·00	3·57	3·88	3·02	8·12	9·38
−100+150	·0041	321·00	32·10	36·90	68·74	32·06	35·94	1·87	39·38	48·76
−150+200	·0029	243·00	24·30	61·20	69·75	24·63	60·57	1·41	22·48	71·24
−200+	....	388·00	38·80	....	69·95	39·43	....	1·13	28·76	....
	....	1000·00	100·00	....	....	100·00	....	....	100·00	....

SCREEN TEST of second tailing: (Lot 1913). Showing distribution of Iron and Titanic Acid.

Mesh.	Aperture in inches.	Weight in grammes.	Direct per cent of total weight.	Cumulative per cent of weight.	Per cent of iron.	Distribution of total iron.	Cumulative per cent of total iron.	Titanic acid per cent.	Distribution of total titanic acid.	Cumulative per cent of titanic acid.
+ 48	·0116	12·00	1·20	1·20	5·53	0 23	0·23	0·90	·12	·12
− 48+ 65	·0082	43·20	4·32	5·52	5·23	0·77	1·00	1·23	·59	·71
− 65+100	·0058	100·00	10·00	15·52	8·74	2·99	3·99	3·81	4·23	4·95
−100+150	·0041	221·50	22·15	37·67	22·91	17·35	21·34	9·86	24·30	29·22
−150+200	·0029	215·00	21·50	59·17	30·50	22·42	43·76	12·56	30·10	59·25
−200	....	408·30	40·83	....	40·30	56·25	....	8·98	40·75	....
		1000·00	100·00			100 00				

REPORT OF INVESTIGATIONS AT THE RESEARCH LABORATORY OF APPLIED ELECTRO-CHEMISTRY AND METALLURGY, QUEENS UNIVERSITY, KINGSTON, ONTARIO, FOR THE MINES BRANCH, DEPARTMENT OF MINES, CANADA. (YEAR 1914.)

HERBERT T. KALMUS.

Throughout the year 1914, and during the early months of 1915, the investigations of the metal cobalt and its alloys, with reference to finding increased commercial uses for them, have been in progress. These researches have been undertaken for the Mines Branch by the writer, with a staff of assistants, at Queens University, Kingston.

ELECTRO-PLATING WITH COBALT.

A very extensive series of experiments on electro-plating with cobalt has been completed. A great many technical points in connexion with the plating of cobalt had not been investigated, although the corresponding investigations for nickel had been comparatively thorough. Before platers could adopt cobalt for commercial purposes on a considerable scale, a number of questions required definitely to be answered by experiments, such as:—

(1) Can cobalt be plated on iron, steel, brass, tin, German silver, lead, etc., in such manner as to yield as uniform, as adhesive, and as satisfactory a finished surface as nickel?

(2) Is cobalt plate harder than nickel plate?

(3) Is cobalt plate less corroded than nickel plate by ordinary atmospheric action?

(4) What bath is most suitable for the deposition of cobalt, when a heavy protective coating, which may be buffed to a superior finish, is required to be deposited in a minimum of time?

(5) Can a satisfactory cobalt bath be maintained at such an increased concentration as compared with the nickel bath, that plating from it may proceed with greater speed?

(6) Is the cobalt bath more or less troublesome than the nickel bath as regards crystallization, etc.?

(7) Should alkali, acid, or neutral baths be used for cobalt plating?

(8) Is the nature of the deposit improved by hardeners such as boric acid, citric acid, magnesium salts, etc.?

(9) How does the maximum current density at which cobalt may be deposited commercially compare with the maximum current densities used in the commercial deposition of nickel?

(10) What electromotive force had best be used for cobalt plating, using the bath found most suitable for a given class of work?

(11) How do cobalt anodes compare with nickel anodes as regards solubility, under the conditions of the plating bath?

(12) What are the relative current efficiencies of cobalt and nickel plating under the best conditions?

(13) How do the electrical conductivities of satisfactory cobalt and nickel plating solutions compare?

(14) Can cobalt be deposited to considerable thicknesses from any solution in commercial practice?

(15) What are the relative costs of cobalt and nickel plating?

A very large number of plating experiments were conducted by us for purposes outlined by the above questions, in connexion with which some sixteen different types of solutions or baths were employed and studied. Following is the list:—

Series 1. Simple cobalt-ammonium sulphate.
" 2. Cobalt-ammonium sulphate with an excess of ammonium sulphate.
" 3. Cobalt-ammonium sulphate with an excess of ammonium sulphate, to which is added citric acid.
" 4. Cobalt-ammonium sulphate with ammonium chloride.
" 5. Cobalt chloride with ammonium chloride.
" 6. Cobalt-ammonium sulphate with boric acid.
" 7. Cobalt-ammonium sulphate, cobalt carbonate, and boric acid.
" 8. Cobalt sulphate, potassium citrate, and ammonium chloride.
" 9. Cobalt phosphate with sodium pyro-phosphate.
" 10. Cobalt-ammonium sulphate with magnesium sulphate.
" 11. Cobalt sulphate, neutral ammonium tartrate, with the addition of tannic acid.
" 12. Cobalt sulphate, potassium tartrate, and tartaric acid.
" 13. Cobalt sulphate, sodium chloride, and boric acid.
" 14. Cobalt sulphate, ammonium sulphate, magnesium sulphate with boric acid.
" 15. Cobalt-ethyl sulphate, sodium sulphate, and ammonium chloride.
" 16. Cobalt sulphate, ammonium sulphate, ammonium chloride, and boric acid.

Hundreds of plating experiments were tried, the full report on which is made in the paper (Part III) entitled, "Electro-plating with Cobalt." A set of conclusions was drawn with regard to the experiments under each series, and from the conclusions of all the series the important facts were established that solutions IB and XIIIB were of extreme commercial interest. As a result, the writer, in co-operation with the Russell Motor Car Company of West Toronto, Ont., undertook a series of experiments under strict commercial conditions on these two solutions. These experiments continued through a period of months, and are reported in full in the paper above mentioned. Following are the conclusions with regard to these two solutions:—

SOLUTION I B.

$CoSO_4$, $(NH_4)_2$ SO_4, $6H_2O$.

5 pounds salts; 6 gallons water; sp. gr. 1·050—neutral.

Conclusions.

1. Cobalt plates from these cobalt-ammonium sulphate solutions, on brass and iron are firm, adherent, hard and uniform, and may readily be buffed to a satisfactorily finished surface. They take a very high polish, with a beautiful lustre, which although brilliantly white, possesses a slightly bluish cast.

2. The specific electrical conductivity of these cobalt-ammonium sulphate solutions is very much higher than that of the corresponding nickel solutions.

3. All of these cobalt plates within the current density ranges described as satisfactory, are as smooth, adhesive and generally satisfactory as the best nickel plates.

4. Solution I B, which is a nearly saturated solution of $CoSO_4$. $(NH_4)_2$ SO_4, containing 200 grams of $CoSo_4$. $(NH_4)_2$ SO_4. $6H_2O$ to the litre of water, yields satisfactory cobalt deposits at all current densities up to 4 amperes per square decimetre (37·2 amperes per square foot). This very rapid plating was performed in a manner similar to that of common plating practice.

5. There is no nickel bath operating in the manner of the usual commercial plating procedure at anything like as high a current density as cobalt solution I B. More specifically, the allowable current density with which an adherent, firm, smooth, white, hard plate may be obtained with solution I B, without sign of pitting or peeling, and yet which may be readily and satisfactorily finished, is four times that for which the same results may be obtained with the fastest commercial nickel solutions.

6. Solution I B may be used for plating on the usual surfaces, including brass, iron and steel. No preliminary coating of copper is necessary when plating with these baths on iron and steel.

7. Solution IB may be used with a large proportion of rolled anodes without becoming acid or depleted in metal.

8. Solution IB does not change appreciably in cobalt content or in acidity when used over long periods of time at the high recommended current density.

9. The current efficiency of solution I B is extremely high at a current density of 1 ampere per square decimetre. The mean of our measurements, agreeing very well among themselves, gave a value of 98·0 per cent. The current efficiency of solution IB is as high at 3 amperes per square decimetre as is common for the best nickel solutions used in nickel plating practice at very much lower current densities. The average of three closely agreeing current efficiency measurements with solution I B, at 3 amperes per square decimetre was 90·5 per cent.

10. Solution I B, when operated slightly alkaline, yields plates which are greyish in colour, which peel, pit and show blisters. This solution, when operated acid, yields plates which, while fairly adherent, firm and smooth, are dark and freakish.

This bath should be run neutral, for these plates are adherent, firm, smooth, white, hard, yet easily buffed to an excellent finish.

11. Solution I B requires very little, if any, ageing to put it in condition, but yields satisfactory plates almost from the start.

12. The "throwing" power of solution IB is remarkably satisfactory.

13. The anodes in solution IB are remarkably free from a coating, such as characterizes nickel anodes.

SOLUTION XIII B.

Cobalt sulphate, $CoSO_4$	312·5 grams.
Sodium chloride, NaCl	19·6 grams.
Boric acid	Nearly to saturation.
Water	1,000 c.c.
Total bath, approximately	1·5 litres.

Conclusions.

1. Solution XIII B is the most completely satisfactory solution, for a great variety of purposes, which we have found. We know of no solution, plating with nickel, which begins to compare with solution XIII B for the range of work which it will do, and for the extreme high current densities at which it will operate. It is possible to get a plate in three minutes or less, with solution XIII B, which will stand all the usual physical commercial tests, and which will buff as satisfactorily as a plate which has taken one hour from the usual nickel plating baths.

2. Cobalt plates from this simple cobalt sulphate solution in the presence of sodium chloride and boric acid (solution XIII B) on brass and iron, are firm, adherent, hard, and uniform, and may readily be buffed to a satisfactorily finished surface. They take a very high polish, with a beautiful lustre, which, although brilliantly white, possesses a slightly bluish cast.

3. The specific electrical conductivity of solution XIII B is much higher than that of the corresponding nickel solution.

4. Solution XIII B does not yield the best cobalt plate at low current densities, that is, in the neighbourhood of 0·50 to 1·0 ampere per square decimetre, which is a common range for nickel plating work. Solution XIII B begins to plate most satisfactorily at a current density in the neighbourhood of 3·5 amperes per square decimetre, and continues to give satisfactory plates at all current densities up to 26·4 amperes per square decimetre. This is equivalent to a current density of over 240 amperes per square foot, and even at this speed, the limit of the solution has not yet been reached.

5. All of these cobalt plates within the wide current density range described as satisfactory for solution XIII B, are as smooth, adhesive and generally satisfactory as the best nickel plates.

6. Solution XIII B does not change appreciably in cobalt content or in acidity when used over long periods of time at current densities as high as 1 ampere per square decimetre. It only showed a very gradual diminution in cobalt content under the most severe conditions of the ageing test described above. We know of no other cobalt solution and of no nickel solution which would stand up under the conditions of this ageing test.

7. There is no nickel bath of which we are aware operating in the manner of the usual commercial plating procedure at anything like as high current density as solution XIII B.

8. Solution XIII B may be used for plating on brass, iron and steel, for which cathodes the above conclusions apply.

9. Solution XIII B may be used to deposit a heavy cobalt plate. These plates may apparently be deposited to any desired thickness, and they are firm, adherent, massive, of extreme hardness and show no tendency to curl or split.

10. Heavy plates may be obtained from solution XIII B to much better advantage than from solution XV[1] which has been patented for the purpose with nickel, that is, heavy deposits may be obtained from solution XIII B at current densities of 5 or 6 amperes per square decimetre, whereas solution XV must be operated at low current densities in the neighbourhood of 0·30 amperes per square decimetre. If a current density of above 6 amperes per square decimetre is used with solution XIII B for heavy deposits, under the conditions and dimension of our baths, it was found that trees were formed on the cathode.

11. Our experiments show that solution XIII B "throws" very satisfactorily.

12. Among the satisfactory properties of this remarkable solution should be mentioned an extremely high current efficiency, which we found at 1·0 and 5·0 amperes per square decimetre to be almost 100 per cent.

13. Solution XIII C, which is the nickel analogue of solution XIII B, yielded satisfactory plates up to about 5 amperes per square decimetre, but showed splitting at current densities greater than that. Nickel solution XIII C does not possess the remarkable qualities of its cobalt analogue XIII B, although in many respects it is an improvement on standard nickel solutions.

14. Solution XIII B requires very little ageing; it operates satisfactorily almost from the start.

15. Solution XIII B is so remarkable in its properties that it was thought highly worth while to develop it further under commercial conditions. See commercial tests, page 136.

Mr. Walter S. Barrows, foreman of the plating department of the Russell Motor Car Company, made a report to the writer in connexion with these two solutions as follows:—

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[1] Cobalt ethyl sulphate, 100 g.; Sodium sulphate, 10 g.; Ammonium chloride, 5 g.; Water, 1,000 cc. G. Langbein & Co., D. R. P. 134736, Sept. 18, 1902.

REPORT OF MR. BARROWS ON SOLUTION I B.

"After preparing a cobalt plating solution according to your formula for bath I B, and having used this bath daily during the past eight weeks, plating a great variety of copper, brass, iron, steel, tin, German silver, lead, and Britannia metal articles of different shapes and sizes under exactly the same conditions as met with in general nickel plating at the factory of the Russell Motor Car Company, West Toronto, and after regarding the characteristics of this particular solution absolutely from a commercial viewpoint, I can heartily confirm any statement you have made to me regarding this remarkable solution. This bath was equipped with cobalt anodes, 98·75 per cent cobalt, which were sent to me from your laboratory.

"The runs made have varied from five minutes to 24 hours, and in each case the bath has proved wonderfully efficient.

"The cobalt plates obtained were smooth, white and fine grained, very adherent and uniform. In fact the surfaces of these deposits after several hours' run were so very smooth and uniform that a 4-inch cotton buff coloured them to a mirror finish quite easily. We use 14-inch and 16-inch buffs to colour 3-hour deposits of nickel.

"To test the hardness of the cobalt as compared with nickel, with reference to either buffing or polishing with emery, we plated strips of brass, one-half the surface with cobalt and one-half with nickel, always giving the nickeled portion the thickest plate. Then buffing or polishing across the two deposits we found invariably that the nickel was removed from the brass before the cobalt, and in some cases in one-half the time.

"Though so hard and firm, these plates colour beautifully with little effort, and require the use of much less buffing composition than comparatively thin plates of nickel. Automobile parts of irregular shape were plated from 10 to 20 minutes, and finished on a 6-inch buff operated at 3,000 r.p.m. without the slightest evidence of a defect in the plating. To accomplish this with our fastest nickel baths would require at least 60 minutes of plating.

"As a protective coating for iron or steel surfaces, I am convinced that a comparatively thin plate of cobalt will prove equally as effective as a thick plate of nickel from an ordinary double sulphate nickel bath, and the time and power required for the production of such plates is decidedly in favour of the cobalt.

"The deposits are also very adherent, no difficulty having been experienced in this respect, although tests were made repeatedly by bending, hammering and burnishing.

"One of the weak points of several so-called rapid nickel plating solutions which we have tried commercially, is their poor "throwing" powers: i.e., they do not deposit the nickel readily in the indentations or cavities of the cathode. The cobalt solution I B meets this requirement in a most efficient manner, the deposits on the distant portions of the cathode withstand the tests imposed in every case.

"Another most important feature of this solution, which should commend itself to every practical plater and manufacturer of plated wares, is the extremely high current density at which this solution may be employed without danger of pitting the plated surface. I have plated with this cobalt solution I B satisfactorily and under commercial conditions, at a current density of 42 amperes per square foot. This is 4·2 times the speed of our fastest commercial nickel solutions.

"As a further test we plated steel tubes of 1-inch diameter (2·5 cm.) for two hours, with a current density of 27 amp. per square foot, and then drew the tubes down to 0·625 inch diameter without injuring the deposit. Though extremely hard, the ductility of the deposited metal proved remarkable.

"All of our tests have been made in a still solution, without agitation of any kind, and the plates were subjected to the most severe treatment considered practical for high-grade metallic coatings on the various metals heretofore mentioned.

"We are also of the opinion that the anodes in the cobalt bath IB will remain free from coatings, such as characterize average anodes used in nickel baths, and that the cost of maintenance will be practically nothing compared to double sulphate nickel solutions.

"I can assure you that my experience thus far with these cobalt solutions has been intensely interesting, and I sincerely believe that their use commercially would revolutionize the art of electro-plating such wares as are now nickel plated.

"The simplicity of its composition, its self-sustaining qualities, the remarkable speed of deposition, together with the several points mentioned previously, should appeal to the commercial requirements of this progressive age."

REPORT OF MR. BARROWS ON SOLUTION XIII B.

"After thoroughly testing cobalt plating bath XIII B, made according to your formula, I take pleasure in submitting the following report.

"I found the bath very simple to prepare, and at once began to operate the solution with high current densities. The results obtained were exceedingly gratifying. Evidently bath XIII B will require no prolonged ageing treatment, as splendid, white, hard, perfect deposits were obtained with extremely high current densities within three hours after bath was prepared.

"The experiments have been varied and the tests of plates severe and deliberate, the results have invariably been such as to cause me to regard cobalt bath XIII B the greatest achievement in modern electroplating improvements.

"The operation of the bath is positively fascinating; the limit of speed for commercial plating is astonishing, while the excellence of the plates produced is superior to those of nickel for many reasons.

"The efficiency of the freshly prepared solution, together with the self-sustaining qualities of the bath are without a parallel in any plating solution of any kind I have ever used.

"Thin embossed brass stampings were plated in bath XIII B for only one minute, then given to a buffer who did not know the bath existed and who was accustomed to buffing 1½ hour nickel deposits on these same stampings. This man buffed the cobalt plates upon a 10-inch cotton buff wheel revolving at 3,000 r.p.m. The finish was perfect, with no edges exposed. These stampings have been plated in two dozen lots for one minute, and from a total of 500 stampings we have found but three stampings imperfect after buffing. Each stamping is formed to a spiral after finishing, without injury to the deposit. Grey iron castings with raised designs upon the surface were plated one minute in cobalt bath XIII B, then burnished with 400 pounds of one-eighth inch steel balls for one-quarter hour without the slightest injury to the cobalt coating, as was proven by a 36-hour immersion in 15 ounces of water acidulated with 1 ounce of sulphuric acid.

"While attempting to reach the limit of current densities which would be practical with this bath XIII B, I have plated brass automobile trimmings with a current density of 244 amperes per square foot. These pieces were plated in lots of six, and a total of 100 were plated, buffed and ready for stock in one hour's time. No unusual preparation was made for the run, and the work was performed by one man. Size of piece plated, 1½-inch by 5 inches.

"Automobile hub-caps were plated three minutes in cobalt bath XIII B and buffed to a beautiful lustre of deep rich bluish tone by use of a 7-inch cotton buff revolving at 1,200 r.p.m. The deposits were ample for severe treatment usually received by such articles. Comparative tests of these deposits were made as follows: Same style castings plated in double sulphate nickel solution one hour were suspended as anodes in a solution of equal parts muriatic acid and water, sheet lead cathodes were used and a current of 200 amperes at 10 volts passed through the bath. The nickel was removed from the castings in thirty seconds, while forty-five seconds' time was required to remove the cobalt plates.

"The above mentioned plating tests were made with still solution, no form of agitation being employed. By aid of mechanical agitators these current densities could be greatly exceeded with highly satisfactory results.

"These cobalt plates were very hard, white and adherent and coloured easily with slight effort.

"Several plates were produced upon sharp steel surgical instruments. These instruments finished perfectly and, owing to the hardness of the cobalt plate, only a thin deposit was required to equal the best nickel deposits which we received as samples. Cobalt deposits should prove especially valuable for electroplating surgical instruments for this reason, non-adherent thick deposits being very dangerous for this class of work.

"Owing to the unusual mild weather in this locality during the past month, I have not concluded test with cobalt plates on highly tempered nickel-steel skate blades, but judging from appearances and various severe indoor tests we do not hesitate to report success in this direction. A three minute deposit from bath XIII B resists corrosion equally as long as a one-hour nickel deposit, the finish is even superior to nickel, while every test employed during the process of manufacturing the nickel-plated article has proved equally ineffective with cobalt plates, therefore, by reason of the effectiveness of thin cobalt deposits we believe cobalt plates should prove wonderfully efficient on skates, or any keen edged tool requiring a protective metallic coating.

"The runs made with bath XIII B have varied from 1 minute to 15½ hours, and in each case the results were remarkable. Electrotypes were reproduced one-sixteenth inch thick. Electro-dies were faced with cobalt one-eighth inch thick, the electrotypes being graphite covered wax and lead moulds, while the dies were made on oxidized silver-faced Britannia metal.

"The deposits from cobalt bath XIII B were very adherent and pliable, by proper regulation of the current beautiful white, hard, tough plates may be produced quickly on any conducting surface.

"The 'throwing' powers of cobalt bath XIII B makes possible its employment for plating deeply indented or grooved articles, such as reflectors, channel bars or articles with projecting portions.

"We also obtained the best plates with extremely high current densities, although plates finished with 75 amperes per square foot were of good colour and easily buffed. The production of excellent plates with a current density of 150 amperes proved particularly easy and densities in this neighbourhood were employed for the greater portion of our tests.

"Cobalt bath XIII B will produce excellent hard, white, tough plates absolutely free from pits or blemish at a current density of 150 amperes per square foot and under ordinary commercial conditions. This is fifteen times the speed of our fastest commercial nickel solution.

"Furthermore, the anode tops and hooks remain free from creeping salts. The solution retains its original clean appearance and the anodes dissolve satisfactorily, no slime or coating formed, brushing or cleaning anodes therefore will be unnecessary. The anodes used with this bath were 98·75 per cent cobalt which were sent me from your laboratory. The bath at the commencement of our tests was strongly acid to litmus, and has remained unchanged throughout our experiments. The specific gravity of the solution when freshly prepared was 1·24 and is the same to-day.

"The rich deep bluish-white tone of the cobalt plates upon polished brass surfaces is particularly noteworthy. This feature should assist greatly in making cobalt deposits very popular for brass fixtures, trimmings and plumbers' supplies.

"My experience with cobalt bath XIII B is by no means at an end. I intend to continue to use it until present supplies are exhausted and then equip a larger bath if supplies are obtainable. As a commercial proposition I am satisfied it is wonderfully efficient and economical.

"Taking into account the difference in cost of cobalt as compared with nickel, I am satisfied the metal costs for plating a given quantity of work with cobalt would be considerably less than for nickel plating a like quantity.

"Furthermore, the use of cobalt bath XIII B equipped with automatic apparatus for conveying parts through the bath would reduce the labour cost 75 per cent, such apparatus would be practical for a greater variety of wares than is now the case with nickel.

"We cannot speak too highly of cobalt bath XIII B, and confidently believe its future history will surpass the history of any electro-plating bath now in general use.

"In conclusion, please accept my warmest congratulations upon your successes with cobalt solutions, and heartily appreciating the opportunity of testing these solutions, I desire to sincerely thank you, kind sir, for the benefits derived therefrom."

From these commercial tests on cobalt plating, the following general conclusions may be drawn:—

1. Several cobalt solutions were found to be suitable for electro-plating with cobalt under the conditions of commercial practice. Best among these are the following:—

SOLUTION I B.

Cobalt-ammonium sulphate, $CoSO_4 (NH_4)_2 SO_4 6H_2O$, 200 grams to the litre of water, which is equivalent to 145 grams of anhydrous cobalt-ammonium sulphate, $CoSO_4 (NH_4)_2 SO_4$, to the litre of water. Sp. gr. = 1·053 at 15° C.

SOLUTION XIII B.

Cobalt sulphate, $CoSO_4$	312 grams.
Sodium chloride, NaCl	19·6 "
Boric acid	Nearly to saturation.
Water	1,000 c.c

Sp. gr. = 1·25 at 15° C.

2. Cobalt plates from these solutions, on brass, iron, steel, copper, tin, German silver, lead and Britannia metal articles, of different shapes and sizes, deposited under conditions identical with those met with in general nickel plating practice, are firm, adherent, hard and uniform. They may readily be buffed to a satisfactorily finished surface, having a beautiful lustre, which, although brilliantly white, possesses a slightly bluish cast.

3. The electrical conductivity of these solutions is considerably higher than that of the standard commercial nickel solutions, so that other things being equal, they may be operated at a lower voltage for a given speed of plating.

4. Solution I B is capable of cobalt plating on the various sizes and shapes of objects met with in commercial practice at a speed at least four times that of the fastest satisfactory nickel solutions.

5. Solution XIII B is capable of cobalt plating on the various sizes and shapes of objects met with in commercial practice at a speed at least fifteen times as great as that of the fastest satisfactory nickel solutions.

6. Plates from both of these solutions on various stock pieces, satisfactorily withstood the various bending, hammering and burnishing tests to which the commercial nickel work is ordinarily submitted.

7. These two very rapid cobalt solutions are remarkable for their satisfactory throwing power. That is, they readily and satisfactorily deposit the cobalt in the indentations of the work.

8. These two very rapid solutions operate at these high speeds in a perfectly still solution without agitation of any kind.

9. These solutions are both cleaner, that is freer from creeping salts and precipitated matter, than the standard commercial nickel baths.

10. The cobalt deposited at this rapid speed is very much harder than the nickel deposited in any commercial nickel bath. Consequently a lesser weight of this hard cobalt deposit will offer the same protective coat as a greater weight of the softer nickel deposit. Considering solution XIII B, operating at 150 amperes per square foot, on automobile parts, brass stampings, etc., etc., a sufficient weight of cobalt to stand the usual commercial tests, including buffing and finishing, is deposited in one minute. With the best nickel baths, it takes one hour, at about 10 amperes per square foot, to deposit a plate equally satisfactory. Therefore, the actual weight of metal on the cobalt plate must be approximately one-fourth that of nickel.

11. For many purposes, under the condition of these rapid plating solutions, one-fourth the weight of cobalt, as compared with nickel, is required to do the same protective work. Consequently, if nickel is worth 50 cents a pound in the anode form, cobalt would be worth nearly $2 a pound in the same form, to be on the same basis, weight for weight of metal. In addition, there are other advantages of cobalt in saving of labour, time, overhead, etc.

12. A smaller plating room would handle a given amount of work per day with cobalt than with nickel.

13. With these very rapid plating solutions, by the use of mechanical devices to handle the work, the time required for plating, as well as the labour costs may be tremendously reduced. Solution I B, and particularly Solution XIII B, are so rapid as to be revolutionary in this respect.

14. Obviously the cost of supplies, repairs, etc., would be less with cobalt-plating than with nickel-plating, as the size of the plant for a required amount of work is less.

15. The voltage required for extremely rapid cobalt-plating is greater than that for most nickel-plating baths; it is not so great but that the machines at present in use may in general be operated. For the same speed of plating, the cobalt solution requires much the lower voltage.

16. For a given amount of work the power consumption for this rapid cobalt work is less than that for nickel This is obvious, because the total amount of metal deposited in the case of cobalt is very much less, whereas the voltage at which it is deposited is not correspondingly greater.

17. Ornamental work on brass, copper, tin, or German silver would require only a one-minute deposit. Even wares exposed to severe atmospheric influences, or friction, could be admirably coated with cobalt in solution XIII B in fifteen minutes. The

tremendous possibilities of this solution are not to be completely realized unless mechanical devices are applied to reduce hand labour to a considerable extent.

18. Thick deposits from these solutions are vastly superior to any that we have seen produced from nickel solutions. The tendency to distort thin cathodes is less pronounced, while electrotypes and electro-dies have been given a superior thick deposit in a most satisfactory manner. The lines were hard, sharp and tough and the surface smooth. Nickel does not equal cobalt for excellence of massive plates.

19. Many of these tests were passed upon by uninterested skilled mechanics at the plant of the Russell Motor Car Company, who invariably reported in favour of the cobalt as above.

20. Both solutions IB and XIIIB are substantially self-sustaining, once they are put into operating condition, and the amount of ageing required to do this is very much less for them than that for the present commercial nickel baths.

A number of automobile parts, and a large number of skates, cobalt plated, were turned out at the plant of the Russell Motor Car Company under Mr. Barrows' direction, and many of the skates have now (February 6, 1915) been under observation in actual use for several months.

On this date Mr. Barrows reported that skates plated from solution XIII B, many of which had had extremely hard usage in the hands of boys, etc., were showing up with surprising satisfaction.

There is absolutely no stripping of the plate along the edge of the skate, either before or after use, which unfortunately is not uncommon with nickel-plated skates. Furthermore, the cobalt-plated skates seem to be decidedly superior to the nickel-plated skates as regards their resistance to corrosion. Another very noticeable feature about the cobalt-plated skates is that they are very free from scratches after rough usage as compared with nickel. That is to say, the cobalt plate is decidedly harder than the nickel plate. Most of the skates in question were plated in three minutes at 90 to 100 amperes per square foot. Nickel plates at the same plant are plated in one hour at about 4 amperes per square foot.

There is apparently considerably more cobalt metal plate on these skates than need be to make them equivalent to nickel-plated skates.

MAGNETIC PROPERTIES OF COBALT AND OF Fe_2Co.

A series of experiments were conducted on the magnetic properties of cobalt and of Fe_2Co. These experiments are only just being completed, and include investigations under the following headings:—

1. Permeability of pure cobalt.
2. Hysteresis of pure cobalt.
3. Magnetic properties of the alloy Fe_2Co.

Magnetic constants of pure cobalt were studied by two independent methods, and the results should establish the values of these properties with considerable accuracy.

The greatest difficulties were experienced in obtaining sound castings of the compound Fe_2Co. The smallest quantities of occluded gas naturally caused extreme variations in the values of the magnetic constants determined. The results, therefore, with regard to this alloy are somewhat uncertain as regards commercial reproducibility, although our results, in connexion with those of Professor Pierre Weiss, of Zürich, Switzerland, establish the fact that this compound has a magnetic permeability between 5 and 10 per cent greater than that of the best Swedish soft iron. All of these experiments will be reported during the coming months in a paper entitled "Magnetic Properties of Cobalt and of Fe_2Co," by Herbert T. Kalmus and Kenneth B. Blake.

COBALT ALLOYS WITH NON-CORROSIVE PROPERTIES.

Since it is impossible to be certain *a priori* what effect the addition of any metal will have on the properties of another, and as it has been shown that certain metals in small quantities improve the resistance of iron to atmospheric corrosion, these investigations were undertaken for the purpose of determining the effect of the addition of small quantities of cobalt on the atmospheric corrosion of iron and mild steel. We have particularly in mind the addition of small quantities of cobalt to the very pure iron prepared by the open hearth method for sheet roofing material.

The comparative effects of small amounts of cobalt, nickel and copper were studied.

Our interest was stimulated by the positive nature of certain very early preliminary experiments, described in the next paragraph.

PRELIMINARY EXPERIMENTS.

Very early in the course of these investigations on cobalt and its alloys, in the autumn of 1912, a preliminary set of alloys was prepared by adding small percentages of both cobalt and nickel to very pure iron. These alloys were exposed for several months on the roof of Nicol Hall, Queens University, Kingston, Ontario. After this exposure they were removed, and the amount of corrosion determined. In every case it was found that the addition of small percentages of cobalt and nickel had decreased the corrosion of the pure iron.[1]

Following this, a second set of alloys was made with the same materials, in the same way, and exposed under the same conditions as the previous set, for a period from June 16, 1913, to October 16, 1913. At the end of this exposure of 122 days, the alloys were taken in, and the rate of corrosion in grams per square centimetre of exposed surface per year was computed.

Unfortunately, two of the alloys of this set were spoiled during the exposure, owing to dropping from the supports and coming in contact with the metal roof, so that the series is not sufficiently complete to warrant giving all the details. However, the results were in general accord with those of the previous set, which led us to believe that the addition of cobalt in proper proportions, to pure iron might prove of benefit to its non-corrosive properties.

The general method of procedure with these preliminary experiments was the same as that described in detail for the complete sets of experiments to be described below.

The two sets of experiments above described must be considered preliminary for a number of reasons, primarily because no heat treatment was given to the alloys.

CONCLUSIONS.

1. From these preliminary experiments, additions of small percentages of both Co and Ni to American ingot iron seemed to add to its non-corrosive property.
2. Cobalt seemed to be more effective than nickel when used in like amount.
3. These results were such as to stimulate further interest, but were not sufficiently complete or satisfactory to warrant definite conclusions.

As a result of these preliminary experiments three series of alloys were made and exposed, containing various percentages of cobalt, nickel and copper and combinations of these in American ingot iron, from 0·25 per cent to 3 per cent of the elements mentioned. These alloys were prepared very nearly carbon free, and also containing small amounts of carbon.

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[1] The "pure" iron was American Ingot Iron, supplied by the American Rolling Mill Company, Middletown, Ohio.

Series 1 was exposed on the roof of Nicol Hall from March 18, 1914, to August 31, 1914, an exposure of 3,984 hours. In addition to analyses of the various alloys, their diameter, thickness, and weight of the exposed disc, both before and after exposure were measured, and the loss in weight in grams per square centimetre of original surface per square hour of exposure computed from these measurements.

A second complete series consisting of about 20 alloys was prepared. This series was a check on the first series, and was exposed on October 10, 1914. A record of analysis, dimensions, etc., was made, but the final measurements have not been made, as these samples are still corroding.

On December 22, 1914, a third complete set of alloys, about 100 in number, was exposed in a manner similar to that of the first two series. The alloys of Series 3 were prepared, paying particular attention to the heat treatment. The final measurements of this series have not yet been made, as the alloys are still being exposed to atmospheric corrosion.

In addition to these series, in co-operation with the American Rolling Mills Company, Middletown, Ohio, who are producing large quantities of American ingot iron for sheet roofing purposes, a number of 8 foot sheets of American ingot iron with various percentages of cobalt were prepared. Some of these sheets are being exposed at the plant of the American Rolling Mills, Middletown, Ohio, and others are being exposed on the roof of Nicol Building, Queens University, Kingston, in company with the samples of the three series mentioned. These sheets have been regularly photographed from time to time and observations as to their condition, etc., made.

In connexion with the preparation of these three sets of alloys about 30 microphotographs have been taken, illustrating the intimate structure of the alloys in question.

All these facts in detail, together with the complete data, will be published by the writer during the coming months in a bulletin of the Mines Branch under the title, "Cobalt Alloys with Non-corrosive Properties."

Cochrome Wires—A Comparison with Nichrome.

Under this heading a paper will appear during the coming months by Herbert T. Kalmus and Kenneth B. Blake, setting forth a series of experiments in which cobalt-iron-chromium-manganese wires were prepared, analogous to the well-known nichrome, for comparison with the latter for use as heating elements. The comparative properties of these wires were studied under the following headings—hardness, brittleness, tensile strength, electrical resistance cold, temperature co-efficient of electrical resistance, oxidation at high temperatures, and melting point. The work on these wires is not yet completed and the conclusions may be distinctly modified before final publication is made. The preliminary conclusions which may be drawn from the experiments thus far are as follows:—

1. *Mechanical Properties.*—The cochrome wires of the compositions represented by the five samples measured do not depart widely from nichrome wires as regards mechanical properties. These cochrome wires may be swaged with about the same ease as nichrome. They are slightly harder, and samples A B 19 and A B 20 have a higher tensile strength than nichrome. There is very little difference in the brittleness of the two types of wire.

2. *Electrical Properties.*—The specific electrical resistance of the various members of this cochrome series at room temperature is from 0·5 to 0·6 that of nichrome under the same conditions. The lowest value for cochrome which we have found is 60·5 microhms per cm. cu., and the highest value 74·9 microhms per cm. cu., as against 110 microhms per cm. cube for nichrome.

The specific resistance of cochrome and nichrome approach one another as the temperature is raised from room temperature. The temperature co-efficient of resistance for cochrome varies between 0·00065 and 0·00085 per degree C., whereas the corresponding value for nichrome is 0·00052. These values are mean temperature co-efficients between 20° and 1,000° C., and while not very accurate are fairly comparative. The current carrying capacity is approximately the same for cochrome and nichrome wires of the same size.

3. *Oxidation at High Temperatures due to Electric Current.*—Cochrome wires which we have studied oxidize much more readily than nichrome wires at the same temperature, when heated by an electric current. The temperature range which we particularly studied was from 900° C. to 1,200° C.

4. *Corrosion in Acids.*—Nichrome is less attacked by 20 per cent H_2SO_4 than is cochrome under the conditions of our experiments.

5. *Melting Temperatures.*—The melting temperatures of the cochrome varies from 1293° to 1379° C., all of them being lower than that of nichrome, which we found to be 1380° C.

6. *Properties for use as Heating Element.*—Cochrome is inferior to nichrome for most purposes for which these wires might be used for winding heating coils. The principal disadvantage is that of increased oxidation at temperatures from 900° to 1,200° C. The high temperature co-efficient of resistance of cochrome, as compared with nichrome, tends to equalize their resistances with increasing temperature. For most purposes it annuls the advantages of cochrome due to its lesser specific resistance at low temperatures. It might find special application at intermediate temperatures because of its lower resistance, or it might find special application in atmospheres other than oxidizing ones.

The work of this laboratory, on cobalt, has stimulated a variety of interests to experimenting in various directions, and, as well, has had a direct influence upon the consumer of the metal cobalt, both for the preparation of alloys and in the plating industry. Inquiries of an important commercial character from manufacturing purchasers have repeatedly come to the attention of the writer, and the indications from a variety of sources are for a distinctly increased market for metallic cobalt.

FUELS AND FUEL TESTING DIVISION.

I.

WORK AT FUEL TESTING STATION.

B. F. Haanel,

Chief of Division.

The work of the Division of Fuels and Fuel Testing during the year 1914 consisted in the investigation of eleven commercial samples of coal, in the experimental boiler provided for that work—the installation of which was completed early in the year—and the testing in the gas producer of five samples of coal. The coals tested for steaming purposes were obtained from the following mines: Cardiff Collieries, Ltd.; Gainford Coal Co., Ltd.; Twin City Coal Co., Ltd.; Tofield Coal Co., Ltd.; The Rosedale Coal and Clay Products, Ltd.; Yellowhead Pass Coal and Coke Co., Ltd.; Drumheller Coal Co.; Newcastle Coal Co., Ltd.; Canmore Coal Co., Ltd.; Jasper Park Collieries, Ltd.; and the Pembina Coal Co., Ltd. The coals tested in the gas producer were the following: Pembina Coal Co., Ltd.; Drumheller Coal Co., Ltd.; Jasper Park Collieries, Ltd.; and the Newcastle Coal Co., Ltd. The coals on hand at the beginning of the new fiscal year—which will be investigated during the following season—are: Georgetown Collieries, Ltd.; McGillivray Creek Coal and Coke Co., Ltd.; West Canadian Collieries, Ltd.; Franco-Canadian Collieries, Ltd.; Greenhill Mine, West Canadian Collieries, Ltd. In addition to these commercial samples, the detailed investigation of which involved much chemical work, the chemical laboratory received for analysis, proximate, ultimate, or both, and determination of heating value, the following samples: Ninety-five coals, thirty-four peats, eleven oils or oil sands, seven ashes, four natural gases, and six miscellaneous samples. The work of the chemical laboratories is increasing at a rapid rate, and the staff, as a consequence, is scarcely able to keep up with the routine work.

With a view to rendering assistance to the coal operators of the Dominion of Canada in their efforts to reduce the mine accidents due to explosions resulting from mine gas, the Mines Branch undertook to analyse samples of gas from all the mines operating in the various provinces. Arrangements have been made whereby the chief inspectors of those provinces affected can furnish samples of mine gas, in specially constructed sample flasks furnished by the Mines Branch. Instructions were issued, explaining in detail how the sample should be taken and mailed to this office. The laboratory of the fuel testing station is now equipped with the special apparatus required for this class of work, and up to the close of the year we had received several samples from British Columbia, Alberta, and Nova Scotia.

The machine shop was kept exceedingly busy constructing new pieces of apparatus and machinery for the ore concentrating laboratory, the fuel testing station, and the laboratories of the main building of the Mines Branch, Sussex street, Ottawa. The subjoined report of the mechanical superintendent of the fuel testing station shows, in detail, the class of work performed for the various laboratories; the time of labourer or machinist spent on the individual pieces of work; and the cost of both labour and material. The labour charges account only for the time of the labourer while employed in the machine shop, not for his time in other work required to be done in the laboratories. An examination of the report will show that very decided economies have resulted in both the repair of old and construction of new apparatus, which, heretofore, had to be done outside, in the various machine shops.

The office work during the year consisted in the preparation of the report entitled, "Peat, Lignite, and Coal: Their Value as Fuels for the Production of Gas and Power in the By-Product Recovery Producer," and the final report on the results of the large scale tests which were conducted and completed this year.

The writer, during the month of August, was instructed to witness the test of the Johnson Electric Zinc Smelter at Hartford, Conn., in conjunction with Mr. G. C. Mackenzie, Chief of the Division of Ore Dressing and Metallurgy. This work necessitated the writer's absence from Ottawa during the month of August.

In October, the writer visited the Chief Inspector of Mines for the Province of Alberta, in order to confer on the arrangements for future shipments to Ottawa of coal for testing purposes. On this trip, he obtained samples of oil from the Calgary oil fields, which are now being investigated at the laboratories of the fuel testing station.

In addition to the regular work of this division, the writer and Mr. J. Blizard were engaged for some time in the investigation and writing of a report on the Graham process for the manufacture of peat fuel.

During the latter part of the year, the staff of the Division of Fuels and Fuel Testing was increased by the permanent appointment of Messrs. J. H. H. Nicholls and T. W. Hardy to the chemical laboratories, and E. S. Malloch, B.Sc., as additional technical engineer to the division.

Toward the close of the year, an experimental briquetting press was purchased for the purpose of investigating the feasibility of briquetting western lignites, which will shortly be undertaken.

The summary reports of Messrs. Stansfield, Mantle, and A. von Anrep are herewith subjoined.

II.

CHEMICAL LABORATORIES OF FUEL TESTING STATION.

EDGAR STANSFIELD.

Chemist in Charge.

These laboratories were utilized during the year, not only for the chemical work of the Division of Fuels and Fuel Testing, as described below, but also for that of the Division of Ore Dressing and Metallurgy. The staff of chemists employed has been materially increased. In February, Mr. H. C. Mabee—appointed to the Division of Ore Dressing and Metallurgy—took charge of the chemical work of that division. In October, Mr. T. W. Hardy, and in November, Mr. J. H. H. Nicholls, were appointed assistant chemists to the Division of Fuels and Fuel Testing; although Mr. Hardy has spent part of his time assisting Mr. Mabee in the work of the Ore Dressing Division. Dr. Carter has continued throughout the year in the work of fuel testing and the examination of oils and waxes.

The laboratory accommodation has been increased by the addition of a small room which has been fitted up for calorimeter work; and the ventilating system has been improved by the addition of a plenum system, with heating control for the air supply.

The equipment has been increased by the purchase of the following special apparatus, in addition to smaller apparatus and general supplies: Sartorius analytical balance, May-Nelson rotary vacuum pump, Lennox electric blower, Hoskins electric muffle, Hoskins electric hot plate, Leeds and Northrup electric resistance thermometer for calorimetry, Scimatco optical pyrometer, Engler oil distillation apparatus, Thurston oil tester, Parr sulphur bomb, Drehschmidt sulphur in gas apparatus, Burrell mine air analysis apparatus, and a meter tester. Moreover, the following new apparatus, or improvements to old apparatus, have been designed and made on the premises: Kjeldahl nitrogen apparatus, safety attachment to electric water still, automatic gas sampler, Jaeger nitrogen in gas determination apparatus, apparatus for determination of specific gravity of oil, and additions to Randall and Barnhart gas analysis apparatus.

The total number of samples submitted for analysis during the year, exclusive of routine gas samples, was, approximately, the same as in the previous year; but the samples submitted from sources outside the Department of Mines were nearly twice as numerous. The actual work involved in testing the samples submitted was considerably more than the corresponding work of the year before: more special investigations were carried out, and some progress was made with the arrears dating from the time when the present laboratories were being built, so that the total output was far in excess of any previous year. There appears to be no slackening in the steady increase in the demands made upon the laboratories; it is therefore regrettable that they are now working at nearly full capacity, both as regards the number of chemists for whom there is accommodation, and also as regards the varieties of work requiring special apparatus, for which laboratory space can be found.

The samples received include ninety-five coals, thirty-four peats, eleven oils or oil sands, seven ashes, four natural gases, and six miscellaneous samples. Twenty-seven samples were submitted by the Geological Survey; ten by the Board of Railway Commissioners; seventeen by the Department of Militia and Defence; two by the Department of Naval Service, and thirty-two from other parties. Some of the work of the laboratory consisted, as usual, of routine gas analysis in connexion with the large scale boiler and producer trials, carried out on the premises. The determinations made in this connexion include those of the composition and calorific value of gases, together with their ammonia, tar, and water content.

Special work carried out during the year includes: a preliminary investigation on the air drying of coal begun in March—still in progress, daily determinations being made; the design and testing of the new and modified apparatus enumerated above; and the design of a "total heat" attachment for the Boys gas calorimeter: this latter apparatus was not quite completed at the end of the year. The system of recording and reporting the work done in the laboratory has been further improved, and a number of suitable books and forms designed and printed for the purpose. A report on "Products and By-products of Coal" has been prepared by Stansfield and Carter, and will be published shortly. Moreover, at the close of the year arrangements were made for the taking and analysis of mine air samples from the collieries of the Dominion; special apparatus was purchased; record and report forms and books printed; sample tubes obtained and distributed; a special wax for sealing the tubes was prepared; and other preparations made for carrying out this important work in the coming year.

In July, the writer had the privilege of visiting the fuel testing laboratories of the University of Illinois at Urbana, and, through the courtesy of the Director of the Engineering Experiment Station, learned something of the work carried out and the methods employed.

III.

INVESTIGATION OF PEAT BOGS, 1914.

ALEPH VON ANREP.

According to the instructions received from the Chief of the Fuels and Fuel Testing Division, I spent six and one-half months of the field season of 1914 in the investigation of the peat bogs of the provinces of Quebec, Prince Edward Island, and Nova Scotia. The work was continued in order to ascertain the extent, depth, and quality of peat contained in the various bogs.

In connexion with this work, the writer left Ottawa on June 4, Mr. Y. Lamontagne acting as temporary assistant, for a period of a month and one-half. Owing to Mr. Lamontagne's desire to complete his college course, Mr. A. Gentles filled the position throughout the remainder of the season.

As a brief summary of work completed during the season, the following statement is appended:—

QUEBEC PEAT BOGS.

The peat bogs investigated in Quebec during part of June and July, 1914, were:—

(1.) The L'Assomption peat bog, situated 2 miles south of L'Epiphanie station, and about 1½ miles northeast of Cabane Roade station in the Seigneury of L'Assomption.

The total area covered by this bog is approximately 1,565 acres, the depth of the bog varies from 3 to 15 feet.

(2.) St. Isidore peat bog, situated about 3 miles south of St. Isidore station in the Seigneuries of:—

Chateauguay—La Prairie county.
Beauharnois—Chateauguay county.
La Salle—Napierville county.

The total area covered is approximately 1,931 acres, the depth varying from 3 to 11 feet.

(3.) Holton peat bog, situated 2 miles east of Holton station and 1 mile west of Barrington, in the counties of Chateauguay, Napierville, and Huntingdon.

The total area covered is about 6,181 acres, the depth varying from 4 to 6 feet.

The approximate total area investigated in the Province of Quebec during the season of 1914 was 9,677 acres.

PRINCE EDWARD ISLAND PEAT BOGS.

During the investigations in Prince Edward Island, carried on in the latter part of July and in the month of August, 1914, the following bogs were surveyed:—

(4.) The Black Marsh peat bog, situated 6 miles north of Tignish, lot 1, North county.

The total area covered was approximately 650 acres, varying in depth from 3 to 6 feet.

(5.) The Portage peat bog, situated about 1 mile east of Portage station, Halifax township, Prince county.

The total area of this bog is about 775 acres, of which 148 acres are peat litter, with a depth from 4 to 7 feet.

(6.) The Miscouche peat bog, situated about 1 mile from St. Nicholas station in lots 16 and 17, Richmond township, Prince county.

The total area covered by this bog is about 2,900 acres, of which 103 acres are peat litter with an average depth of 13 feet, and 2,797 acres, peat fuel, with a depth varying from 2 to 7 feet.

(7.) The Muddy Creek peat bog, situated about 3 miles southwest of St. Nicholas station, in lot 17, Richmond township, Prince county.

The total area covered was about 61 acres, with an average depth of 3 feet.

(8.) The Mount Stewart peat bog, situated in lot 35, about 1 mile south of Mount Stewart village.

The approximate total area investigated in Prince Edward Island during the season 1914 was 4,386 acres.

NOVA SCOTIA PEAT BOGS.

The peat bogs investigated in Nova Scotia, from the beginning of September to the middle of December, 1914, were:—

(9.) The Cariboo peat bog, situated about 1½ miles west from Berwick station, Kings county, on the line of the Dominion Atlantic railway, and about 2 miles west by the Post road.

The total area covered by this bog is about 887 acres, of which 200 acres with a depth varying from 16 to 26 feet, and 687 acres with a depth varying from 3 to 12 feet, are suitable for the manufacture of peat fuel.

(10.) The Cherryfield peat bog, situated about one-half mile southeast of Cherryfield station, Lunenburg county.

The total area covered by the bog is approximately 160 acres, with a depth varying from 3 to 20 feet.

(11.) The Tusket peat bog, situated to the southeast and east of Tusket station, Yarmouth county.

The total area covered by this bog is approximately 235 acres, the depth varying from 3 to 13 feet.

(12.) The Makoke peat bog, situated about 1½ miles south of Tusket station, Yarmouth county.

The total area covered is about 460 acres having a depth of from 4 to 12 feet.

(13.) The Heath peat bogs, situated in Yarmouth county, 1½ miles east of Argyle Head, about 1 mile east and west of Central Argyle station, and 2 miles east of Lower Argyle.

The total area of this bog is about 2,174 acres.

(14.) The Port Clyde peat bog, situated in Shelburne county, about 3 miles west of Port Clyde station, on the Halifax and Southwestern railway.

The total area covered by this bog is approximately 1,666 acres, the depth varying from 3 to 11 feet.

(15.) The Latour peat bog, situated in Shelburne county, about 1½ miles southwest of Upper Port Latour.

The total area of this bog is about 849 acres, having a depth of from 3 to 11 feet.

(16.) The Clyde peat bog, situated in Shelburne county, about 2½ miles northeast of Clyde River village. Two and one-half miles north of this village, the bog follows the Clyde river.

The total area of this bog is approximately 2,240 acres, with a depth varying from 2 to 21 feet.

The approximate total area investigated in the province of Nova Scotia during the season of 1914, is 8,671 acres, making a total area investigated during the season 1914, of 22,734 acres.

This figure is somewhat less than that of the previous year, but accounted for by the fact that the bogs investigated were spread over three Provinces, and many of them were difficult of access, owing to the wooded nature of the surrounding district.

During the latter part of July, I visited the peat plant at Alfred, completed earlier in the season, and which was in operation the whole day, thus offering an opportunity for inspection.

Detail description, deliminations, profiles and maps of the above mentioned peat beds, etc., will be published in a separate report.

IV.

REPORT ON MECHANICAL WORK DONE AT THE FUEL TESTING STATION, ETC.

To B. F. Haanel, B.Sc.,
Chief Engineer,
Division of Fuels and Fuel Testing,
Mines Branch, Dept. of Mines.

Sir,—Herewith appended is an abstract of the records that have been kept, showing the amount of work done, and the labour and material expended thereon: arranged under the heading of the department to which the same has been charged, and covering the period from April 1, 1914, to March 31, 1915.

The work shown in this report does not include the cleaning of machinery, attention to belts, pulleys, shafting, bearings, etc., to keep the plant in first-class running order. I may mention that to keep account of the cost of the above work, I am adopting a daily time card, so that the hourly occupation of each man is charged to whatever work he is doing during the day, the total of the same representing the total number of hours he has worked during the day, thus accounting for the occupation of each employee.

All of which is respectfully submitted.

A. W. MANTLE,
Mechanical Supt.

FUEL TESTING STATION.

———	Labour.	Material.
	$ cts.	$ cts.
Main bearing for Korting gas engine—		
Labour, 74 hours at 48c.	35 52	21 00
Making emery wheel stand—		
Labour, 33 hours at 48c.	15 84	4 50
Making and fitting brackets for small motor—		
Labour, 30 hours at 48c.	14 40	1 40
Making parallel strips for machine shop—		
Labour, 15 hours at 48c.	7 20	4 00
Forging and machining slot holes for shaper—		
Labour, 19 hours at 48c.	9 12	1 28
Making face plate for milling machine—		
Labour, 18 hours at 48c.	8 64	2 00
Two angle plates for machine shop—		
Labour, 19 hours at 48c.	9 12	3 60
Machining jaws of vise for shaper—		
Labour, 3 hours at 48c.	1 44	
Making two forge stands for holding bars—		
Labour, 3½ hours at 28c.	98	2 70
Making set of six cutters for keyways—		
Labour, 22½ hours at 48c.	10 80	1 08
Making expanding bushing for grinder—		
Labour, 2 hours at 48c.	96	25
Repairing pokers for producer—		
Labour, 3 hours at 48c.	1 44	
Repairing antipulsator—		
Labour, 6 hours at 28c.	1 68	
Polishing and lacquering electric fixtures—		
Labour, 37½ hours at 28c.	10 50	
Buff sink fittings—		
Labour, ¾ hour at 28c.	21	
Making pattern for electrical cutout on still—		
Labour, 2 hours at 28c	56	

FUEL TESTING STATION.—*Concluded.*

——	Labour.	Material.
	$ cts.	$ cts.
Making two air boxes for Westinghouse producer—		
Labour, 41 hours at 48c	19 68	14 64
Making "T" slot cutter—		
Labour, 11½ hours at 48c	5 52	23
Making special tool holder for shaping machine—		
Labour, 19 hours at 48c	9 12	55
Making pattern for tool holder—		
Labour, 5 hours at 28c	1 40	50
Making tools for milling machine (fly cutters)—		
Labour, 5 hours at 48c	2 40	
Making special relief valve for Westinghouse producer—		
Labour, 10 hours at 48c	4 80	2 85
Changing piping on Westinghouse producer to suit new air boxes—		
Labour, 26 hours at 28c	7 28	5 90
Making measure for producer—		
Labour, 2 hours at 28c	56	10
Repairing portable engine, which includes making new cross head, new slide bars, cylinder head, piston rod, new valves and thorough overhauling. Straightening crank shaft and fitting key. (Last item done at Lawson's.)	28 50	
New cross head—		
Labour, 30 hours at 48c	14 40	2 40
New cylinder cover—		
Labour, 21 hours at 48c	10 08	4 80
" 220 hours at 28c	61 60	
Fitting and repairing—		
Labour, 220 hours at 25c	55 00	7 50

CHEMICAL LABORATORY.

Making brackets and fittings for roller sun blind—		
Labour, 46½ hours at 28c	13 02	
" 19½ hours at 25c	4 88	
" 5 hours at 48c	2 40	4 80
Making automatic electric cutout for water still—		
Labour, 14 hours at 48c	6 72	75
Making and fitting iron drying shelves—		
Labour, 10 hours at 28c	2 80	1 40
Making total heat attachment for Boys calorimeter—		
Labour	12 50	6 85
Making small copper water trap 6 inches by 1 inch—		
Labour, 4 hours at 48c	1 92	30
Making special nitrogen distillation apparatus—		
Labour, (J. Philips, tinsmith)	14 72	4 50
Total	$407 71	$100 38
Add—		
Making mixing chamber for steam and air on Westinghouse producer—		
Labour, 8 hours at 48c	3 84	
" 10 hours at 28c	2 80	14 10
" 10 hours at 25c	2 50	
Total	$416 85	$114 48

ORE DRESSING LABORATORY.

Making and erecting belt shifter for No. 1 pump—		
Labour, 13 hours at 28c	3 64	
13 hours at 25c	3 25	3 40
Making and erecting belt shifter for No. 2 pump—		
Labour, 12 hours at 28c	3 36	
12 hours at 25c	3 00	3 25
Making and erecting belt shifter for No. 3 pump—		
Labour, 14 hours at 28c	3 92	3 70
14 hours at 25c	3 50	

ORE DRESSING LABORATORY—*Continued.*

———	Labour.	Material.
	$ cts.	$ cts.
Making and erecting belt shifter for No. 4 pump—		
Labour, 12½ hours at 28c	3 50	3 60
12½ hours at 25c	3 13	
Making and erecting belt shifter for Deister table—		
Labour, 15 hours at 28c	4 20	3 80
15 hours at 25c	3 95	
Making and erecting belt shifter for Overstrom table—		
Labour, 14½ hours at 28c	4 06	3 75
14 hours at 25c	3 50	
Making and erecting belt shifter for No. 2 elevator—		
Labour, 12 hours at 28c	3 36	3 55
12 hours at 25c	3 00	
Special belt tighteners on concentrating tables—		
Labour, 40 hours at 48c	19 20	
" in fitting, 19 hours at 28c	4 42	5 75
Making two special steel tanks for Richards jig—		
Labour, 298¼ hours at 28c	83 51	28 70
Repairing and adjusting No. 1 elevator—		
Labour, 10 hours at 28c	2 94	
10½ hours at 25c	2 63	
Adjusting Deister table bearings—		
Labour, 11 hours at 28c	3 08	
Repairing and adjusting friction clutch on crusher—		
Labour, 8 hours at 28c	2 24	2 70
Making and erecting belt shifter for air compressor—		
Labour, 24 hours at 28c	6 72	3 60
Fitting spiral ore conveyers to bins—		
Labour, 64 hours at 28c	17 92	7 50
64 hours at 25c	16 00	
Making spout for Richard laboratory jig No. 1—		
Labour, 1 hour at 28c	0 28	0 10
Making conveyer boxes—		
Labour, 20 hours at 40c	8 00	3 40
Making motor belt tighteners, machining castings and cutting gears—		
Labour, 151 hours at 48c	72 48	
" in fitting, 65 hours at 28c	18 20	4 80
Making special elevating screws for Overstrom table—		
Labour, 16 hours at 28c	4 48	0 64
Erecting air compressors—		
Labour, 24 hours at 28c	6 72	
" 24 hours at 25c	6 00	1 50
Erecting shafting and clutch for air compressors—		
Labour, 28 hours at 28c	7 84	
Making four ball thrust bearings for No. 1 and No. 2 line shafts—		
Labour, 44 hours at 48c	21 12	7 25
Fitting ball thrust bearings in wall and on shaft—		
Labour, 32½ hours at 28c	9 10	0 25
Machining two pairs of grinding plates for Baumé pulverizer—		
Labour, 12 hours at 48c	5 75	4 16
Making bracket pattern for shaft bearings in roaster building—		
Labour, 6 hours at 28c	1 68	0 25
Making brackets for shaft bearings roaster building—		
Labour, 6 hours at 28c	1 68	3 40
Making large anchor bolts for large smokestack for roaster building—		
Labour, 8 hours at 48c	3 84	6 97
"Special"—Making cyanide machine including 12 sheaves, 6 spindles, 12 bearings, shafting and two pulleys—		
Labour, 96 hours at 48c	46 88	
In erecting, 56 hours at 25c	14 40	9 30
Erecting rotary roaster furnace—		
Labour, 125 hours at 28c	35 00	
" 88 hours at 25c	22 00	91 75
" 384 hours at 43¾c	168 00	
Making eight special columns for steel work in roaster building—		
Labour, pattern making, 8 hours at 28c	2 28	50
" machine castings, 24 hours at 48c	11 52	
Cutting pipes for columns—		
Labour, 6 hours at 48c	2 88	51 60

ORE DRESSING LABORATORY—*Concluded.*

	Labour.	Material.
	$ cts.	$ cts.
Erecting steel structure for receiving tank and overhead gear and shafting—		
Labour, 254 hours at 28c	71 12	239 96
" 210 hours at 25c	52 50	
Making and fitting small door in roaster building—		
Labour, 30 hours at 20c	8 40	3 60
Making special roller feeder for pneumatic jig—		
Labour,—pattern-making, 8 hours at 40c	3 20	
" machine work, 86 hours at 48c	41 28	4 50
Total	854 66	507 24

SUSSEX STREET.

	Labour.	Material.
Making ten brass discs ½-inch larger in diameter than sample—		
Labour, 5½ hours at 48c	2 64	1 50
Making six brass discs as per sample—		
Labour, 4 hours at 48c	1 92	1 25
Making four brass plates as per sample—		
Labour, 3 hours at 48c	1 44	70
Straightening copper boiler, truing circle of mouth—		
Labour, 3 hours at 48c	1 44	
Fitting dust collecter—		
Labour, 4 hours at 28c	1 12	
Making emery wheel attachment for motor—		
Labour, 6 hours at 48c	2 88	15
Making improved electroscope—		
Labour, pattern-making, 8 hours at 48c	3 84	
" machining, 48 hours at 48c	23 04	10 50
Making cement mixing table—		
Labour, 20 hours at 48c	9 60	35 78
Erecting machinery for Mr. Cole—		
Labour, 24 hours at 48c	11 52	
" 24 hours at 20c	4 80	
Total	64 24	49 88

SUMMARY.

	Labour.	Material.
Fuel Testing Station	348 75	81 78
Miscellaneous Work—		
Repairs to portable engine	198 46	21 10
Chemical laboratory	58 96	18 60
Ore Dressing laboratory	854 66	507 24
Roaster building	255 56	157 82
Sussex Street	64 24	49 88
Total	1,780 63	886 42

DIVISION OF CHEMISTRY.

THE CHEMICAL LABORATORY, SUSSEX STREET.

F. G. WAIT.

Chief of the Division.

The work in the chemical laboratory has, for the most part, been along the same lines as in former years. One new field of research, however, has been opened up, and work in it carried on continuously since June, namely, the investigation of the mineral waters of Canada.

A few explanatory remarks regarding the scope of this new work may, appropriately, be given here.

The investigation is to comprise not only a complete chemical analysis of the several waters, together with a study of their physical properties, but special attention is to be given to their radio-activity.

A well or spring water may contain in solution—in addition to the saline constituents usually present:—

(*a*) Radium emanation: the gas which is a product of the continual decomposition of radium, or its salts, and which has come to be regarded as a therapeutically important factor; and

(*b*) the gas (*a*) and extremely small quantities of radium salts.

As radium emanation rapidly decays—one-half the initial quantity dying in four days—its estimation should be made at the time of the collection of the sample, or as soon as possible thereafter.

To satisfactorily make this examination, it is intended that an expert officer of the Department shall personally visit each water source, and make, on the spot, those tests which I have stated should be made at the time of collection; take such observations of the physical character of the water as may be desirable and possible; and, at the same time, collect and send to Ottawa a sufficient quantity of the water for the subsequent chemical analysis.

Work along these lines has been carried on during the summer of 1914 by Dr. John Satterly, Associate Professor of Physics in the University of Toronto, assisted by Mr. R. T. Elworthy, B.Sc. (London), and, by the last named, after Dr. Satterly's return to Toronto, in September.

In order to facilitate the prompt examination of the waters collected, arrangements were made for the determination of the radio-activity at three centres, namely:

1. The laboratory of the Mines Branch at Ottawa.
2. The bottling works of the Caledonia Springs Co., at Caledonia Springs, Ont., and
3. In the laboratories of the Macdonald Physics Building, of McGill University, at Montreal.

At each of these places suitable accommodation was provided for the setting up of electroscopes, and the operation of the necessary accessories, and to each of these the samples collected in their respective neighbourhoods were sent, and the desired determinations made with all possible expedition.

For the determination of the dissolved radium, as well as for the chemical analysis, a sufficient quantity of the water was forwarded to Ottawa.

The following springs or sources have been visited, and their waters examined in the manner outlined:—

(a) Examination made in Ottawa:—

Gillan's spring, near Pakenham.
Sanitaris Water Co.'s spring, at Arnprior.
Borthwick spring, near Hawthorne.
Victoria sulphur spring, near Ottawa.
Russell Lithia Water Co.'s springs (2) at Bourget.
Carlsbad springs—five in number.
Several civic wells, and other private sources, in and about Ottawa.

(b) At Caledonia Springs:—

Five of the best known Caledonia springs.
Two saline waters owned by Charles Gurd & Co., of Montreal, situated at Caledonia Springs.
Adanac water, at Bourget.
Plantagenet mineral water; and
A copious spring at Alfred, Ont.

(c) At Macdonald Physics Building, Montreal:—

Abenakis springs (2) at St. Francis du Lac.
Berthier.
Maskinonge.
Potton.
Radnor Forges.
Richelieu.
Ste. Agathe.
St. Benoit.
Ste. Genevieve.
Ste. Hyacinthe.
St. Leon.
St. Severe.
Varennes.
Viauville: remarkable for the large quantity of hydrogen sulpide it contains.

together with samples from several of the "Artesian and other Deep Wells of the Island of Montreal," referred to in a report published by the Geological Survey of Canada, under the above caption, by Dr. F. D. Adams.

Detailed results of the work done this season will not be published until the chemical analyses are completed; but it can be stated that in most of the instances the waters examined were slightly radio-active, giving values of the same order of magnitude as those from other parts of the world where results have been recorded.

With regard to the other work carried on during the year, the several items are susceptible of classification, and for purpose of ready reference, may be arranged under the following headings:—

ASSAYS.

One hundred and thirty-two samples of gold, silver, and—in a few instances—platinum ores, from the undermentioned Provinces, have been examined:—

i. From Nova Scotia, one sample.
ii. " Quebec, six samples.
iii. " Ontario, thirty-nine samples.
iv. " Manitoba, one sample.
v. " Saskatchewan, twenty-two samples.

vi. From Alberta, two samples.
vii. " British Columbia, five samples.
viii. " Yukon Territory, nine samples.
ix. and forty-eight others, concerning which insufficient, or no data as to locality of occurrence, was furnished.

CLAY.

Qualitative examinations of six samples of clay have been made, to ascertain if they were suitable for employment either in brick making, or as an ingredient of artificial Portland cement. The examinations so made were of a very unsatisfactory and indefinite character, hence it is gratifying to be able to allude to the new Division of Ceramics, now in process of establishment in connexion with the Mines Branch, and to which all clay samples may in future be sent for examination and testing.

None of the samples referred to above were of enough interest to merit special notice here.

COPPER ORES.

Twelve samples of copper-bearing ores: one from Nova Scotia; one from New Brunswick; three from Ontario; two from the Yukon; and five from unspecified localities have been examined. In connexion with this collection of copper ores, however, there is much to be desired in the way of more complete information as to locality of occurrence. As the matter stands, our report can only state that the particular specimen examined comes from an undesignated locality; often without even the name of the province being given. It is manifest, therefore, that a report so indefinite is of little value, either to the recipient, because it lacks definiteness, or to the Department, since it conveys no information of the mineral worth of any particular deposit or area.

IRON ORES.

Eighteen samples of iron ores have been submitted, either for complete, or for partial analysis, from the following localities:—

(a) Cape Breton county, N.S. Four samples from—
  i. The Curry property.
  ii. W. Mackenzie farm at Marion Bridge.
  iii. " Pit No. 2.
  iv. Grand Mira, South.
(b) Richmond county, N.S. Two samples from—
  i. D. McIntyre's property, Loch Lomond.
  ii. Robinson property, at Barra Head.
(c) Antigonish county, N.S. One sample from—
  Arisaig iron district;

while eleven other samples must be put down as from 'undefined localities.'

LEAD ORES.

The smelter returns from the output of several of the auriferous quartz workings in the Yukon, having been found to be slightly above that indicated by the test assays, it was deemed advisable to determine the lead content of such as were thought might be plumbiferous. To that end, some 378 samples were analysed. Of that number,

20 contained only traces of lead.
60 " less than one per cent of lead.
11 " more than one, but less than two per cent.
17 " " two, " three per cent.
10 " " three, " four per cent.
12 " " four, " five per cent.
5 " " five per cent, while
219 contained no lead whatever.

LIMESTONES.

During the year, fifty-two samples of limestones and dolomites have been analysed by Mr. Leverin.

Nineteen samples were from the following named quarries in the vicinity of St. John, N.B.:—

i. Charles Miller's, two samples; one of blue, and one of yellow limestone.
ii. Stetson and Cutter's, four samples; three of blue limestone, and one of white dolomite.
iii. Purdy and Green's, two samples of blue limestone.
iv. Randolph and Baker's, seven samples; three of blue, two of white, and one of yellow limestone, and one of white dolomite.
v. From Drury Cove, three samples of blue limestone.
vi. From Green Head, one sample of altered limestone.

The remaining thirty-two samples were collected by Mr. Fréchette, from the undermentioned localities in western Quebec:—

Pontiac county, lot 26, range I, of Clarendon.
" an island at Portage du Fort.
" quarry at Portage du Fort.
" Carswell's quarry, at Bryson (2 samples).
" lot 4, range VIII, of Clarendon.
" lot 8, range I, of Clarendon.
" on C. N. R. property, at Bristol.
" lot 12, range III, of Onslow.

Wright county, quarries at Hull; at Ste. Cecile de Masham; at Farrelton; and at Paugan Falls.

Ottawa county, lot 39, range VIII, of Aylwin.
" lot 16, range III, of Aylwin.
" lots 6 and 7, range VI, of Aylwin.

Labelle county, from bed of Lievre river at Masson.

Argenteuil county, lot 21, range I, of Harrington.
" " 10, " VIII, of Grenville.
" " 15, " IX, of Grenville.
" " 7, " IV, of Grenville.
" " 15, " III, of Grenville.
" quarry near Calumet.
" lot 17, range IV (Lanes Purchase), north of Lachute.
" quarry one-half mile south of Lachute.
" quarry at Carillon.
" from Ottawa river between Cushing and Stonefield.

(And one sample from the Ontario end of the dam at Carillon.)

Terrebonne county, from P. Sanche's quarry, 3 miles N.E. of Ste. Therese.
" from a quarry at Ste. Therese.
" from a quarry one-half mile south of Ste. Therese.
" from a point 2 miles west of Piedmont.

Laval county, from N. Brunel's quarry, near St. Vincent de Paul.

Mr. Fréchette's collection comprised some 110 samples; but the analyses of the above 32 only had been completed within the time covered by this summary.

MOLYBDENITE.

Three samples of this mineral have been examined. One was from lots 7 and 8 of range II of Eardley township, Pontiac county; and two from the west half of lot 28, concession IV, of Bagot, Renfrew county, Ontario.

NICKEL AND COBALT ORES.

Eight samples—one each from—

(i) A point 1 mile from tide water, on the east side of King street, St. Stephen, N.B.
(ii) Calumet island, Pontiac county, Que.
(iii) Sesekinika lake, Ont., and
(iv) Lot 20, concessions III and IV of Bagot township, Renfrew county, Ont., and
Four from unspecified localities.

ROCK AND MINERAL ANALYSES.

With the continued augmentation of the staff of both the Geological Survey and Mines Branches of the Department of Mines, there has been a gradual increase in the number of specimens of rocks and minerals sent for exhaustive chemical analysis.

Mr. M. F. Connor and Mr. N. L. Turner have both been carrying on this class of work, Mr. Connor's whole time being devoted to it, while Mr. Turner has been called upon to do other work from time to time.

Even with the service of two chemists available, it is not possible to issue reports as soon as the collectors of the samples desire.

It has accordingly happened on more than one occasion that summary, or other, reports have either been delayed, or have been issued in an incomplete condition.

It would appear that additional assistance in this class of work will soon be demanded.

During 1914, analyses of the following have been completed and reported, and work upon others commenced:—

Six feldspars from Ottawa county, Quebec, as follows:—

(i) O'Brien mine, lot 21, range VI, of West Portland township.
(ii) Villeneuve mine (microcline), lot 21, range I, of Villeneuve.
(iii) Villeneuve mine, (albite, peristerite), lot 21, range I, of Villeneuve.
(iv) Leduc mine (amazonite), east half of lot 25, range VIII, of Wakefield township.

(v) Leduc mine, second sample.
(vi) Pearson mine, lot 13, range XII, of Buckingham township.

Three feldspars from Saguenay county, Quebec.

(vii) Canadian Feldspar Company's mine at Manicouagan bay.
(viii) Lac Pied du Monts mines, at Lac Pied du Monts (two samples).

Two feldspars from Frontenac county, Ontario.

(ix) Gamey mine, on lot 5, concession XIII, of Portland township.
(x) Richardson mine, lot 1, concession II, of Bedford township.

One feldspar from Lanark county, Ontario, from—

(xi) Silver Queen, or Smith mine, situated on east half of lot 13, concession V, of North Burgess.

The foregoing twelve samples were all collected by Mr. H. S. de Schmid, of the Mines Branch staff.

(xii) Residual red clay, collected by Mr. R. G. McConnell, on Texada island, B.C.

(xiii) Muscovite granite, from one-fourth mile southwest of Larder river, and one-fourth mile below its junction with Ross Meadow brook, N.S.

(xiv) Biotite granite, from a point a mile and a half north of Wallaback lake, N.S.

The two immediately foregoing were collected by Mr. W. J. Wright, of the Geological Survey.

(xv) Quartz diorite.
(xvi) Granodiorite.
(xvii) Pulaskite.
(xviii) Dike.

One sample of each of the foregoing was collected in the Beaverdell district of British Columbia by Mr. L. Reinecke, of the Geological Survey.

(xix) Analcite rock, and
(xx) Analcite crystals.

Collected by Mr. J. D. Mackenzie, of the Geological Survey staff, on section 3, township 6, range 4, west of 5th meridian.

(xxi) Silt, from Thompson river, near Ducks, B.C.

Collected by Dr. R. A. Daly.

(xxii) Six rocks, collected by Mr. O. E. Leroy, of the Geological Survey Branch, at Franklin, B.C., as follows:—

Monzonite.
Minette.
Syenite.
Felspathic pyroxenite.
Basalt.
Trachyte.

(xxiii) Six specimens from Kyoquot sound, Vancouver island, collected by Mr. C. H. Clapp.

(xxiv) Three rocks from the Mount Royal tunnel in the city of Montreal, collected by Professor J. A. Bancroft, of McGill University, were fully analysed, and a partial analysis and a preliminary report made upon six others from the same locality.

(xxv) A slightly pyritiferous argillite from an undefined locality in New Brunswick—sample submitted by Honourable James Domville.

WATERS.

In addition to the work done in water investigation, as already referred to, five waters have been qualitatively examined.

Two were from Ontario; one sample being taken from a boring 175 feet deep, near Pendleton, and another from a spring on lot (?), concession I, of Alfred, both in Prescott county.

One sample was sent by Mr. W. B. Nicholson, of Gilbert Plains, Manitoba.

A sample sent from Hayter, Alberta, was thought by the sender to be indicative of oil, but examination proved that this was not the case.

The fifth sample examined was collected at Refuge cove, on the west coast of Vancouver island, by Mr. Charles Clapp, of the Geological Survey staff.

ZINC ORES.

Determinations of zinc were made in two samples submitted.

One was collected by Mr. E. Lindeman, of the Mines Branch staff, at East Bay mine, in Cape Breton county, N.S.; the other was submitted by Mr. G. C. Mackenzie as an umpire sample of certain of the zinc ores abounding at or near Nelson, B.C.

MISCELLANEOUS MATERIALS.

Under this heading is grouped a wide variety of materials, some of which are of more than passing interest, but on account of the meagre information furnished cannot be made use of.

Sand, bricks, clay (supposed pigment), mica, shale, marl, silt, graphitic rock, meteorite, are some of the materials included here. Twenty-four such samples were examined.

Some 882 specimens of various kinds have thus been accounted for, and the work upon them completed and reported.

In carrying out the necessary practical work, the three assistants, Mr. M. F. Connor, B.Sc., Mr. H. A. Leverin, Ch.E., and Mr. N. L. Turner, M.A., have given close attention to the duties assigned them, and their work has been highly commendable.

REPORT OF THE DIVISION OF MINERAL RESOURCES AND STATISTICS.

JOHN MCLEISH.

Chief of Division.

A preliminary report on the Mineral Production of Canada, during the calendar year 1914, has already been completed, and separately published, and will be included as an appendix to this report.

The work of this division, which has been described in previous Summary Reports, consists chiefly in the annual collection of statistics of mining and metallurgical production, and the compilation and publication of reports thereon.

The period covered by the statistical record is the calendar year, the twelve months ending December 31. Thus, in January, 1914, schedules were distributed to mining companies throughout Canada, requesting returns of production during the calendar year 1913. In many cases the mine operators have not the information available until several weeks, or even months, after the close of the year. However, sufficient information was available to complete a preliminary report, which was sent to press during the last week in February, and was distributed during the following week. The preparation of the complete and final reports was then undertaken. A revised edition of the report on Economic Minerals and Mining Industries of Canada was prepared for distribution at the Panama Pacific Exposition. The usual lists of mine and quarry operators were compiled, including, for the first time, a list of non-metal mine operators, and a list of sand and gravel operators.

It is with the deepest regret that we have to record the loss, by death, of Mr. Cosmo T. Cartwright, Assistant Mining Engineer in this Division. Mr. Cartwright died in Kingston, October 27, after having been in failing health from about the middle of August. For several years, Mr. Cartwright has prepared the special chapters in the annual statistical report on the production of Gold, Silver, Copper, Lead, Nickel, and Zinc, and had just completed his report covering the year 1913. Being a man of the highest integrity and personal honour, his passing is deeply deplored by his associates, and as he was particularly well informed concerning the mining industry in western Canada his loss has been a severe one to the Division. No matter how capable his successor, it will require considerable experience to render equivalent service.

The writer, together with Mr. Cartwright, attended the annual convention of the Canadian Mining Institute in Montreal, March 4 to 6, in the interests of the Division, and, as usual, a short paper was presented on the Mineral Production of Canada during 1913. A visit was paid to Sydney, N.S., April 14 to 17, and an illustrated paper on certain phases of the mining industry was presented to the Mining Society of Nova Scotia. Through the courtesy of the Dominion Steel Corporation, the iron and steel plant at Sydney, and several of the collieries in the district were visited, subsequently, several days were spent at New Glasgow, Halifax, and Truro.

On September 25, I received notification of my appointment as member of a special committee to investigate certain points in connexion with the iron mining industry in Canada, and from that date to the close of the year a good deal of my own time was taken up with the work of that committee.

The publication as advance chapters of separate parts of the final report on mineral production was again continued; and in pursuance of this plan, five separate chapters were completed on the dates shown in the following list.

REPORTS AND LISTS OF MINE OPERATORS COMPLETED FOR PUBLICATION DURING THE YEAR.

Reports:—

- Preliminary Report on the Mineral Production of Canada during the calendar year 1913—February 24.
- The Production of Iron and Steel in Canada during the calendar year 1913—July 14.
- The Production of Coal and Coke in Canada during the calendar year 1913—July 27.
- The Production of Copper, Gold, Lead, Nickel, Silver, Zinc and other metals in Canada during the calendar year 1913—July 30.
- The Production of Cement, Lime, Clay Products, Stone and other structural materials in Canada during the calendar year 1913—August 24.
- A General Summary of the Mineral Production of Canada during the calendar year 1913—September 4.
- Annual Report on the Mineral Production of Canada during the calendar year 1913—September 9.
- Economic Minerals and Mining Industries of Canada, Panama Pacific Edition 1914—October 19.

Lists of Mine and Quarry Operators:—

- List of Coal Mine Operators in Canada—June 6.
- List of Mines in Canada (other than metal mines, coal mines, stone quarries, clay plants, etc.)—July 21.
- List of Manufacturers of Clay Products, of Sand-Lime Brick and of Cement in Canada—September 22.
- List of Stone Quarry Operators in Canada—October 5.
- List of Lime Kilns in Canada—October 6.
- List of Operators of Sand and Gravel pits or deposits—October 14.

The correspondence of the division during the year comprised about 9,870 letters and circulars sent out, and 3,868 received. The amount of work involved in the compilation of statistics of production, imports and exports; the preparation and revision of lists of operators; the writing and checking of reports; indexing of mining literature, and of the incorporation of mining companies, together with other routine work of the division, has increased very greatly during the past few years. During 1914, the assistance of one temporary clerk was secured, namely, from November 20 to the end of the year.

Much time is taken up in the preparation of information for correspondents and others respecting the mining industries and mineral resources of the country; an endeavour being made in all cases, so far as the records and reports of the Department will permit, to furnish enquirers with the information required, or to advise them where it may be obtained.

During 1914, and particularly after the outbreak of the war, a considerable number of inquiries have been received relative to the mineral resources of Canada, and more especially with regard to possible supplies of barytes, celestite or strontium sulphate, chromite, infusorial earth, magnesite, molybdenite, etc.

The war had an immediate effect in the dislocation of commerce; the closing of market exchanges involving the temporary cessation of metal and mineral quotations, all of which seriously restricted the output, and accentuated the decrease in production, which was already expected, as a result of the financial stringency of 1913, and the culmination of land and other speculation.

So soon, however, as control of the sea was demonstrated, market quotations and trading were resumed at reduced prices.

The continuance of the war increased the demand for many metals such as copper, lead, zinc, antimony, molybdenum, etc., the prices of which rapidly rose to levels equal to, or higher than, those previously prevailing.

In view of the dependence of the Empire upon German and European sources for such products as potash salts, coal tar dyes, and other coal tar by-products, cyanide salts, magnesite, kieselguhr, and other mineral products, both natural and manufactured, the war has demonstrated the desirability of the development, as far as possible within the Empire, of those various mineral and metal resources, not only the ores, but also the refined products, now so essential to the nation's life.

The war's demands for iron and steel products has given considerable stimulus to Canadian iron and steel plants at a time when the demands of the general commercial market were approaching a minimum. It is reported that arrangements have already been made for the recovery of toluol and benzol at the coke oven by-product plant at Sydney, and there is every evidence that the mining and metallurgical industries are being stimulated in many directions.

HILLCREST MINE DISASTER.

J. G. S. Hudson.

On the morning of June 19, 1914, a violent explosion occurred in the underground workings of the Hillcrest Colliery, Alberta, causing the death of 189 men; the worst disaster in the history of coal mining in Canada. When the press notices of the explosion, and the appalling loss of life appeared, the Deputy Minister of Mines instructed me to proceed to Hillcrest without delay, and to render any assistance in my power to the Inspector of Mines for that Province; to the management of the Coal Company; and to the representatives of the workmen employed. My written instructions were as follows:—

Office of the Deputy Minister,
Ottawa, June 20, 1914.

J. G. S. Hudson, Esq.,
Mines Branch, Department of Mines,
Ottawa.

Dear Sir,—You are instructed to proceed at once to Hillcrest, Alberta, to investigate the recent appalling disaster at the Hillcrest collieries. You will obtain as full an account of the disaster as possible, with all obtainable facts bearing upon its cause, severity, and consequences. For this purpose you will be present at the inquest. If there is any assistance which you can render the Provincial or other authorities in meeting the overwhelming situation created by this catastrophe, you will place your services at their disposal.

Yours truly,
R. W. Brock.

On receipt of these instructions I left Ottawa on Saturday night, June 20, and arrived at Hillcrest, Alberta, on Wednesday morning, June 24, 1914, and at once proceeded to the Hillcrest mine, where I met Mr. John T. Stirling, Chief Inspector of Mines, Province of Alberta; his Deputy Inspectors of Mines; Mr. I. C. Roberts, Mining Engineer of the United States Bureau of Mines, Denver, Colorado; the General Manager of the colliery, Mr. John Brown; and other officials, and with them proceeded to make an inspection of the underground workings of the mine. After repeated visits, I cannot add any new evidence of importance to that submitted in my first report, which is as follows:—

Frank, Alberta, July 13, 1914.

R. W. Brock, Esq.,
Deputy Minister of Mines,
Department of Mines, Ottawa.

Sir,—We have travelled and examined all that part of the mine wherever the men met their death, either from the violence of the explosion or from poisoning by gas formed after the explosion occurred.

Many parts of the mine show very heavy disruptive force. This is especially noticeable where the levels or other working places required timbering; where the roof of the mine was loose; in haulage landings where mine cars were assembled; and the almost total demolition of the stoppings placed in the mine to conduct the ventilating currents to the working faces.

The Hillcrest mine has a remarkably good natural roof, having only a small portion of what is locally known as cap-rock, that is, a rock between the coal and the characteristic rock forming the roof. It is extremely doubtful if the good roof had not been so strong, whether the larger part of the mine would have ever been regained. It would have been extremely difficult to recover the bodies of the men within so short a time, for on the Saturday following the explosion (which occurred 9.30 A.M. Friday) the greater number of the men who perished were taken out of the mine. As you would anticipate from the fact that in the Hillcrest disaster more men lost their lives than in any previous mine explosion in Canada, a great many mining men were attracted to the scene of the explosion, to ascertain the cause thereof, as the Hillcrest mine was considered one of the best mines in the Crowsnest Pass district.

The usual reports as to the condition of the mine were in order, and on the morning of the explosion there was not an unusual amount of inflammable gas in the mine reported, when the geological formation and heavy angle of inclination at which the seams lie—as in the case of all the mines in the district—are taken into account. In most cases the workings have been started from a level in the mountain side, but at a later date have gone down to the deep, and are under a heavy pressure from the superincumbent strata. These conditions are conducive to exudation of gas, and possible accumulation of coal dust; both conditions of which are now recognized as sources of danger and liability to sudden explosions.

In our inspection of the underground workings, any indications which were found were very contradictory as showing the exact locality where the initial point of ignition took place. This applies also to the disruptive force—demonstrated by the evidence—on mine timber, mine cars, and ventilating stoppings which were in many cases demolished. In one instance an air receiver 3 feet 6 inches in diameter × 9 feet 0 inches long, was carried a distance of 220 feet along the level. The force of the explosion was of great violence at the mine openings, and ventilating fan exits.

At the mouth of one of the slopes the haulage engine house built of concrete 8 inches thick, was blown in; mine cars on the surface were broken, and flung about, and large volumes of smoke and dust were ejected.

On being notified of the disaster, the mine rescue car of the Alberta Department of Mines, stationed at Blairmore, was hurried to the scene of the explosion, with oxygen breathing apparatus, and other appliances, which were of great service, and demonstrated, without any question of a doubt, that the expenditure of money in this equipment was perfectly justifiable.

As in most coal mining accidents, the number of volunteers who offered their services for the recovery of the bodies was without limit; and they rendered assistance which cannot, in many cases, be even acknowledged, since their names were not even known. Many cases of individual bravery can be recorded. In one case, a man re-entered the mine after getting out safely, to try and rescue his two sons, but was unsuccessful, and perished. Another fire boss got out safely from his section of the mine, and went back in the first rescue party, though he had lost two brothers and three cousins. Very many cases such as these might be cited, and goes to show that in cases of emergency, good men always come forward for the rescue parties.

After the explosion, one part of the mine was on fire, but by well directed energy and hard work the individual fires were got under control, thus saving much anxiety, and allowing the rescue parties to proceed with their search work and recovery of the bodies.

As soon as possible after identification and burial of the bodies, relief committees were formed to look after the women and children left dependent.

The official record of the men who lost their lives, due to the explosion, is as follows:—

Number of men who entered the mine on the morning of June 19, 1914	237
Number of men rescued	48
Bodies identified	181
Bodies unidentified	6
Bodies still in the mine (July 13, 1914)	2
Total number of men killed	189

It has been a very difficult matter to determine the actual number of widows and children dependent on the mine workers who lost their lives in the explosion, since quite a large number were from European countries. And it will take some time before the Consuls representing the respective countries can communicate with the proper authorities; but so far it is certain that there are 89 widows and 106 children. Much appreciation was expressed that the Dominion Government acted so promptly, and with such liberality in voting the sum of $50,000 for the relief of the widows and children. The Government of Alberta have also appropriated $20,000 for the same object, and substantial sums were contributed by corporations and private individuals.

Under the statute laws of the Province of Alberta, the Workman's Compensation Act provides that the Hillcrest Coal Company are liable for compensation to the relatives of the men who lost their lives.

I am of opinion that very few mining men would reach a unanimous decision as to the direct cause of the explosion. No direct evidence can be produced as to what actually did take place. All the men who could have given comprehensive statements of facts are dead, so that the findings of the inquiry has, necessarily, to be based on theoretical assumptions, and not on actual facts.

The following is a copy of the official report of the Investigation Commission:—

"REPORT OF THE COMMISSION APPOINTED FOR THE INVESTIGATION AND ENQUIRY INTO THE CAUSE AND EFFECT OF THE HILLCREST MINE DISASTER.

"Calgary, October 20, 1914.

"The Honourable Charles Stewart,
Minister of Public Works,
Edmonton, Alberta.

"Sir,—I have the honour to submit herewith, my report based upon the evidence taken at the enquiry into the Hillcrest Mine disaster, in pursuance of the power vested in me by the Commission bearing date the 24th day of June A.D. 1914. I would ask you to be good enough to place the report before the Lieutenant Governor in Council.

"The hearing of the evidence was begun by me on the 2nd day of July of this year and continued until the 11th day of that month inclusive. The very fullest opportunity was given to the public as well as to all parties interested, to give under oath any evidence or information they desired to give, and throughout the enquiry it was constantly intimated by me that no one who desired to give evidence would be denied that opportunity, and further that if any one could give the names of any parties whose evidence, in their opinion, would be of any assistance to the Commission, upon the handing in of the names of such parties to the counsel appearing for the Government, they would be at once summoned before the Commission and required to give evidence.

"All the evidence available was taken and what might be said to be a fairly thorough inspection of that part of the mine where the explosion was supposed to have occurred, was made by the Commission.

"The report has been delayed owing to not having received the result of the tests of coal dust that were to be made by the United States Bureau of Mines, which tests it was agreed by counsel should be taken into consideration in making this report.

"In addition to Mr. W. M. Campbell, K.C., who appeared on behalf of the Government of the Province, Mr. Colin Macleod acted for the owners of the mine, Mr. J. R. Palmer for the Miners' Union, and Mr. A. J. Kappalle, of Vancouver, for the Royal Italian consul, representing the Italian subjects who were among the victims of the disaster.

"I am forwarding under separate cover the evidence taken at the enquiry, together with the various exhibits put in in evidence.

"I have the honour to be, Sir,

"Your obedient servant,

"A. A. Carpenter,
"*Commissioner.*

"The explosion in the mine of the Hillcrest Collieries, Limited, occurred, according to the evidence taken at the inquiry, at about 9.30 o'clock in the morning of the 19th of June this year. At the time of the explosion there were 235 employees of the company in the mine. Of these, 189 perished, the only ones saved being those in the northerly portion of the mine, in the workings of what is referred to as Number 1 North Level, where the effect of the explosion was but slightly felt.

"The scope of this inquiry was by the terms of the Commission, to determine as far as possible the cause and effect of this disaster. To follow out the objects of the enquiry, the possible causes of an explosion in a mine of this kind have first to be considered. It is then necessary to arrive as far as possible at the actual condition of the mine immediately prior to the explosion both in regard to the ventilation of the mine, the presence of gas, the condition of the mine in regard to dust, and the character of that dust as regards explosiveness, and any other conditions that might give rise to or contribute to the cause of the explosion. It is also necessary to consider what care the officials of the mine had exercised prior to the explosion, both in the supervision of their employees and generally in the operation and working of the mine. Finally the nature and seat of the explosion, if possible, must be determined.

"In general it may be said that with the exception of what is known as a blown-out shot, all mine explosions must originate with the ignition of gas. In the case of a blown-out shot, however, dust may be ignited directly, and given dust in sufficient quantities and of a sufficiently explosive character, an explosion may result, and a blown-out shot, may of course, result in ignition of the gas. Apart from this, the ignition of gas may be caused in a number of ways. An open flame such as from a match or a naked lamp, a defective safety lamp, the spark from a pick or tool, or the sparking of electric wires or motors may be said to be the most common causes of the ignition of gas in a mine. A fall of rock of such a character as will give off a spark upon falling, and which draws down with it a pocket of gas may also cause this ignition. The mere ignition of gas however, does not necessarily lead to a mine explosion. A great deal will depend on the explosive character of the firedamp, and the condition of the mine air and workings in respect of gas, dust and moisture.

" As regards the possibility of the Hillcrest explosion being originated by a blown-out shot, it is agreed by all the witnesses, that that cause may be eliminated in the present enquiry. All shots in the mine are fired by the examiner by means of an electric battery and cable, and the examiner who alone would have fired the shots in that portion of the mine where the explosion did occur was found with the firing cable wound around his body and the battery key in his pocket. The other examiner on duty in the mine was among those in the workings of Number 1 North Level, all of whom were saved.

" In this mine no naked lights are allowed, the lamp in use being the Wolf Safety Lamp, and these lamps are examined by the examiner before being given out to the men, and were on the morning of the explosion examined by the two examiners on duty at that time. At the same time a safety lamp may become defective through improper handling, as for instance if it is not held erect and comes in contact with the flame, the glass may break, or it may be broken by means of a pick or some tool or by a fall or rock. The probabilities are against a defective safety lamp being the origin of this explosion, but that possibility cannot be elminated.

" The lighting of a match is a cause which also cannot be eliminated. It is a contravention of The Mines Act for men to take matches, pipes or tobacco into a mine of this character, and the management of the mine have the right to search the men for such articles before they go down into the mine, but whether such a search was made or not in this case there is no evidence. Both in this case and in the case of a defective safety lamp the personal equation must largely come in, and it must be remembered that a case of carelessness or foolhardiness on the part of any one employed in such a mine may result in an appalling disaster.

" With regard to a fall of rock such as has been mentioned, obviously no conclusion can be arrived at. The rock formation in this mine is the same as at Bellevue, where some four years ago, a number of explosions, the origin of which was attributed to the sparking emitted upon such a fall, occurred. Evidence was given by two witnesses, (pages 57, 58 and 199 in the evidence) that they had seen a fall of rock cause sparks, some four years ago, in the old working of this mine.

" There is also evidence given as to the striking of sparks by a pick. Given a proper mixture of gas and air an ignition might follow from such a cause.

" As to the sparking of electric wires or motors, there were three electric pumps in Number 2 slope, placed respectively one hundred and thirty feet, nine hundred feet and fifteen hundred feet down the slope and the cables for driving these pumps ran down this slope. The report of the electrician shows that the wires were properly insulated and whatever the effect might be from the danger of these cables and pumps, with the system of ventilation that apparently prevailed in this instance, there is no suggestion that the explosion originated in Number 2 slope and that cause of ignition may, I think, be eliminated.

" The question of the ventilation of the mine is manifestly one of great importance to be considered in connection with this investigation. There is always a certain amount of gas being generated from the coal in a mine of this description, particularly from the working faces, and it is through the proper ventilation of the mine and the proper direction of the air currents, that this gas is carried off, freeing those working places from the undue presence of gas which otherwise would constitute a constant menace to the safety of the mine.

"The exact details of the ventilation system of this mine were known only to the Mine Manager, Mr. Quigley, and the Overman, Mr. Taylor, and both of these officials were among the victims of the disaster. Under the provisions of the Alberta Mines Act the mine operators are not required to keep in their office a plan of the ventilation system of the mine, our Act therein differing from the Coal Mines Act of Great Britain, which makes it obligatory upon the company to keep such a plan in its office. Consequently there was no plan kept of this ventilation system, and as a consequence of the death of these officials, the only evidence that was available in this regard was that of the surviving examiners. At the enquiry a plan of the mine was produced and upon it the examiners traced as nearly as they could the direction of the air currents in their respective districts. While the production of a plan of the ventilation system, as is required to be kept under the provisions of the British Act, would have beyond doubt been more satisfactory, I think on the whole, the evidence of the examiners presents a fairly accurate idea of the ventilation system of this mine.

"By way of explanation, it may be said that there are two entrances to the Hillcrest mine, one called the Rock tunnel, leading to Number 1 slant or slope, and to the new slant, and the other, which is designated as Number 2 slope or slant. All the coal from the workings above or rather east and south of Number 1 slant, is taken up through the Rock tunnel and this part of the mine for the sake of convenience is referred to as Number 1 Mine, while the coal from all the other portions of the mine is taken up the Number 2 slant or slope, and these portions of the mine are, for the same reason, referred to as Number 2 Mine. In reality, however, all the workings are connected and comprise but one mine.

"There were two fans employed in the ventilation of the mine. One, an electrically driven fan of the Sheldon-Sirocco type, placed a little to the south of the Rock Tunnel, acted as an exhaust fan, while the other, a steam driven fan, located a little to the north of the entrance to Number 2 slope, was used as a forcing fan. This latter fan, at the time of the accident, was forcing the air into the workings of that part of the mine known as Number 1 North Level. The return air from Number 1 North Level, apparently joined the intake air going down Number 2 slope. These combined currents travelled down this slope to Number 2 South Level, along the level to the face, returning back along the working faces of Number 2 South, to Room 31, and thence to the exhaust fan through an overcast over the new slant, after ventilating the working places of Number 1 South Level. Another current passed down Number 1 slant, returning along the counter, after having ventilated the places in the level off this slant, and the places above the slant where the pillars were being extracted. The current going through the Rock Tunnel to some extent split at the junction of this tunnel with Number 1 slant and the new slant, a portion travelling down the new slant as far as a stopping at about the second cross-cut in Room 31. That this current, however, did not play any important part in the ventilation of the mine may be judged by the fact that no measurement apparently was ever taken of the air passing down the new slant. The evidence was that a certain amount of this current leaked through this stopping into Room 31, and from these joined the air current ventilating the workings of Number 1 South Level.

"The workings below Number 2 slope as far down as Number 3 South Level according to the plan marked by the Examiners appear to have been ventilated, at least to some extent, by a split of the air current down Number 2 slope, but below Number 3 South Level, the workings were ventilated by means of compressed air and it was almost universally agreed, I think, that the use of compressed air for ventilation purposes in a mine of this character, was objectionable.

"The turning of the return air current from Number 1 North Level, in with the intake current travelling down Number 2 slope and used to ventilate the balance of the workings of Number 2 mine, was severely criticized by Mr. Fraser, the expert witness for the miners and by others, owing to the fact that this would mean that air already vitiated through the ventilation of one portion of the mine, would be turned in to mix with the fresh current of air used to ventilate another part of the mine. It is true that there was an overcast crossing Number 2 slope, a little above the junction of this slope and Number 1 South Level, and had the return air from Number 1 North Level, been carried through this overcast to the surface no objection in regard to this part of the ventilation system could have been raised, and it was at least suggested by counsel for the Company, that this overcast was probably in use at the time of the explosion. The evidence however, I think, is clear, that this overcast was not being used at that time, and it seems to have been a fact that this return current from Number 1 North Level, did travel down Number 2 slope and from there along with the intake current down the slope through the other portion of the workings of Number 2 mine.

"Measurements of the quantity of air taken into the mine at the different intakes are made once a week by the Overman, and the last of these measurements before the disaster, was taken on the 16th of June. On that day, these measurements show that 14,500 cubic feet of air per minute were being forced into the workings of Number 1 North Level, 24,000 cubic feet were being taken in down the Number 2 slope and 54,600 cubic feet were being drawn down Number 1 slant. The conclusion Mr. Fraser arrived at, seems to be that in taking the volume of air coming down Number 2 slope at 24,000 cubic feet, the Overman had included the return air from Number 1 North Level. I cannot come to this conclusion myself. To do so would I think be to impute a species of fraud to this official and a manifest attempt on his part to give a false idea of ventilation of the mine. I do not think there is anything to warrant the adoption of such a view. It is apparent from the measurements that there was a sufficient quantity of air passing through the mine, to insure proper . . . ventilation, provided the air was properly distributed.

"By The Mines Act it is provided that every mine shall be divided into districts or splits of not more than seventy men in each district and each district shall be supplied with a separate current of fresh air. There was a very considerable difference of opinion as to the definition of the word "split." Mr. Fraser adopted the view that the term as used, has the same meaning as the term "ventilation district" used in the British Coal Mines Act, and, as to Number 2 mine, it was suggested by him that Number 1 North Level, and Number 2 South Level, were both on the same split. On the other hand Mr. Drinnan, the company's expert, was inclined to give a much wider, or at least a more vague, interpretation of the term, and, in his opinion, Number 1 North Level, and Number 2 South Level, comprised two distinct splits. Mr. Brown, the company's manager, was of much the same opinion, and I might say here that if the return current from Number 1 North Level, travelled through the overcast, over Number 2 slope, there would be no possible doubt but that there were two distinct districts or splits in Number 2 mine. I am distinctly under the impression, however, that at least the intention of the Alberta Act was that the term "district" or "split" should receive the same meaning as the term "ventilation district" in the British Coal Mines Act.

"Assuming for the moment that there were two distinct splits in Number 2 mine, it still seems that there were considerably more men employed in these workings than the Act sanctions. It is to be regretted that the reports kept by the company do not give very definite information as to the number of men employed in the various parts of the mine. The explanation given was that the men, with the exception of the miners, are often moved from one part of the mine to another. This is quite conceivable, and is indeed undoubtedly the case, but without more definite track being kept of the whereabouts of the men than was apparently done here, it is difficult to see how the section of The Mines Act limiting the number of men in each district or split, can be observed.

"The estimate of Mr. Fraser, as to the number of men employed in Number 2 mine, exclusive of Number 1 North Level, in view of the evidence, is, I think, excessive. It is impossible to fix exactly the number of men employed in Number 2 mine at the time of the disaster. The rescue parties, as may be readily conceived, paid little attention to the location where the bodies of the victims were found, and even the location of the bodies would not be conclusive in this regard, as there is little doubt but that many of the men, after the explosion, left their working places, in an attempt to escape, before they succumbed to the effect of the afterdamp.

"According to the figures submitted by the company as showing the number of men checked into the mine on the morning of the disaster, there were fifty-nine men in Number 1 mine and one hundred and seventy-six in Number 2 mine. All of the men in Number 1 North Level, forty six in number, were saved, so that in the remaining portion of Number 2 mine the company's figures would show that there were one hundred and thirty men. The evidence bears out, however, the company's explanation that the men were moved about the mine after being sent into it, as while the figures show that there were three tracklayers in Number 2 mine, and none in Number 1 mine, the evidence is that one of these men was killed in Number 1 mine. Again, while there is no strict evidence on the point, it appears that the number of buckers found in Number 1 mine was very considerably greater than the company's figures show. I think that possibly an extreme estimate of the men employed in Number 2 mine apart from Number 1 North Level, would be 120, and it was probably less. Assuming that there were 120 men there at the time of the disaster, it will be seen that the quantity of air coming down Number 2 slope would be at least sufficient to allow the required two hundred cubic feet per man that is required by the Act. It is true that this does not take into consideration the fact that there were some horses in the mine at the time, but neither, however, does it take into account the compressed air below Number 3 South Level, nor the air going down the new slant. On the other hand, if Number 2 mine was all in one district or split, there would be considerably over the required 200 cubic feet per man. Upon the whole it appears that while the Act appears to have been violated so far as employing more than seventy men in a split or district, it is probable that there was a sufficient volume of air in this portion of the mine to allow the requisite amount per man as is required by the Act, and the evidence does not warrant any finding that the noncompliance of the Act in this regard contributed to the explosion.

"It may be taken for granted, I think, that both the ventilating fans were properly working up to the time of the accident. Any stoppage of the electrically driven fan would have been at once noticed by the man in charge of the switchboard at the power house. So far as the evidence goes it does not seem that any notice had been given to the steam driven fan for about half an hour before the occurrence of the explosion. The working of this fan could be heard by the hoistman in the engine house, provided the window of the engine house was open, but the fan itself could not be seen from there. While there is nothing to suggest that this fan was not working at the time of the disaster, and the evidence all goes to show that it was, it does seem that closer oversight should have been kept upon this fan, when its stoppage might cut off the entire ventilation of one portion of the mine. The attachment of an automatic indicator to the fan would avoid any such danger.

"In regard to the turning of the return air from Number 1 North Level down Number 2 slope, the weight of evidence, I think, goes to show that the system of ventilation in this regard, if not absolutely objectionable, was at least not to be commended, but while this is so, there is nothing to show that this practice contributed any to the cause of the explosion. Neither can it be said that the use of compressed air in the workings of Number 2 slope below Number 3 South Level, is accountable in any way for the disaster. It was practically admitted, I think, that the explosion did not originate in this portion of the mine.

"With regard to the operation of a hand fan in Number 1 North Level, and in Number 2 South Level opposite the raises, the evidence shows that the mine had not been working during the two days immediately prior to the day of the disaster, and the evidence of the Examiner, William Adlam, is to the effect that these raises were full of gas. The fan boys who operated the hand fan went into the mine at the same time as the miners, and consequently it is to be presumed that after the miners had begun work, if there were men working at the face of the entries, the gas from the raises would be driven over them, and that such a practice is bad is admitted by a number of expert witnesses. So far as the question concerns Number 1 North Level, it is of no importance, as there was no explosion in that part of the mine, and in regard to Number 2 South Level, it must be remembered the fan would start to expel the gas from the raise when the morning shift went on, that is at seven o'clock in the morning, and the explosion did not occur until two and a half hours afterwards. There is again nothing, I think, to show that the explosion originated at this point, nor, I think, did any of the witnesses so contend. And as to the general practice of using these fans, under such conditions, it must be said that Mr. Hudson, representative of the Dominion Department of Mines, and a man of wide experience in mining matters, was unwilling to criticize their use.

"It appears from the evidence, that while the system of ventilation in some details has, and I think, with some reason, been criticized by some of the witnesses giving evidence at the inquiry, so far as the men of the mine were concerned, there seems to have been only one opinion in regard to the ventilation and that was, that the ventilation was good so far as their own particular working places were concerned. There was apparently no complaint whatever by the men in that regard.

"It is true that a month or more before the disaster the conditions were not so good. Evidence was given that travelling caps, that is the existence of such an amount of gas in the ventilating current as would show a flame in a test with a safety lamp, were found. But this condition was before the driving through of Room 31, and upon the completion of that work, this condition was remedied. Since that time, and up to the time of the disaster, there had been no complaints on the part of the men, nor had there been anything that would indicate any unsatisfactory condition in the ventilation of the mine. The report of the Pit Committee, representing the miners, made on the 18th of May, just a month before the disaster, sets out that they found the ventilation good and general conditions good, and the evidence is to the effect that between that time and the time of the disaster there were no circumstances that would lead any one to believe that the condition of the mine had, in the meantime, undergone any change. Notwithstanding the fact, therefore, that the system of ventilation is, as I have said before, in a number of details open to criticism, the evidence does not warrant me, I think, in attributing the cause of the explosion to any faulty ventilation of the mine.

"The question of gas in the mine must be intimately connected with the question of ventilation. At the same time the presence of gas is not necessarily an indication of an inefficient system of ventilation. The accumulation of gas may arise from the fact that the brattices have not been led up sufficiently to the faces of the workings and consequently the air current is not conducted sufficiently near the faces so as to carry away the gas. And in a mine of this nature it may be said that generally there is always more or less gas.

"In any mine where inflammable gas has been found within three months, an inspection of the roadways leading through the mine, and the working places must, under the provisions of The Mines Act, be made within three hours before each shift goes to work in the mine. During this inspection a test is made for gas, and the Examiner makes a report as to the condition of the mine, such report being recorded in a book kept for that purpose and a copy of this report is posted up immediately in a conspicuous place at the mine. The last inspection of this nature, made before the explosion, was by the Examiner, William Adlam, who went into the mine about ten minutes to four and came out at twenty minutes past six six o'clock on the morning that the disaster occurred. His report showed the presence of gas in working places 2, 5, 12, 17, 7, 8 and 43. Of these places, 2, 12 and 17 are in the workings of Number 1 North Level, 7 and 8 in Number 3 South Level, and 5 and 43 in Number 2 South Level. The Examiner swears that in accordance with his duties in that regard he fenced off these places so that the miners would not go into them until the gas had been cleared out.

"It is the custom for the brattice men, who attend to the placing of the brattices, so as to conduct the air current up to the working face and so clear those places of gas, to go into the mine a half hour or so before the shift goes in. The Examiner or Examiners on duty at that hour gives or give the orders based upon the report of the Examiner who has just made his inspection. The lamps of the brattice men are examined by the Examiners who have gone on duty, and in this case John Ironmonger swears that he examined the lamps of the brattice men when going into the mine. It is, I think, only fair to assume that the brattice men on this morning went in as customary to attend to the fixing of the brattices so as to rid the mine of the gas indicated in the Examiner's report. If the brattice men attended to their duties, and it is only fair to assume they would do so, the mine, with the exception of the raises, should have been speedily freed of gas.

"I confess that the evidence of Adlam somewhat bewildered me in regard to the quantities of gas referred to in his report. My impression from his evidence given in the first instance was that there were comparatively only small quantities of gas in the places indicated in his report. Upon his being recalled his evidence gave me the impression that the quantities of gas were much greater than his evidence led me to believe in the first instance, and I am somewhat at a loss to reconcile his different statements in this regard. Adopting his later statement, it is evident that the raise in Number 1 North Level, and the raise in Number 2 South Level, were, as he says, full of gas. With these raises full of gas it does seem that it would have been advisable that these places should have been cleared before the miners entered the mine. Such a course at least would have avoided an element of danger that had to exist if the raises were being cleared after the miners had gone to work. Notwithstanding, however, that the gas was in the quantities I have mentioned, Adlam says that he did not consider that there was an unusual amount of gas in the mine that morning, and Mr. Hudson, who heard all the evidence, expressed his opinion that nothing indicated an undue amount of gas at that time.

"The theory of Mr. Fraser was that the explosion originated in the workings of Number 2 South Level. If such were the case, except so far as it would tend to vitiate the air current going through Number 2 South, the gas in all the working places but 5 and 43 may be eliminated so far as this phase of the investigation is concerned. The mine had been idle on the 17th and 18th of June, the two days immediately before the day of the disaster, but the ventilation system, with the exception of the working of the hand fans, was in full operation, and a perusal of the Examiners' reports for those days shows the mine to have been more than ordinarily free of gas during that time. There does not seem to be anything in the evidence in regard to the presence of gas in the mine that assists in leading to any conclusion as to the cause of the disaster, nor to lead to condemnation of the general system of ventilation then in use in the mine.

"One of the great sources of danger in a mine lies in the presence of dust, provided that dust is of a sufficiently explosive or inflammable nature. The really dangerous dust is the fine impalpable dust that clings to the roof and walls and timbers used throughout the mine. This may, if of a sufficiently explosive character, be ignited by a blown-out shot or by contact with a flame of sufficiently high temperature. In the course of an explosion it generates its own gas and will rapidly spread through a mine where there is sufficient dust to feed the explosion, but the dust, if sufficiently wet, loses for the time being its explosive character.

"In regard to the character of the dust in the Hillcrest mine, both counsel for the mine owners and the miners at the inquiry agreed that I should avail myself of the result of the tests made by the United States Bureau of Mines as to the explosibility of samples of dust taken from the Hillcrest mine. Without adopting any technical language, it may be said that these tests show that the dust in this mine is of a fairly highly explosive character and the dust would ignite by a blown-out shot or by an ignited pocket of gas. It may be said that the general supposition of practically all of the witnesses at the inquiry was that the dust was of this character, so that the evidence has all been given based upon this supposition, which has now been confirmed by these tests.

"As to the quantity of dust in the mine, the evidence is to some extent conflicting. Mr. Aspinall, who was the Government Inspector of Mines for the district in which the Hillcrest mine is situated, a year or so prior to the disaster, stated that he would consider this a fairly dusty mine, and in his report of the 4th of July last year calls attention to the fact that there was considerable dust in certain places in the mine, but apparently the only immediate danger that was anticipated from the presence of this dust was from shot-firing, and it seems that shot-firing was discontinued in the places complained of. On the other hand the evidence of nearly all of the men working in the mine who gave evidence was to the effect that prior to the explosion they would not consider this a dusty mine.

"With the exception of Number 1 slant, the main roadways are more or less wet. Number 1 North Level may be said to be distinctly wet, and so with Number 2 slope below Number 2 South Level, and this may also be said to apply to the northern part of Number 2 South Level. One of the means adopted to prevent the spreading of the dust explosions in a mine is by the watering of and keeping damp the main roadways in a mine, although this system is not universally approved of, as nothing but the thorough soaking of the dust eliminates the danger. This system of dealing with the dust, however, has not been adopted in any of the Western Provinces, and it cannot be said therefore that the company failed in their duty in not adopting such a course. The main roadways, as I have just said, were with some exceptions, wet, and it seems to have been the general opinion that the watering of, the rooms and the working faces would be impracticable.

"I do not think that the evidence is such as to show that the company had any reason to believe that there was a dangerous quantity of dust in this mine. At the same time it must be remembered that an explosion such as occurred on the 19th of June, would undoubtedly increase this dust, and undoubtedly means should be adopted now by the company to eliminate as far as possible the danger from this dust by removing it as far as practicable from the mine or adopting any precautions that can be adopted to prevent the spreading of a dust explosion should it occur. It is needless, I think, to say that the greatest care should now be exercised in regard to shot-firing in the mine. A blown-out shot, as has been pointed out, is the one means of igniting dust directly, and blown-out shots are by no means uncommon in a mine. It is very questionable whether shot-firing should not be entirely eliminated from this mine until the conditions in regard to dust are very much improved from what they were at the time of this inquiry.

"Some criticism was made by Mr. Fraser in regard to the kind of stoppings that were adopted by the management of this mine. It was suggested that had the stoppings been of a more permanent nature the explosion would not have spread to the extent that it did. This, however, seems to be a debatable question, and the evidence shows that the stoppings in this mine were of the same character as are used in the mines throughout the Western Provinces. There is nothing in the evidence to lead me to the conclusion that if the stoppings had been of a different character the extent of the explosion would have been curtailed. There is evidence indeed to the effect that substantial stoppings by first confining the forces developed by the explosion might have eventually rendered the disaster greater even than it was.

"Apart from the matters I have already dealt with, there does not appear to be anything in connection with the management of the mine, nor in the care taken by the company in its operations that could have led or contributed in any way to the disaster.

"The initial cause of the explosion does not appear to be ascertainable. I have, almost at the outset of this report, mentioned the ordinary causes of ignition of gas in a mine. Shot-firing having been eliminated, the explosion must of course have originated from the ignition of gas, but by what means there has been absolutely no suggestion. Certain of the ordinary causes of ignition have been or may be eliminated here, but there is no means whatever of fixing upon which of the remaining causes it was that started the explosion.

"As to its character, Mr. Drinnan was of the opinion that it was almost entirely a gas explosion, and that dust contributed very little if any to it. With this exception, however, the expert witnesses all were of the opinion that it was a gas explosion augmented by the ignition of dust and that dust played a considerable part if not the greatest part in the explosion. The finding of a very considerable amount of coked coal dust was one of the facts that was relied upon by those who advanced this latter theory, and in view of the result of the tests of the dust I think this view is the most reasonable one to adopt.

"It is impossible also to determine the seat or place of origin of the explosion. Mr. Fraser expressed the opinion that it occurred in the workings above Number 2 South Level, but he is unable to point out any exact locality. The other experts were unable to come to any conclusion in this regard. In certain parts of the mine it can be said that the explosion did not originate, but apparently the place where it did originate cannot be determined.

"It will be seen from the foregoing portions of this report, that the course adopted by the management of the mine in relation to the ventilation thereof, and other matters closely related to the question of ventilation, was apparently either objectionable or at least open to criticism, but the evidence does not go so far as to show that this was responsible for the disaster. And it must be said that Mr. Hudson stated that he would not attempt to criticize the ventilation of any mine from the plan, and without having the advice of the men who are conducting the ventilation from day to day. As one of the witnesses states it, so far as this explosion is concerned, something must have happened in the mine of which we have no evidence.

The only conclusion, therefore, that I can arrive at, as a result of the whole evidence adduced at the inquiry is that the disaster was caused by an explosion of gas, the origin and seat of which is unascertainable, this explosion being augmented by the ignition of dust throughout the mine.

"Although the cause of the explosion cannot be determined, a consideration of the facts and circumstances brought out by the evidence at the inquiry suggests certain recommendations which, it is submitted, may lessen the extent of the danger that was shown to be attendant upon the operation of this mine. Most of these have already been suggested in this report.

"Attention has been called to the fact that the Number 2 fan was without direct supervision for about half an hour before the occurrence of the explosion, and it has been pointed out that the stopping of the fan for any considerable length of time might be attended with serious consequences. It is suggested that such a fan should be either under the constant supervision of some one or should have an automatic indicator attached thereto in lieu of such personal supervision.

"The question of shot-firing in the mine has also been already discussed. It is suggested that, until the danger from dust in this mine is considerably reduced, shot-firing should be either discontinued entirely or that the men be withdrawn from the mine during such firing.

"A recommendation in regard to the search of the employees, at stated intervals, for matches, pipes and tobacco, has, I understand, already been made by the coroner's jury in connection with this disaster. It can be only added that where the personal equation must be so largely a factor in the safety of a mine, too great care cannot be exercised in such a matter as this.

"Two further recommendations which do not immediately deal with the safety of the men employed in the mine are suggested. The difficulty arising from the absence of a plan of the ventilation system of a mine at the inquiry has already been referred to. And it has been pointed out that under the British Coal Mines Act the operators are required to keep such a plan in their office. It is suggested that a similar provision be inserted in our own Act. The difference of opinion existing in regard to the definition of a district or split has also been referred to. I have already indicated my own view in regard to the question, but it is suggested that a definition of the term be inserted in our Act, so that no difference of opinion can possibly, or at least reasonably, arise.

A. A. CARPENTER,
Commissioner."

"CALGARY, October 20, 1914."

DRAUGHTING DIVISION.

H. E. Baine.

Chief of Division.

The staff of this division consists of a chief officer, two map compilers, two assistant map draughtsmen, and a mechanical draughtsman.

During the year, some 49 maps were compiled and published, together with 200 mechanical drawings, charts, etc.

The blue print machine installed by the Mines Branch has given every satisfaction; some 1,200 prints having been made and supplied during the year.

The following is a list of maps, mechanical drawings, diagrams, etc., prepared, during the calendar year 1914. The name of the officer for whom they were prepared will be found in the margin:—

Dr. Parks.—

Building stones, Vol. III.

Map of the Province of Quebec, showing the chief belts.

Map of the Province of Quebec, showing the chief slate quarries.

3 drawings.

E. Lindeman.—

Iron Ore Deposits of Nova Scotia.

Magnetometric map, McPherson mine, Barachois, Cape Breton county, Nova Scotia.

Magnetometric map, Upper Glencoe, Inverness county, Nova Scotia.

Magnetometric map. Grand Mira, Cape Breton county, Nova Scotia.

2 geological sections.

A. W. G. Wilson.—

Copper Smelting Industry of Canada.

42 diagrams, charts, etc., to accompany report on copper.

B. F. Haanel.—

Peat, Lignite, and Coal.

50 mechanical drawings, charts, etc.

S. C. Ells.—

Bituminous Sands of Alberta.

Map of northen portion of Alberta, showing position of outcrops of bituminous sands.

6 drawings, charts, etc.

John McLeish.—

Mineral Map of Canada, to accompany "Economic Minerals and Mining Industries of Canada".

H. T. Kalmus.—

Metallic Cobalt Research Series, Vol. II.

16 drawings, charts, etc., to accompany report on "The Physical Properties of the Metal Cobalt".

G. C. Mackenzie.—

Magnetic Iron Sands of Natashkwan.

Map of Natashkwan magnetic iron sands, Saguenay county, Quebec.

15 drawings, charts, etc.

Hugh S. de Schmid.—

10 small maps, 37 diagrams, charts, etc., to accompany report on "Phosphate."

Summary Report, 1914.—

2 maps, 13 drawings, charts, etc.

L. H. COLE.—

Salt Industry of Canada.

Map showing saline springs and salt areas of the Dominion of Canada.
Map showing saline springs and salt areas in the Maritime Provinces.
Map of the Michigan-Ontario salt basin.
Map showing saline springs in northern Manitoba.
13 small maps and 13 diagrams, charts, etc.

F. G. CLAPP.—

Petroleum and Natural Gas Resources of Canada.

Map of Dominion of Canada, showing the occurrence of oil, gas and tar sands.
Map showing gas and oil fields and pipe lines in southwestern Ontario.
Map showing location of main gas line, Bow island, Calgary.
48 geological sections.

ALEPH VON ANREP.—

Peat bog maps:—
Sunderland peat bog, Brock township, Ontario county, Ontario.
Amaranth peat bog, Amaranth township, Dufferin county, Ontario.
Manilla peat bog, Mariposa township, Victoria county, Ontario.
Cargill peat bog, Greenock township, Bruce county, Ontario.
Clareview peat bog, Sheffield township, Lennox and Addington counties, Ontario.
Westover peat bog, Beverly township, Wentworth county, Ontario.
Stoco peat bog, Hungerford township, Hastings county, Ontario.
Richmond peat bog, Goulbourn and Marlborough townships, Carleton county, Ontario.
Luther peat bog, townships of Luther, East and West, Wellington and Dufferin counties, Ontario.
Marsh Hill peat bog, Reach and Brock townships, Ontario county, Ontario.
Mermaid peat bog, Bedford township, Queens county, Prince Edward Island.
The Black Banks peat bog, Halifax township, Prince county, Prince Edward Island.
43 drawings, charts, etc.

REPORT COVERING THE OPERATIONS OF THE DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C., DURING THE YEAR ENDING DECEMBER 31, 1914.

Dr. Eugene Haanel,
Director of Mines,
Ottawa, Ont.

Sir,—I have the honour to submit herewith report covering the operations of the Dominion of Canada Assay Office, Vancouver, B.C., for the calendar year ending December 31, 1914, accompanied by statements showing Assayers' and Melters' supplies on hand.

CHANGES IN STAFF.

R. Allison, janitor, appointed assistant melter, June 20, 1914.

E. A. Pritchett, appointed janitor, June 20, 1914, vice R. Allison.

R. D. McLellan, appointed general assistant, June 29, 1914, left the service September 11, 1914.

H. E. Warburton, appointed temporary clerk, July 4, 1914, called out for military duty August 10, 1914, left the service October 3, 1914.

DETAILED STATEMENT.

There were 1,112 deposits of gold bullion, requiring 1,300 melts and 1,300 assays (quadruplicate check assays being made in each instance) including the assembling and remelting of the individual deposits after purchase into bars weighing about 1,000 troy ounces and the assaying of same. The aggregate weight of the deposits before melting was 166,148·83 troy ounces, and after melting 163,543·62 troy ounces showing a loss in melting of 1·5680 per cent. The loss in weight by assaying was 20·01 troy ounces (base and parted silver), the average fineness of the resulting bullion, viz: 163,523·61 troy ounces; being ·594½ gold and ·308 silver. The net value of the gold and silver contained in deposits was $2,029,251.31.

The gold bullion received came from the following sources, viz.:—

Source.	Number of deposits.	Before melting.	Weight after melting.	Net value.
		(troy ounces.)	(troy ounces.)	$
British Columbia	893	109,037·86	106,591·28	1,105.489 01
Yukon Territory	209	56,720·31	56,567·34	916,914 44
Alberta	1	30·08	29·70	511 55
Alaska	9	360·58	355 30	6,336 31
	1,112	166,148·83	163.543·62	2,029,251 31

Weight before melting	166,148·83	troy ounces.
Weight after melting	163,543 62	" "
	2,605·21	" "
Loss percentage by melting	1·5680 %.	

Credits and Disbursements for the Purchase of Gold Bullion During the Year Ending December 31, 1914.

Unexpended balance,—"Letters of Credit," January 1, 1914.		$ 117,486 33
Credits established during year ending December 31, 1914..		2,000,000 00
"Letter of Credit" balance written off at close of fiscal year, March 31, 1914..	$ 43,531 30	
Disbursements for the purchase of bullion..	2,029,251 31	
Unexpended balance,—"Letter of Credit," December 31, 1914..	44,703 72	
	$2,117,486 33	$2,117,486 33

Disbursements for the Purchase of Gold Bullion and Receipts from Sale During the Year Ending December 31, 1914.

Disbursements for the purchase of bullion on hand January 1, 1914, bars Nos. 656, 678 to 687 inclusive..		$ 28,425 48
Disbursements for the purchase of bullion during the year ending December 31, 1914, per cheques Nos. 499 to 598 inclusive (omitting No. 499 cancelled) and Nos. 1 to 705 inclusive..		2,029,251 31
Proceeds from sale of bullion during year ending December 31, 1914..	$2,022,790 86	
Value of bullion on hand December 31, 1914, bars Nos. 951 to 994 inclusive..	36,918 09	
Difference in favour of this office..		2,032 16
	$2,059,708 95	$2,059,708 95

Contingent Account for Year Ending December 31, 1914.

Unexpended balance, January 1, 1914..		$ 0 63
Funds provided for Official cheques No's 1540, 1692, 1843, 9, 132, 361, 593, 785, 982, 1139, 1275, and 1444..		4,099 00
Amount remitted, Receiver-General per draft No. 15 at close of fiscal year, March 31, 1914..	$ 32 34	
Expenditure during year ending December 31, 1914..	4,055 55	
Unexpended balance, December 31, 1914..	11 74	
	$ 4,099 63	$ 4,099 63

Contingent Expenditure During Year Ending December 31, 1914.

Fuel (gas)..	$ 583 35
Power..	231 35
Express charges on bullion..	1,673 55
Electric vault protection..	300 00
Postage..	35 00
Telephones..	79 90
Duty, expressage, freight, etc., on supplies..	31 57
Assayers' and melters' supply (purchased locally)..	686 33
Electric drill..	38 00
Button balance..	220 00
Sundries..	176 50
	$4,055 55

Proceeds from Residues Sold.

Residue sold to United States Assay Office, Seattle, Wash., U.S.A., (Bar No. A-8)..	$ 872 51
24 empty acid bottles sold to B.C. Assay and Chemical Supply Co. Limited, March, 1914..	2 88
	$ 875 39

Residues on Hand, December 31, 1914.

Recovered from slags, sweepings, old furnaces, old crucibles, etc., 65·21 ounces gold bullion, value..	$ 831 65
36 empty acid bottles.	

MISCELLANEOUS RECEIPTS.

Draft No. 42, in favour of Deputy Minister of Mines (a payment for crushing and melting 1,352·62 ounces quartz)	$ 40 00
Draft No. 49, in favour of Deputy Minister of Mines (a payment for treating 25 pounds slag)	9 50
	$ 49 50

The following shows the business done by the Assay Office during the past five years, viz.:—

Calendar Year.	Number of deposits.	Weight.	Net Value.
		(troy ounces)	$
1910	490	46,064·31	746,101 92
1911	442	39,784 70	647,416 38
1912	527	59,068·83	974,077 14
1913	783	111,479·95	1,448,625 37
1914	1,112	166,148·83	2,029,251 31

I have the honour to be, sir,

Your obedient servant,

G. MIDDLETON,

Manager.

December 31, 1914.

G. MIDDLETON, Esq.,
Manager, Dominion of Canada Assay Office,
Vancouver, B.C.

SIR,—I beg to report the following assayers' supplies on hand at above date, viz.:—

Silver nitrate crystals	¾	oz.
Calcic chloride	2	"
Lead foil, C. P.	88	lb.
" granulated, C. P.	2	"
Zinc, mossy, C. P.	½	"
Litharge	1	"
Copper wire	1	spool.
Acid, nitric, C. P.	3½	Winchesters.
" hydrochloric, C. P.	½	Winchester.
" sulphuric, C. P.	¼	"
Ammonia	½	"
Small clay crucibles	13	only.
Scorifiers, 4-inch	1	
" 2½-inch	55	
Spare mufflers	22	
" doors	2	
" supports	6	
" back stops	15	
Bone ash	15	lb.
Cupels	5,966	
Gold cornets	·33	oz.
" in solution	22·56	"
" proof	12·35	"
Silver	224·77	"

Your obedient servant,

J. B. FARQUHAR,

Chief Assayer.

December 31, 1914.

G. Middleton, Esq.,
Manager, Dominion of Canada Assay Office,
Vancouver, B.C.

Sir,—I beg to inform you that we have the following supplies on hand in the Melting Department, viz.:—

2 sets of linings, with supports and covers complete for No. 2 furnace.
4 " " " 4½ "
5 " " " 7 "
6 graphite crucibles, No. 6.
2 " " 14.
40 " " 16.
3 " " 30.
6 " " 40.
35 " " marked $\begin{smallmatrix} & o & \\ o & & o \\ & o & \end{smallmatrix}$
2 crucible covers, No. 6.
5 " " 14.
3 " " 30.
8 lb. sodium nitrate.
25 " borax glass.
20 " carb. soda.

Your obedient servant,
D. ROBINSON,
Chief Melter.

ACCOUNTANT'S STATEMENT, 1913-14.

The following is a statement of the difference in value of assays between Seattle Assay Office and Dominion of Canada Assay Office between April 1, 1913, and March 31, 1914:—

Paid for bullion at Dominion of Canada Assay Office, Vancouver.	$1,456,468 70
Received for bars from United States Assay Office, Seattle.. ..	1,457,653 11
Difference in favour of Dominion of Canada Assay Office.. ..$	1,184 41

Statement of Deposits of Gold and Earnings.

Deposits of gold..		$1,457,653 11
Earnings:—		
Melting 28·72 oz. bullion for J. Greer..		$ 1 50
Treating 26·38 pounds slag for John Hopp..		13 10
Value of 24 empty jars sold B.C. Assay and Chemical Supply Co.		2 88
Value of residue sold United States Assay Office..		872 51
		889 99
Difference between amounts paid and received for bullion..$		1,184 41
		$ 2,074 40

Statement of Deposits of Gold and Earnings.

The following is a statement of the appropriation, receipts and expenditure of the Dominion of Canada Assay Office for the year ending March 31, 1914, and shows the unexpended balance to be $12,131.17.

	Appropriation.	Expenditure.
Appropriation, 1913-1914..	$ 27,000 00	
Receipts per the foregoing statement..	889 99	
Difference between amounts paid and received for bullion..	1,184 41	
Fuel..		403 30
Power and light..		197 12

	Appropriation.	Expenditure.
Postage and telegrams..		93 19
Telephone..		78 00
Express charges..		1,203 11
Assayer's supplies..		747 33
Printing and stationery..		190 47
Premium on bonds..		600 00
Contingencies..		137 16
Electric burglar alarm service..		300 00
Wages:—		
G. Middleton..		2,650 00
J. B. Farquhar..		1,900 00
H. Freeman..		1,500 00
D. Robinson..		1,575 00
A. Kaye..		1,800 00
G. N. Ford..		1,500 00
R. Allison..		975 00
F. W. Taylor..		200 00
T. B. Younger..		893 55
Balance unexpended and lapsed..		12,131 17
	$ 29,074 40	$ 29,074 40

ACCOUNTANT'S STATEMENT, 1914-15.

The following is a statement of the difference in value of assays between Seattle Assay Office and Dominion of Canada Assay Office between April 1, 1914, and March 31, 1915:—

Paid for bullion at Dominion of Canada Assay Office, Vancouver..	$2,105,136 12
Received for bars from United States Assay Office, Seattle.. ..	2,107,334 40
Difference in favour of Dominion of Canada Assay Office.. ..	$ 2,198 28

STATEMENT OF DEPOSITS OF GOLD AND EARNINGS.

Deposits of gold..	$2,107,334 40
Earnings:—	
Crushings and melting 1,352·62 ounces quartz for A. A. Logan...	$ 40 00
Treating 25 pounds slag for John Hopp..	9 50
Value of 48 empty acid bottles sold B. C. Assay and Chemical Supply Co..	5 76
Value of residue sold United States Assay Office..	993 70
	$ 1,048 96
	$ 2,198 28
	$ 3,247 24

The following is a statement of the appropriation, receipts and expenditure of the Dominion of Canada Assay Office for the year ending March 31, 1915, and shows the unexpended balance to be $4,044.12:—

	Appropriation.	Expenditure.	Unexpended Balance.
Maintenance of Assay Office, Vancouver, B.C..	$ 20,000 00	$ 15,955 88	$ 4,044 12

	Appropriation.	Expenditure.
Appropriation, 1914-15..	$ 20,000 00	
Receipts per the foregoing statement..	1,048 96	
Difference between amounts paid and received for bullion..	2,198 28	
Fuel..		625 75
Power and light..		244 19
Postage and telegrams..		134 17
Telephone..		79 90
Express charges..		1,780 58

	Appropriation.	Expenditure.
Assayer's supplies..		847 17
Printing and stationery..		106 10
Premium on bonds..		610 45
Contingencies..		152 85
Electric burglar alarm service..		300 00
Wages:—		
G. Middleton..		2,650 00
J. B. Farquhar..		1,900 00
A. Kaye..		1,800 00
H. Freeman..		1,500 00
D. Robinson..		1,575 00
R. Allison..		1,056 96
G. N. Ford..		1,500 00
T. B. Younger..		1,200 00
E. A. Pritchett..		702 50
H. E. Warburton..		255 00
A. D. McLellan..		182 50
Balance unexpended..		4,044 12
	$ 23,247 24	$ 23,247 24

LIST OF REPORTS, BULLETINS, ETC., PUBLISHED DURING THE YEAR 1914.

S. Groves,

Editor, Department of Mines.

No. 105. Austin Brook Iron-bearing District, New Brunswick. By E. Lindeman, M.E. Published January 7, 1914.

203. Building and Ornamental Stones of Canada. Vol. II: Maritime Provinces. By Wm. A. Parks, Ph.D. Published July 22, 1914.

209. Copper Smelting Industries of Canada. By Alfred W. G. Wilson, Ph.D. Published September 24, 1914.

222. Lode Mining in Yukon: An Investigation of Quartz Deposits in the Klondike Division. By T. A. MacLean, M.E. Published September 25, 1914.

245. Gypsum in Canada: Its Occurrence, Exploitation and Technology. By L. H. Cole, B.Sc. Published December 10, 1914.

254. Magnetite occurrences near Calabogie, Renfrew County, Ontario. By E. Lindeman M.E. Published August 8, 1914.

257. The Production of Cement, Lime, Clay Products, Stone, and other structural materials in Canada, during the calendar year 1912. By John McLeish, B.A. Published January 24, 1914.

259. Preparation of Metallic Cobalt. By Herbert T. Kalmus, B.Sc., Ph.D. Published April 6, 1914.

262. Annual Report on the Mineral Production of Canada, during the calendar year 1913. By John McLeish, B.A. Published March 6, 1914.

283. Preliminary Report on the Mineral Production of Canada, during the calendar year 1913. By John McLeish, B.A. Published March 3, 1914.

303. Moose Mountain Iron-bearing District, Ontario. By E. Lindeman, M.E. Published August 18, 1914.

316. The Production of Coal and Coke in Canada, during the calendar year 1913. By John McLeish, B.A. Published December 3, 1914.

322. Economic Minerals and Mining Industries of Canada. Panama-Pacific Edition Published December 31, 1914.

List of Mines Branch Reports, Bulletins, Maps, etc. Published February 14, and May 14, 1914.

Price list of Special Technical Reports. Published May 14, 1914.

FRENCH TRANSLATIONS PUBLISHED DURING THE YEAR 1914.

M. Sauvalle.

Chief of Publishing and Translating Division.

No. 971. (26a) French translation: Annual Report on the mining industries of Canada for the calendar year 1905. Published in 1914.

(26a) French translation: General Summary Report of Mines Branch for 1913. Published July, 1914.

56. French translation: The Bituminous, or Oil-shales, of New Brunswick and Nova Scotia, also on the Oil-shale industry in Scotland. By R. W. Ells, LL.D. Published August 6, 1914.

100a. French translation: The Building and Ornamental Stones of Canada: Building and Ornamental Stones of Ontario. By W. A. Parks, Ph.D. Published January 26, 1914.

149. French translation: Magnetic Iron sands of Natashkwan, Saguenay County, Que. By G. C. Mackenzie, B.Sc. Published September, 1914.

169. French translation: Pyrites in Canada: its occurrence, exploitation, dressing and uses. By A. W. G. Wilson, Ph.D. Published September 24, 1914.

195. French translation: Magnetite occurrences along the Central Ontario railway. By E. Lindeman, M.E. Published September, 1914.

219. French translation: Austin Brook Iron-bearing District. By E. Lindeman, M.E Published September 29, 1914.

263. French translation: Recent advances in the construction of electric furnaces for the production of pig-iron, steel and zinc. Bulletin 3. By Eugene Haanel, Ph.D. Published November 16, 1914.

264. French translation: Mica, its occurrence, exploitation, and uses. By Hugh S. de Schmid, M.E. Published July 9, 1914.

265. French translation: The mineral production of Canada for 1911. Published August, 1914.

288. French translation: Production of Coal and Coke of Canada, during the calendar year 1912. By John McLeish, B.A. Published December 31, 1914.

290. French translation: Production of Copper, Gold, Lead, Nickel, Silver, Zinc and other metals of Canada during the calendar year 1912. By C. T. Cartwright. Published November 1, 1914.

307. French translation: Catalogue of French publications of the Department of Mines. Published July 1, 1914.

308. French translation: Investigations of Coals in Canada. Volume I. By J. B. Porter, Ph.D., and others. Published November 1, 1914.

ACCOUNTANT'S STATEMENT MINES BRANCH.

Statement of Appropriating and Expenditure, 1913-14.[1]

Mines Branch.	Grant.	Expenditure.	Grant not used.
Investigation of ore deposits, economic minerals, peat bogs, determination of fuel values of coals, lignite and peat of Canada, including wages of machinist and labourers, and additional machinery; investigation of ore dressing, including wages of labourers, machinery and equipment of laboratory; collection of information regarding minerals, and metallurgical industries and operations..	$ 77,000 00	$ 54,799 29	$ 22,200 71
Publication of reports, translation of reports into French, purchase of books, stationery, chemical laboratories' expenses, apparatus, instruments, office contingencies, additional assistance.. ..	69,500 00	69,030 90	469 10
Investigation of metallurgical problems of economic importance..	10,000 00	9,999 86	0 14
For apparatus and equipment, salaries of inspectors, chemists, machinist, clerical assistance, and travelling expenses in connexion with the investigations of the manufacture and storage of explosives in Canada..	55,000 00	480 24	54,519 76
Zinc investigations per Bill No. 182..	34,266 77	30,948 99	3,317 78
Investigation of quartz and copper deposits in the Yukon..	9,000 00	8,620 36	379 64
	$ 254,766 77	$ 173,879 64	$ 80,887 13
Dominion of Canada Assay Office, Vancouver, B.C.			
Maintenance of Assay Office, Vancouver, B.C..	27,000 00	14,868 83	12,131 17

(Signed) JNO. MARSHALL,

May 22, 1914. *Accountant.*

Statement of Appropriation and Expenditure by Mines Branch for Year Ending March 31, 1914.

	Appropriation.	Expenditure.
Amounts voted by Parliament..	$ 329,341 77	
Receipts for Assays and Analyses..	377 85	
Civil List Salaries..		$ 68,199 86
Publication of Reports..		46,564 75
Zinc Investigations..		28,613 58
Fuel Testing Plant, Ottawa..		15,782 82
Concentrating Laboratory..		15,775 53
Metallurgical Investigations..		9,999 86
Quartz Investigations..		8,620 36
Printing, stationery, books, mapping material.. ..		8,242 66
Investigation of Iron Ore deposits..		7,876 67
Wages, outside service..		5,916 41
Laboratory..		3,358 99
Investigation of Peat and Coal..		3,213 71
International Geological Congress..		2,627 89
Investigation of Tar Sands..		2,610 57
Monograph on Petroleum and Natural Gas..		2,002 85
Miscellaneous..		1,985 04
Investigation of Copper deposits..		1,828 51
Publication of Maps..		1,663 36
Monograph on Building Stones..		1,428 89
Instruments..		668 18
Travelling Expenses..		655 08
Investigation of Explosives..		480 24
Monograph on Mica..		450 60

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[1] This fiscal year ends March 31, 1914.

	Appropriation.	Expenditure.
Mineral Statistics..		$ 404 90
Investigation of Salt Deposits..		351 23
Coal Tests..		239 24
Legal Fees..		215 00
Investigation of Oil Shales..		155 16
Investigation of ore deposits..		135 80
Investigations of Manufacturer's Raw Materials..		54 20
Balance unexpended..		89,597 68
	$ 329,719 62	$ 329,719 62

Summary.	Vote.	Expenditure.	Unexpended Balance.
Civil Government Salaries..	$ 74,575 00	$ 68,199 86	$ 6,375 14
Investigation of ore deposits, economic minerals, etc..	77,000 00	54,799 29	22,200 71
Printing, books, stationery, apparatus, chemical laboratories' expenses, miscellaneous..	69,500 00	69,030 90	469 10
Investigation of metallurgical problems of economic importance..	10,000 00	9,999 86	0 14
Investigation of manufacture and storage of explosives in Canada..	55,000 00	480 24	54,519 76
Investigation *re* quartz and copper deposits in Yukon..	9,000 00	8,620 36	379 64
Zinc investigation, per Bill 182..	34,266 77	28,613 58	5,653 19
	$ 329,341 77	$ 239,744 09	$ 89,597 68

ACCOUNTANT'S STATEMENT MINES BRANCH.

STATEMENT OF APPROPRIATIONS AND EXPENDITURE, 1914-15.[1]

Mines Branch.		Grant.	Expenditure.	Grant not used.
Investigation of ore deposits, economic minerals, peat bogs, determination of fuel values of coals, lignite and peat of Canada, including wages of machinist and labourers, and additional machinery; investigation of ore dressing, including wages of labourers, machinery and equipment of laboratory; collection of information regarding minerals, and metallurgical industries and operations..		$ 91,000 00	$ 66,913 79	$ 24,086 21
Publication of reports, translation of reports into French, purchase of books, stationery, chemical laboratories' expenses, apparatus, instruments, office contingencies, additional assistance.. ..		69,500 00	69,498 10	1 90
Investigation of metallurgical problems of economic importance..		10,000 00	10,000 00	
For apparatus and equipment salaries of inspectors, chemists, machinist, clerical assistance, and travelling expenses in connexion with the investigations of the manufacture and storage of explosives in Canada..		55,000 00	456 71	54,543 29
Completion of experiments in zinc smelting..		10,000 00	8,831 11	6,822 08
Under Statute: Zinc Investigation: Advance from 1913-14..	$ 2,335 41			
Zinc Investigation: Balance unexpended, 1913-14..	3,317 78			
		5,653 19		
Civil Government Contingencies..		1,500 00	1,042 66	457 34
		$ 242,653 19	$ 156,742 37	$ 85,910 82
DOMINION OF CANADA ASSAY OFFICE, VANCOUVER, B.C.				
Maintenance of Assay Office, Vancouver, B.C..		20,000 00	15,955 88	4,044 12

(Signed) JNO. MARSHALL,
Accountant.

MAY 26, 1915.

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[1] This financial statement covers nine months of the calendar year which is also the period of greatest activity. Therefore it has been deemed advisable to include the financial report most closely associated with the work described in this summary report. The statement for the previous financial year is also published herewith.

STATEMENT OF APPROPRIATIONS AND EXPENDITURE BY MINES BRANCH FOR YEAR ENDING MARCH 31, 1915.

		Appropriations.	Expenditure.
Amounts voted by Parliament:—			
General Appropriations..	$ 238,817 78		
Civil List Salaries..	92,812 50		
Civil Government Contingencies..	1,500 00		
		$ 333,130 28	
Advance from 1913-14, accounted for in 1914-15..		2,335 41	
Receipts for Assays and Analyses..		359 50	
Civil List Salaries..			$ 77,717 97
Civil Government Contingencies..			1,042 66
Wages..			5,810 76
Publication of Reports..			52,372 27
Fuel Testing Plant..			14,486 67
Concentrating Laboratory..			17,540 47
Ceramic Laboratory..			2,708 06
Chemical Laboratory..			1,983 55
Printing, stationery, books, mapping material.. ..			5,712 85
Publication of Maps..			522 50
Miscellaneous..			2,593 56
Instruments..			1,031 42
Investigation *re* Metallurgical Problems..			10,000 00
" Iron Ores..			11,322 61
" Zinc..			8,831 11
" Tar Sands..			8,486 68
" Peat and Coal..			3,308 00
" Mineral Waters..			2,985 09
" Moulding Sands..			1,489 65
" Limestones..			946 17
" Salt Deposits..			505 75
" Non-Metallic Minerals..			504 43
" Quartz..			479 68
" Explosives..			456 71
" Oil Shales..			165 98
" Copper Deposits..			114 70
" Manufacturer's Raw Materials..			62 17
Monograph on Building Stones..			1,489 65
Mining and Metallurgical Industry..			143 47
Mineral Statistics Industry			5 25
Balance unexpended..			101,005 35
		$ 335,825 19	$ 335,825 19

CASUAL REVENUE.

Sales of Publications.. .. .. $ 237 42

Summary.		Vote.	Expenditure.	Unexpended Balance.
Civil Government Salaries..		$ 92,812 50	$ 77,717 97	$ 15,094 53
Investigation of ore deposits, economic minerals, etc..		91,000 00	66,913 79	24,086 21
Printing, books, stationery, apparatus, chemical laboratories' expenses, miscellaneous..		69,500 00	69,498 10	1 90
Investigation of metallurgical problems of economic importance..		10,000 00	10,000 00	
Investigation of manufacture and storage of explosives in Canada..		55,000 00	456 71	54,543 29
Completion of experiments in zinc smelting..		10,000 00		
Under Statute: Zinc Investigation: Advance from 1913-14..	$ 2,335 41		11	6,822 08
Zinc Investigation: Balance unexpended, 1913-14..	3,317 78			
		5,653 19		
Civil Government Contingencies..		1,500 00	1,042 66	457 34
		$ 335,465 69	$ 234,460 34	$ 101,005 35

APPENDIX I.

PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR, 1914.

Eugene Haanel, Ph.D.,
Director of Mines.

Sir,—I beg to submit herewith the annual preliminary report on the mineral production of Canada in 1914.

The figures for production in 1914, while subject to revision, are based upon direct returns from mine and smelter operators and are fairly complete.

Special acknowledgments are due to those operators who have promptly furnished reports of their operations during the year.

When complete returns shall have been received the annual report will be prepared containing in greater detail the final statistics as well as information relating to exploration, development, prices, markets, imports and exports, etc.

I am, sir, your obedient servant.

JOHN McLEISH.

Division of Mineral Resources and Statistics,
February 24, 1915.

PRELIMINARY REPORT ON THE MINERAL PRODUCTION OF CANADA, 1914.

STATISTICS SUBJECT TO REVISION.

The preliminary report on the mineral production in Canada in 1914 presented herein shows a total value of the production during the year just closed of $128,475,499. The total value of the production in 1913 was $145,634,812, compared with which the 1914 output shows a decrease of $17,159,313, or 11·8 per cent. The average production per capita was $15.91, as against $18.77 in 1913; $18.27 in 1912, and $14.93 in 1910.

The production of the more important metals and minerals is shown in the following tabulated statement in which the figures are given for the two years 1913 and 1914 in comparative form, and the increase or decrease in value shown. Tabulated statements in greater detail will be found on subsequent pages of this pamphlet.

		1913.		1914.		Increase (+) or Decrease (−) in value.
		Quantity.	Value.	Quantity.	Value.	
			$		$	$
Copper	lb.	76,976,925	11,753,606	75,738,386	10,301,935	− 1,451,671
Gold	oz.	802,973	16,598,923	770,374	15,925,044	− 673,879
Pig-iron	*tons.	1,128,967	16,540,012	783,164	10,002,856	− 6,537,156
Lead	lb.	37,662,703	1,754,705	36,337,765	1,627,568	− 127,137
Nickel	"	49,676,772	14,903,032	45,517,937	13,655,381	− 1,247,651
Silver	oz.	31,845,803	19,040,924	27,544,231	15,097,269	− 3,943,655
Other metallic products		....	1,313,732	....	1,123,919	− 189,813
Total		....	81,904,934	....	67,733,972	− 14,170,962
Less pig-iron credited to imported ores	tons.	1,055,459	15,543,583	687,420	8,863,944	− 6,679,639
Total metallic		....	66,361,351	....	58,870,028	− 7,491,323
Asbestos and asbestic	tons.	161,086	3,849,925	117,573	2,909,806	− 940,119
Coal	"	15,012,178	37,334,940	13,594,984	34,433,108	− 3,901,832
Gypsum	"	636,370	1,447,739	510,663	1,137,157	− 310,582
Natural gas	M. ft.	20,477,838	3,309,381	21,047,028	3,511,302	+ 201,921
Petroleum	bl.	228,080	406,439	214,805	343,124	− 63,315
Pyrites	tons.	158,566	521,181	224,958	735,514	+ 214,333
Salt	"	100,791	491,280	107,038	493,648	+ 2,368
Cement	bl.	8,658,805	11,019,418	7,172,480	9,187,924	− 1,831,494
Clay products		....	9,504,314	....	7,090,898	− 2,413,416
Lime	bush.	7,558,484	1,609,398	6,245,189	1,247,517	− 361,881
Stone		....	5,504,639	....	5,593,485	+ 88,846
Miscellaneous non-metallic		....	4,274,807	....	3,921,988	− 352,819
Total non-metallic		....	79,273,461	....	69,605,471	− 9,667,990
Grand total		....	145,634,812	....	128,475,499	− 17,150,313

* Short tons throughout.

In presenting a total valuation of the mineral production as is here given, it should be explained that the production of the metals copper, gold, lead, nickel and silver is given as far as possible on the basis of the quantities of metals recovered in smelters in Canada, or probably recovered from ores exported, and the total quantities in each case are valued at the average market price of the refined metal in a generally recognized market.

The quantities thus given will differ from those which represent metal contents of ore shipped by amounts due (1) to losses in smelting (2) to the "lag" or lapse of time between the ore shipment and its treatment in the smelter. Thus the production of refined lead during the past two years has been very much lower than that reported as contained in ores shipped from the mines, the difference being due both to smelter losses and the large accumulation of ore at the smelter.

The metal miner is usually paid for his product on the basis of the value of the refined metals less a variety of deductions, and in many cases it would be exceedingly difficult to obtain a record of the net value received. It is for this reason and for the facility of comparisons that the refined values are used.

It will be observed that there has been a general falling off in the production of nearly all mine products, the notable exceptions being pyrites, salt, and natural gas. In the case of pyrites there is an increase of about 42 per cent, and about 6 per cent in quantity of salt produced. The number of cubic feet of natural gas produced shows an increase of about 3 per cent, with an increase of over 6 per cent in value.

The falling off in the production of the metals is no doubt to be ascribed in large measure to the conditions resulting from the war. Especially is this true in the case of the metals: copper, nickel, and silver. The cutting off of markets and the closing of metal exchanges with the consequent cessation of market quotations resulted in the almost immediate closing down or restriction of operation at many properties. However, before the close of the year, many of these adverse conditions had been adjusted, although prices had fallen considerably.

The actual quantities of copper and lead produced were but little less than in the previous year; nickel showed a decrease of 8 per cent, and silver of 13·5 per cent in quantity.

The total values, because of lower prices, showed much larger percentage decreases.

The iron industry was undoubtedly affected by industrial conditions of depression, and shows a falling-off of 30 per cent in tonnage of pig-iron made.

The total value of the metallic production in 1914 was $58,870,028 as against $66,361,351, a decrease of $7,491,323 or 11 per cent.

The production of non-metallic products also shows a large falling off in 1914, the total value for the year being $69,605,471, as against $79,273,461 in 1913, a decrease of $9,667,990 or 12·19 per cent.

The decrease is most pronounced in the case of coal, asbestos and gypsum and in those products such as cement, clay products (building brick, sewer pipe, etc.) and lime, generally classed as structural materials, although there was a small increase in the production of stone quarries.

Industrial depression, the culmination of over development and extravagant land speculation, is largely responsible for this sudden reverse, although the asbestos output would be restricted by the disturbance in foreign markets and the coal production would also be affected by the restricted metallurgical operations. Reference has already been made to the increased production of pyrites, salt, and natural gas.

There were also slight increases in the production of white arsenic, feldspar, grindstones, ochres, phosphate and tripolite. Asbestos shows a decrease of 27 per cent in tonnage and 24 per cent in value, coal a decrease of 10 per cent in tonnage and 9 per cent in value, petroleum a decrease of 5·8 per cent in quantity and 15·6 per cent in value, clay products 25 per cent in total value, and lime 17·4 per cent in quantity and 22·5 per cent in value.

Mineral Production by Provinces. 1913 and 1914.

	1913.		1914.	
	Value of production.	Per cent of total.	Value of production.	Per cent of total.
	$	%	$	%
Nova Scotia	19,376,183	13·30	17,514,786	13 63
New Brunswick	1,102,613	0·76	1,034,706	0·81
Quebec	13,475,534	9·25	12,259,637	9·54
Ontario	59,167,749	40·63	52,147,973	40·59
Manitoba	2,214,496	1·52	2,428,902	1·89
Saskatchewan	881,142	0·60	710,840	0·55
Alberta	15,054,046	10·34	12,773,669	9·94
British Columbia	28,086,312	19·29	24,202,924	18·84
Yukon	6,276,737	4·31	5,402,062	4·21
Dominion	145,634,812	100·00	128,475,499	100·00

The record of production by provinces given in the above table shows the relative importance of the several provinces in the same order as the previous year. A decreased production is shown in each province with the exception of Manitoba, and in this case the increase is due chiefly to the operation of the new cement mill near Winnipeg by the Canada Cement Company and the inclusion of a more complete record of the production of sands and gravels. Ontario again has the largest output with a value of $52,147,973, or 40·59 per cent of the total, practically the same proportion as in the previous year. British Columbia is second with a value of $24,202,924, or 18·8 per cent of the total; Nova Scotia is third, with a production valued at $17,514,786, or 13·6 per cent; Alberta fourth, with $12,773,669, or 9·94 per cent; Quebec fifth, with $12,259,637, or 9·5 per cent; the Yukon sixth, with $5,402,062, or 4·2 per cent; Manitoba seventh, with $2,428,902, or 1·89 per cent; New Brunswick eighth, with $1,034,706, and Saskatchewan ninth with $710,840, each less than 1 per cent.

Annual Mineral Production in Canada since 1886.

Year.	Value of production.	Value per capita.	Year.	Value of production.	Value per capita.
	$	$ cts.		$	$ cts.
1886	10,221,255	2 23	1901	65,797,911	12 16
1887	10,321,331	2 23	1902	63,231,836	11 36
1888	12,518,894	2 67	1903	61,740,513	10 83
1889	14,013,113	2 96	1904	60,082,771	10 27
1890	16,763,353	3 50	1905	69,078,999	11 49
1891	18,976,616	3 92	1906	79,286,697	12 81
1892	16,623,415	3 39	1907	86,865,202	13 75
1893	20,035,082	4 04	1908	85,557,101	13 16
1894	19,931,158	3 98	1909	91,831,441	13 70
1895	20,505,917	4 05	1910	106,823,623	14 93
1896	22,474,256	4 38	1911	103,220,994	14 42
1897	28,485,023	5 49	1912	135,048,296	18 27
1898	38,412,431	7 32	1913	145,634,812	18 77
1899	49,234,005	9 27	1914	128,475,499	15 91
1900	64,420,877	12 04			

The Mineral Production of Canada in 1914.

Subject to Revision.

Product.		Quantity.	Value.
METALLIC.			$
Copper, value at 13·602 cents per pound	lb.	75,738,386	10,301,935
Gold	oz.	770,374	15,925,044
Pig-iron from Canadian ore	* tons.	95,744	1,138,912
Iron ore sold for export	″	60,410	135,300
Lead, value at 4·479 cents per pound	lb.	36,337,765	1,627,568
Nickel, value at 30 cents per pound	″	45,517,937	13,655,381
Silver, value at 54·811 cents per oz	oz.	27,544,231	15,097,269
Cobalt and nickel oxides	lb.	1,387,101	595,999
Cobalt material and residues			82,620
Zinc ore	tons.	13,140	310,000
Total			58,870,028
NON-METALLIC.			
Actinolite	tons.	119	1,304
Arsenic, white	″	1,737	104,015
Asbestos	″	96,542	2,892,266
Asbestic	″	21,031	17,540
Chromite	″	136	1,210
Coal	″	13,594,984	33,433,108
Corundum	″	548	72,176
Feldspar	″	18,060	70,824
Graphite	″	1,647	107,203
Grindstones	″	4,078	54,497
Gypsum	″	510,663	1,137,157
Magnesite	″	358	2,240
Manganese	″	28	1,120
Mica	″		102,315
Mineral pigments—			
Barytes	″	612	6,129
Ochres	″	5,890	51,725
Mineral water			122,574
Natural gas	M. cu. ft.	21,047,028	3,511,302
Peat	tons.	685	2,470
Petroleum	bl.	214,805	343,124
Phosphate	tons.	954	7,275
Pyrites	″	224,956	735,514
Quartz	″	54,148	83,583
Salt	″	107,038	493,648
Talc	″	10,808	40,418
Tripolite	″	650	13,000
Total			43,407,737
STRUCTURAL MATERIALS AND CLAY PRODUCTS.			
Cement, Portland	bl.	7,172,480	9,187,924
Clay products—			
Brick, common, pressed, paving			4,809,046
Sewerpipe			1,102,100
Fireclay, drain tile, pottery, etc			1,169,752
Kaolin	tons.	1,000	10,000
Lime	bush.	6,245,189	1,247,517
Sand and gravel			2,448,738
Sand-lime brick			624,335
Slate	sq.	1,075	4,837
Stone—			
Granite			2,179,930
Limestone			2,730 438
Marble (not complete)			192,533
Sandstone			490,584
Total structural materials and clay products			26,197,734
All other non-metallic			43,407,737
Total value, metallic			58,870,028
Grand total, 1914			128,475,499

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* Tons of 2,000 pounds.

Metal Prices.

—	1909.	1910.	1911.	1912.	1913.	1914.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Copper, New York	12·982	12·738	12·376	16·341	15·269	13·602
Lead "	4·273	4·446	4·420	4·471	4·370	3·862
" London	2·839	2·807	3·035	3·895	4·072	4·146
" Montreal*	3·268	3·246	3·480	4·467	4·659	4·479
Nickel, New York	30·000	40·000	40·000	40·000	40·000	40·000
Silver "	51·503	53·486	53·304	60·835	59·791	54·811
Spelter "	5·503	5·520	5·758	6·943	5·648	5·213
Tin "	29·725	34·123	42·281	46·096	44·252	34·301

* Quotations furnished by Messrs. Thomas Robertson & Company, Montreal, Que.

SMELTER PRODUCTION.

Statistics of the production of copper, lead, and silver smelters and refineries, showing the tonnage of ore treated, the matte, blister, base bullion, or refined metal produced, have been collected by the Mines Branch since 1908.

The total quantity of ores and concentrates treated in these smelters during 1914 was 2,649,935 tons (including 58,894 tons of imported ore), as compared with 3,037,391 tons in 1913. The largest proportion of the total tonnage, about 61 per cent in 1914, consists of the copper-gold-silver ores of British Columbia, chiefly from the Boundary (Phœnix and Greenwood), Rossland and Coast (Britannia, Texada Island and Granby Bay) districts. The nickel-copper ores of the Sudbury district, Ontario, contributed about 35·7 per cent of the tonnage, the balance being lead ores and other ores treated in lead furnaces and the silver cobalt ores of Ontario treated in silver smelters. Gold and silver ores treated by cyanide processes are not included in this record.

The quantities of the several classes of ores, in tons, smelted during the past seven years have been as follows:—

Year.	Nickel-copper ores.	Silver-cobalt ores.	Lead ores.	Copper-gold silver ores.	Totals.
1908	360,180	7,182	53,545	1,797,488	2,218,395
1909	462,336	8,384	54,539	1,850,889	2,376,148
1910	628,947	9,466	57,549	1,987,752	2,683,714
1911	610,834	9,330	55,408	1,517,981	2,193,553
1912	725,065	8,097	59,932	2,212,316	3,005,410
1913	823,403	6,124	88,100	2,119,754	3,037,391
1914	947,053	5,661	71,064	1,612,197	2,649,935

The products obtained in Canada from the treatment of these ores include: pig lead produced at Kingston, Ont. (furnace idle in 1914); refined pig lead and lead pipe produced at Trail, B.C., and fine gold, fine silver, copper sulphate and antimony produced from the residues of the Trail lead refinery; silver bullion, white arsenic, nickel oxide and cobalt oxide produced in Ontario from the Cobalt district ores. In addition to these refined products, blister copper, copper matte, nickel-copper matte, cobalt material or mixed nickel and cobalt oxides are produced and exported for refining.

The aggregate results of smelting and refining operations may be summarized as shown in the next table. Unfortunately the figures cannot be taken to represent the total production from smelting ores mined in Canada, since considerable quantities of copper and silver ores are still shipped to other smelters outside of Canada for smelting.

Smelter and Refinery Production in Canada.

Smelter products obtained and exported for refining.	1911.	1912.	1913.	1914.
	Tons.	Tons.	Tons.	Tons.
(1) Blister copper	10,710	17,063	15,270	13,238
(2) Copper matte	11,320	6,727	5,159	6,291
(3) Nickel-copper matte	32,607	41,925	47,150	46,396
(4) Cobalt material	630	642	122	101

		1912.		1914.	
		Refined products.	Metals contained in matte, blister, and base bullion.	Refined products.	Metals contained in matte, blister, and base bullion.
Gold	oz.	11,977	213,279	11,088	170,818
Silver	"	13,789,709	934,601	11,096,861	873,400
Lead	lb.	37,923,043		36,443,706	
Copper	"		59,245,722		59,237,016
Copper sulphate	"	130,533		152,060	
Nickel	"		49,676,772		45,517,937
Cobalt oxide	"	660,079		895,789	
Nickel oxide	"	268,304		391,312	
White arsenic	"	3,384,249		3,474,322	

(1) Blister copper carrying gold and silver values.
(2) Copper matte " "
(3) Bessemer nickel-copper carrying small gold and silver values as well as metals of the platinum group.
(4) Cobalt material carrying nickel and silver values.

GOLD.

The total production of gold, in placer and mill bullion and in smelter products in 1914, is estimated at 770,374 fine ounces, valued at $15,925,044, as compared with 802,973 fine ounces valued at $16,598,923 in 1913, showing a decrease of $673,879, or about 4 per cent.

Of the total production in 1914, about $5,695,508 was derived from placer and alluvial mining—$6,050,690 in bullion from milling ores, and $4,228,846 from matte, blister copper and other smelter products, etc. In 1913, of the total production, about $6,346,072 were derived from alluvial workings; $5,185,544 in bullion from milling ores, and $5,067,307 from smelter products derived from ores, concentrates, etc., smelted.

The production in Nova Scotia and Quebec is small compared with the other provinces but shows an increase of over 25 per cent in 1914.

The Ontario production, $5,546,356, shows an increase of over a million dollars due to the extension of milling facilities in the Porcupine field.

No records have been received with respect to gold production in the Beaver Lake district of Saskatchewan or of recoveries from the river bars near Edmonton, Alberta, although activity has been reported in both localities.

The production in British Columbia was $5,177,343, of which $524,000 is credited to placer workings as estimated by the Provincial Mineralogist, and $4,653,343 to smelter products and bullion from milling ores. The British Columbia production in 1913 was $6,149,027, being $510,000 from placer workings, and $5,639,027 from smelter products and mill bullion.

The Yukon production shows a falling off of $721,384, the total in 1914 being $5,125,396 including a small value in mill bullion, as against $5,846,780 in 1913. The total amount on which royalty was paid during the year 1914, according to the records of the Mining Lands and Yukon Branch, Interior Department, was 309,691·17 ounces, as against 352,900·04 ounces in 1913.

The exports of gold bearing dust, nuggets, gold in ore, etc., in 1914, were valued at $15,242,200.

SILVER.

The falling off in price of silver amounting to 4 cents on the average price for the year, the cessation of price quotations, and the difficulties of marketing the metal immediately following the declaration of war restricted operations in the Cobalt camp, causing a lower production than might have been expected under normal conditions.

The total Canadian production in 1914 was 27,544,231 ounces, valued at $15,097,269, as against 31,845,803 ounces valued at $19,040,924 in 1913, a decrease of 4,301,572 ounces or 13·5 per cent in quantity, and of $3,943,655, or 20·7 per cent in total value.

Of the total production 24,215,926 ounces or 88 per cent is credited to Ontario. The production from the silver camps is reported as 9,614,069 fine ounces in bullion shipped, and 14,544,524 ounces (after deducting 5 per cent for smelter losses) contained in ore and concentrates shipped from Cobalt district. There is also included in the total a small quantity of silver contained in gold bullion shipped.

The Ontario production in 1913 was 28,411,261 ounces showing a falling off for the province of 4,003,805 ounces, or about 14·1 per cent.

In addition to the bullion shipments from the Cobalt camp, 9,052,993 ounces were produced in other silver refineries in the province, making a total of 18,667,062 ounces or 67·7 per cent of the Ontario production recovered within the province in the form of bullion.

The production in British Columbia, representing refined silver and silver contained in smelter products and estimated recoveries from ores exported, was in 1914 about 3,212,111 ounces, as compared with 3,312,343 ounces in 1913.

In Quebec province there is a small silver content in the pyrites ores shipped, while in the Yukon 67,432 ounces are estimated as being contained in the placer gold produced and recovered from the copper ores shipped from Whitehorse.

The exports of silver bullion and silver in ore, etc., as reported by the Customs Department, were 28,020,089 ounces valued at $15,584,813. There is also an importation recorded of silver in bars, blocks, etc., valued at $629,279.

The price of silver in New York reached a maximum of 59 cents during the first week of May but fell off to 49 cents during the last two months of the year.

COPPER.

The copper situation in 1914 was marked by an increased production in Ontario and Quebec as against a falling off in British Columbia and the Yukon, leaving the net result as a very slight decrease.

The copper contained in matte, blister copper, etc., produced in Canadian smelters together with the estimated recoveries or amounts paid for in ores exported amounted in 1914 to 75,738,386 pounds, which, at the average New York value of refined copper, would be worth $10,301,935. Compared with the production in 1913, which was 76,976,925 pounds valued at $11,753,606, there was a falling off of only 1,238,539 pounds or 1·6 per cent, but, owing to the lower price, a much larger percentage decrease in total value.

The production in Quebec from pyrites ores was 4,201,497 pounds as compared with 3,455,887 pounds in 1913. The actual copper content of the ores shipped was nearly 50 per cent in excess of these figures, but only about two-thirds of the copper is reported as paid for.

The Ontario production is derived chiefly from the nickel-copper ores of the Sudbury district and of the Alexo mine, although there is a small amount of copper contained in the silver ores shipped from Cobalt, some of which is paid for. There was also a small shipment from the Dane mine on the T. & N. O. railway.

The production in 1914 is reported as 28,948,211 pounds, an increase of 3,062,282 pounds over the 1913 output which was 25,885,929 pounds. The Mond Nickel Company contributed a much larger percentage of the total production during 1914 than in 1913, and, as this company's ores are higher in copper than those being worked by the Canadian Copper Company, we have the, perhaps somewhat unexpected, result of a decrease in nickel production accompanied by an increase in copper production from these Sudbury district ores.

The British Columbia production was 41,221,628 pounds as against 45,791,579 pounds in 1913, a falling off of 4,569,951 pounds. The Greenwood smelter closed down in August and the Grand Forks smelter restricted its operations very severely on the outbreak of war, but started up several furnaces again before the close of the year. The blowing in of the smelter at Anyox, treating the Hidden Creek and other coast ores, and the continuance of large shipments from the Britannia mine made the coast production slightly greater than that of the southern interior smelters and, with an increased production at Trail, almost compensated for the falling off in the Boundary district.

The Pueblo mine was again the principal copper producer in the Yukon with an output only slightly less than that in 1913.

The New York price of electrolytic copper fell off from 14·7 cents in February to 12·7 cents during the last week of July. Quotations ceased on the declaration of war, but were resumed in November at a little over 11 cents, increasing to 13·2 cents in December. The average monthly price for the year was 13·602 cents, as against 15·269 cents in 1913, and was, with the exceptions of 1912 and 1913, the highest average since 1907.

There was a large falling off in the imports of copper of all kinds in 1914. The total imports were valued at $4,256,901, and included crude and manufactured copper, 28,280,812 pounds valued at $3,983,322, copper sulphate, 1,143,039 pounds valued at $53,802, and other manufactures of copper valued at $219,777. The total imports in 1913 were valued at $7,415,008, and included crude and manufactured copper, 41,011,961 pounds valued at $6,935,822. copper sulphate 2,037,714 pounds valued at $107,960, and other manufactures valued at $371,226.

The exports of copper were: Copper fine in ore, matte, etc., 68,830,059 pounds, valued at $7,130,778, and copper black or coarse, etc., 6,581,564 pounds valued at $908,201, a total of 75,411,623 pounds valued at $8,038,979.

LEAD.

The smelter production of lead from Canadian ores in 1914 was 36,337,765 pounds which, valued at 4·479 cents per pound, the average price of pig lead in

Montreal for the year, would be worth $1,627,568. The production in 1913 was 37,662,703 pounds, valued at $1,754,705. With the exception of a small tonnage from the Yukon, the 1914 production was entirely from British Columbia ores, and was almost all recovered at the Trail smelter.

The exports of lead in ore, etc., in 1914 are reported as 246,100 pounds valued at $2,681, and of pig lead 510,573 pounds valued at $19,507.

The total value of the imports of lead and lead-products in 1914 was $1,042,538, and included old scrap and pig lead, 15,444,100 pounds valued at $590,557, manufactured lead 3,394,930 pounds valued at $186,165, manufactures n.o.p., $99,285, and litharge and lead pigments $166,531. The imports of litharge and pigment would contain approximately 1,449 tons of metallic lead and the total imports of metallic lead would therefore exceed 10,869 tons.

The average monthly price of lead in Montreal during 1914 was 4·479 cents as against 4·659 cents in 1913. This is the producer's price for lead in car lots as per quotations kindly furnished by Messrs. Thos. Robertson & Co.

The average monthly price of lead in New York was 3·862 cents, and in London £19·079 per gross ton, equivalent to 4·146 cents per pound.

NICKEL.

The declaration of war resulted in the almost immediate closing down of a considerable portion of the mining and smelting operations of the Canadian Copper Company in the Sudbury district, and although they were partially resumed before the close of the year the Company's output was greatly reduced. The Mond Nickel Company on the other hand, having increased the capacity of its smelter at Coniston, nearly doubled its output. Ores from the Alexo nickel mine north of Cobalt were also reduced in this smelter. Ten separate properties were worked by these Companies.

The nickel-copper ore is reduced in smelters and converters to a Bessemer matte containing from 77 to 82 per cent of the combined metals and shipped in that form to Great Britain and the United States for refining; the product of the Canadian Copper Company going to New Jersey and that of the Mond Nickel Company to Wales. A portion of the matte produced by the Canadian Copper Company is used for the direct production of Monel metal, an alloy of nickel and copper, without the intermediate refining of either metal.

The total production of matte in 1914 was 46,396 tons valued by the producers at the smelters at $7,189,031, and containing 28,895,825 pounds of copper and 45,517,937 pounds of nickel. The tonnage of ore smelted (part being previously roasted) was 947,053. The production in 1913 was 47,150 tons of matte, containing 25,875,546 pounds of copper and 49,676,772 pounds of nickel, showing an increase in 1914 in copper content and a falling off in nickel.

There is also a small recovery of nickel in the form of nickel oxide from the Cobalt district ores, the production in 1914 being reported as 391,312 pounds of oxide, valued at $26,483.

The aggregate results of the smelting operations on nickel-copper ores during the past five years and the exports of nickel are shown in tabular form, while a record taken from the "Foreign Commerce of the United States" has been added showing the imports of nickel into, and exports from that country. The values of the United States exports, which are not quoted in the tables, range from 31 to 39 cents per pound and averaged about 34 cents in 1914.

It will be noted that a much larger quantity of nickel finds its way to the United Kingdom through United States refineries than is exported directly from Canada.

Exports of nickel from New Caledonia for the first seven months of 1914 are reported as 52,498 metric tons of ore and 2,275 tons matte, of which the total nickel content would probably not exceed 8,000,000 pounds.

The price of refined nickel in New York remained fairly constant throughout the year, quotations published by the Engineering and Mining Journal, 40 to 45 cents per pound for nickel shot, blocks or plaquettes; electrolytic 5 cents higher per pound.

Production of Nickel in Canada.	1911.	1912.	1913.	1914.
	Tons of 2,000 lb.	Tons of 2,000 lb.	Tons of 2,000 lb.	Tons of 2,000 lb.
Ore mined	612,511	737,584	784,697	1,000,364
Ore smelted	610,834	725,065	823,403	947,053
Bessemer matte produced	32,607	41,925	47,150	46,396
Copper content of matte	8,966	11,116	12,938	14,448
Nickel " "	17,049	22,421	24,838	22,759
Spot value of matte	$ 4,945,592	$ 6,303,102	$ 7,076,945	$ 7,189,031

Exports of Nickel from Canada.	Lb.	Lb.	Lb.	Lb.
Nickel contained in matte, etc.—				
Exported to Great Britain	5,023,393	5,072,867	5,164,512	10,291,979
Exported to United States	27,596,578	39,148,993	44,224,119	36,015,642
Exported to other countries	....	....	70,386	220,706
	32,619,971	44,221,860	49,459,017	46,538,327

Imports of Nickel into United States.	1911.	1912.	1913.	1914.
Gross tons of ore and matte ... tons.	23,993	33,101	37,623	29,564
Nickel contents ... lb.	29,545,967	42,168,769	47,194,101	35,006,700
Exports of Nickel from United States—				
To France ... lb.	5,463,358	5,083,947	3,631,858	3,457,157
To Netherlands ... "	9,101,150	7,387,447	6,622,811	855,168
To United Kingdom ... "	7,196,259	8,191,364	8,221,640	10,836,369
To other countries ... "	3,338,819	5,152,258	10,096,779	12,446,458
Total ... "	25,099,586	25,815,016	29,173,088	27,595,152

IRON ORE.

The iron ore shipments from mines in Canada during 1914 are reported as 244,854 short tons valued at $542,041. These shipments included 199,292 tons of hematite and roasted siderite, and 45,562 tons of magnetite and concentrates.

The total shipments of ore in 1913 were 307,634 tons, including 92,386 tons of hematite and roasted siderite, 209,886 tons of magnetite and concentrates and 5,362 tons of titaniferous ore.

Exports of iron ore from Canada during 1914 were recorded by the Customs Department as 135,451 tons valued at $360,974.

According to mine operators' reports, however, 184,444 tons were shipped to Canadian smelters, and 60,410 tons were exported to the United States. The imports into the United States from Canada are also reported by the Washington Trade Statistics as 58,816 tons, valued at $153,415.

Imports of iron ore in 1914 were, according to Customs records, 1,147,108 tons, valued at $2,387,358.

Shipments of iron ore from the Wabana mines, Newfoundland, in 1914, by the two Canadian companies operating there were 639,430 short tons, of which 422,920 tons were shipped to Sydney, Cape Breton, and 216,510 tons to the United States and Europe. In 1913 the shipments were 1,605,920 short tons, of which 1,048,432 tons were shipped to Sydney, and 557,488 tons to the United States and Europe.

PIG-IRON.

The total production of pig-iron in Canadian blast furnaces in 1914 was 783,164 tons of 2,000 pounds, valued at approximately $10,002,856, as compared with 1,128,967 tons, valued at $16,540,012 in 1913. A large portion of this production is used directly in the manufacture of steel and the values are in part estimated. The output shows a falling off of 345,803 tons or 30·6 per cent, and is the smallest since 1909.

Of the total production in 1914, 9,380 tons were made with charcoal and 773,784 tons with coke. The classification of the production, according to the purpose for which it was intended, was as follows: Bessemer 230,817, basic 346,553, foundry and malleable 205,794.

The ore charged to blast furnaces included 182,964 tons of Canadian ore and 1,324,326 tons of imported ore, and 33,583 tons of mill cinder, etc. The amount of coke used during the year was 921,171 tons, comprising 330,269 tons from Canadian coal, and 590,902 tons of imported coke or coke made from imported coal. The quantity of charcoal fuel used was 920,045 bushels, and of limestone flux 447,636 tons.

The number of men employed at blast furnaces was 1,018, and total wages paid $693,632.

The furnace plants operated for varying periods of time, included those of the Dominion Iron and Steel Co., and the Nova Scotia Steel and Coal Co., at Sydney, and North Sydney; the Algoma Steel Co., at Sault Ste. Marie; the Steel Co. of Canada, at Hamilton; the Standard Iron Co., at Deseronto; and the Canadian Iron Furnace Co., at Port Colborne. All other furnaces were idle throughout the year.

The production of pig-iron by provinces in 1913 and 1914 was as follows:—

—	1913.			1914.		
	Tons.	Value.	Value per ton.	Tons.	Value.	Value per ton.
		$	$ cts.		$	$ cts.
Nova Scotia	480,068	7,201,020	15 00	227,052	2,951,676	13 00
Ontario	648,899	9,338,992	14 39	556,112	7,051,180	12 68
	1,128,967	16,540,612	14 65	783,164	10,002,856	12 77

There was also a production during 1914 in electric furnaces of 7,524 tons of ferro alloys (ferro-silicon and ferro-phosphorus) valued at $478,354, compared with 8,075 tons valued at $493,018 in 1913. This production is chiefly 50 per cent ferro-silicon.

The exports of pig-iron and ferro-silicon, etc., during the year are reported as 19,063 tons, valued at $486,366. The imports were: pig-iron, 78,594 tons, valued at $981,107; charcoal pig 86 tons, valued at $1,082; ferro-manganese and ferro-silicon 22,147 tons, valued at $549,485; or a total of 100,827 tons, valued at $1,531,674.

COAL AND COKE.

The total production of marketable coal for the year 1914 comprising sales and shipments, colliery consumption and coal used in making coke or otherwise used by the colliery operators, was 13,594,984 short tons, valued at $33,433,108, as against 15,012,178 tons, valued at $37,334,940 in 1913, showing a decrease of 1,417,194 tons, or 9·4 per cent in quantity and of $3,901,832, or 10·4 per cent in total value.

In estimating the values of the coals, arbitrary values are assumed for Nova Scotia and for British Columbia, viz: $2.50 per long ton for the former and $3.50 per long ton for the latter. The value of the coal production in the other provinces is that returned by the operators. The production in Nova Scotia was 7,338,790 tons, a falling off of 641,283 tons, or 8·0 per cent. The Alberta production as kindly furnished by Mr. John Stirling, Inspector of Mines, Alberta, was 3,667,816 tons, a decrease of 346,939, tons or 8·6 per cent, while the British Columbia production was 2,238,339 tons a decrease of 476,081 tons or 21·2 per cent. Saskatchewan with a production of 232,541 tons shows an increase of 19,644 tons or 9·2 per cent, while New Brunswick reports a production of 104,055 tons, an increase of 33,744 tons or 48 per cent. The production of the Yukon is reported as 13,443 tons, a decrease of 6,279 tons or 32 per cent from 1913.

Province.	1912.		1913.		1914.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Nova Scotia	7,783,888	$ 17,374,750	7,980,073	$ 17,812,663	7,338,790	$ 16,381,228
British Columbia	3,208,997	10,028,116	2,714,420	8,482,562	2,238,339	6,994,810
Alberta	3,240,577	8,113,525	4,014,755	10,418,941	*3,667,816	9,367,602
Saskatchewan	225,342	368,135	212,897	358,192	232,541	375,438
New Brunswick	44,780	89,560	70,311	166,637	104,055	260,270
Yukon	9,245	44,958	19,722	56,945	13,443	53,760
Total	14,512,829	36,019,044	15,012,178	37,334,940	13,594,984	33,433,108

*Statistics furnished by Mr. John Stirling, Inspector of Mines, Alberta.

The exports of coal in 1914 were 1,423,126 tons, valued at $3,880,175, as compared with exports of 1,562,020 tons valued at $3,961,351 in 1913, a falling off of 138,894 tons or 8·89 per cent.

Imports of coal during the year included bituminous, round and run of mine 7,776,415 tons, valued at $14,954,321, or an average of $1.92 per ton; bituminous slack 2,509,632 tons valued at $3,605,253 or an average of $1.43 per ton; and anthracite 4,435,010 tons valued at $21,241,924 or an average of $4.79 per ton or a total of 14,721,057 tons, valued at $39,801,498. The imports in 1913 were bituminous, round and run of mine 10,743,473 tons valued at $21,756,658; bituminous slack 2,816,423 tons, valued at $4,157,622; and anthracite 4,642,057 tons valued at $22,034,839; or a total of 18,201,953 tons valued at $47,949,119.

There was therefore a decrease in imports of bituminous run of mine of 2,967,058 tons or 27·6 per cent, a decrease in the imports of bituminous slack of 306,791 tons or 10·9 per cent and a decrease in the imports of anthracite of 207,047 tons or 4·5 per cent, or a total decrease in coal imports of 3,480,896 tons or 19·1 per cent.

The apparent consumption of coal during the year was 26,809,778 tons as against a consumption of 31,582,545 tons in 1913. Of the consumption in 1914 about 45·4 per cent was from Canadian mines and 54·6 per cent imported.

Coke.—The total output of oven coke during 1914 was 1,015,253 tons of 2,000 lb. made from 1,533,365 tons of coal, of which 1,030,053 tons were mined in Canada, and 503,312 tons were imported. The total quantity of coke sold, or used by the producers during the year was 1,019,082 tons valued at $3,634,511.

In 1913 the total output was 1,517,133 tons and the quantity sold or used by the producers 1,530,499 tons valued at $5,919,596.

The output by provinces in 1914 was: Nova Scotia, 345,880 tons; Ontario, 377,514 tons; Alberta, 28,541 tons, and British Columbia, 263,318 tons. The production from Ontario was entirely from imported coal.

By-products from coke ovens during the year included 8,572 tons of ammonia sulphate, 5,714,172 gallons of tar, and 3,201,097 thousand feet of gas.

The only coke ovens operated during the year were those at Sydney, Sydney Mines and Westville, Nova Scotia; Sault Ste. Marie, Ontario; Coleman, Alberta; and Fernie, Michel, and Hosmer, British Columbia. At the end of the year there were 797 ovens in operation and 2,297 idle.

ASBESTOS.

The asbestos production in 1914 was obtained from the districts of Black Lake, Thetford, Robertsonville, and Danville, in the province of Quebec. Both output and sales show a considerable falling off, while there is an increase in the stocks on hand at the close of the year, a result which is no doubt due largely, if not entirely, to the war.

The total output in 1914 was 107,668 tons, as against 132,564 tons in 1913, a falling off of 24,896 tons, or 18·7 per cent. Notwithstanding this decrease the output was greater than that of any other preceding year. The sales and shipments of asbestos during 1914 were 96,542 tons, valued at $2,892,266, or an average of $29.96 per ton, as against sales in 1913 of 136,951 tons valued at $3,830,909, or an average of $27.97 per ton. The 1914 sales were exceeded during each of the previous three years. Stocks on hand at December 31, 1914, were 31,171 tons, as compared with stocks of 20,787 tons at the end of the previous year.

The number of men employed in mines or quarries and mills, was 2,992 and amount paid in wages, $1,283,977, as against 2,951 men employed, and $1,687,957 paid in wages in 1913.

The total quantity of asbestos rock milled during the year is reported as 1,717,629 tons which, with a mill production of 103,607 tons, shows an average estimated content of about 6·03 per cent of fibre in the rock.

The output and sales of crude and mill stock separately is shown for 1913 and 1914 in the following tables. The classification is based on valuation: Crude No. 1, comprising material valued at $200 per ton and upwards, and Crude No. 2, under $200; mill stock No. 1 includes mill fibre valued at from $30 upwards, No. 2 from $15 to $30, and No. 3 under $15.

The total sales of crude asbestos in 1914 were 4,147·5 tons, valued at $773,193, or an average of $186.42 as against sales in 1913 of 5,660·3 tons, valued at $989,162, or an average of $174·45 per ton, showing a lower tonnage but a higher average value in 1914.

The total sales of mill stock in 1914 were 92,394 tons, valued at $2,119,073, or an average of $22.94 per ton, against 131,291 tons in 1913, valued at $2,841,747, or an average of $21.64 per ton, again a smaller tonnage but a higher average price than in the previous year.

Exports of asbestos during the twelve months ending December 31, 1914, were 81,081 tons, valued at $2,298,646, as against 103,812 tons, valued at $2,848,047 exported in 1913. There was also an export classed as asbestos sand in 1914, amounting to 18,991 tons, valued at $108,548 tons, or an average value per ton of $5.71.

Output Sales and Stocks in 1914.

	Output.	Sales.			Stock on hand. Dec. 31.		
	Tons.	Tons.	Value.	Per ton.	Tons.	Value.	Per ton.
			$	$		$	$
Crude No. 1	1,450·55	1,335·9	402,417	301 23	984·3	301,237	306 04
" 2	2,610·4	2,811·65	370,776	131 87	1,410·9	187,338	132 78
Mill stock No. 1	16,144	19,388	932,893	48 12	4,616	229,361	49 69
" 2	58,362	47,851	963,973	20 15	15,114	305,809	20 23
" 3	29,101	25,155	222,207	8 83	9,046	76,522	8 46
Asbestos	107,607·95	96,541·55	2,892,266	29 96	31.171·2	1,100,267	35 30
Asbestic	....	21,031	17,540	0·83	....	....	....

Output Sales and Stocks in 1913.

	Output.	Sales.			Stock on hand. Dec. 31.		
	Tons.	Tons.	Value.	Per ton.	Tons.	Value.	Per ton.
			$	$ cts.		$	$ cts.
Crude No. 1	2,015·4	1,853·3	531,200	286 62	880·5	247,877	281 52
" 2	3,010	3,807	457.962	120 29	1,522	178,789	117 47
Mill stock No. 1	23,444	26,198	1,229,908	46 95	6,755	350,165	51 84
" 2	58,592	60,164	1,201,215	19 97	4,809	108,285	22 52
" 3	45,503	44,929	410,624	9 14	6,820	54,604	8 01
Asbestos	132,564·4	136,951·3	3,830,909	27 97	20,786·5	939·720	45 21
Asbestic	....	24,135	19,016	0 79	....	... .	....

PETROLEUM AND NATURAL GAS.

Although crude oil has been struck in several of the prospect wells being sunk in Alberta, and a few thousand gallons obtained from the Dingman Well, No. 1, of the Calgary Petroleum Products, Ltd., were sold, the western fields have not, as yet, reached the stage of commercial production, and the Canadian output is still practically confined to the old established fields in Ontario supplemented by a few barrels pumped from gas wells in New Brunswick.

The annual output, which has been steadily declining during the past seven years, shows a further falling off in 1914. The average price received for crude oil was also lower than in the previous year.

A bounty of one and a half cents per imperial gallon is paid upon the production of crude petroleum, the Petroleum Bounty Act being administered and payments made by the Department of Trade and Commerce.

According to the records of this Department, the total output of petroleum in Ontario and New Brunswick during 1914 was 214,418 barrels, or 7,504,619 gallons, on which a bounty of $340,924 was paid. The average monthly price per barrel at Petrolia was $1.59, as compared with $1·782 in 1913. During the first three months of 1914, $1.89 per barrel was quoted, but the price decreased to a minimum of $1.33 during the past three months of the year.

In addition to the above, 13,549 gallons, or 387 barrels, valued at $2,200, were reported as having been sold from the Dingman Well in Alberta upon which no bounty was claimed. The total Canadian production is therefore stated as 7,518,168 gallons, or 214,805 barrels, valued at $343,124.

The production in 1913 was 7,982,798 gallons, or 228,080 barrels, valued at $406,439. The production in Ontario during 1914 included in the above total was 212,693 barrels. The production by districts in this province, as furnished by the Supervisor of Petroleum Bounties, at Petrolia, was as follows, in barrels: Lambton, 154,186; Tilbury, 18,530; Bothwell, 33,961; Dutton, 2,190; Onondaga, 2,437, and Belle River, 1,191, or a total of 212,495 barrels. In 1913 the production by districts was: Lambton, 155,747; Tilbury, 26,824; Bothwell, 34,349; Dutton, 4,610; Onondaga, 4,172, and Belle River, 464, or a total of 226,166 barrels.

The production in New Brunswick in 1914 was 1,725 barrels, as against 2,111 barrels in 1913, and 2,679 barrels in 1912.

Exports of petroleum entered as crude mineral oil in 1914 were 3,996 gallons valued at $362, and of refined oil 3,922 gallons valued at $826. There was also an export of naphtha and gasoline of 43,023 gallons valued at $11,607.

The total value of the imports of petroleum and petroleum products in 1914 was $11,174,763, as against a value of $13,348,326 in 1913.

The total imports of petroleum oils, crude and refined, in 1914 were 244,487,973 gallons, valued at $11,072,362, in addition to 1,594,236 pounds of wax and candles valued at $102,401. The oil imports included: crude oil, 195,207,210 gallons, valued at $5,750,971; refined and illuminating oils, 12,333,065 gallons, valued at $970,481; gasoline, 24,396,401 gallons, valued at $2,747,360; lubricating oils, 5,767,676 gallons, valued at $940,143, and other petroleum products, 6,282,621 gallons valued at $663,407.

The total imports in 1913 were 222,779,028 gallons of petroleum oils crude and refined, valued at $13,238,429, in addition to 1,628,837 pounds of paraffin wax and candles, valued at $109,897. The oil imports included: crude oil, 162,061,926 gallons, valued at $5,250,835; refined and illuminating oils, 19,393,627 gallons, valued at $1,394,440; gasoline, 29,525,180 gallons, valued at $4,322,941; lubricating oils, 6,789,451 gallons, valued at $1,172,986, and other petroleum products, 5,008,844 gallons, valued at $597,227.

There was thus in 1914 an increased importation of crude oils and a decrease in imports of refined illuminating oils, lubricating oils and gasoline.

NATURAL GAS.

The total production in 1914 was approximately 21,047 million feet, valued at $3,511,302, of which 426 million feet valued at $54,249 was produced in New Brunswick, 13,675 million feet valued at $2,206,733 in Ontario, and 6,946 million feet valued at $1,250,320 in Alberta.

The production in 1913 was 20,478 million cubic feet, valued at $3,307,381, of which 829 million feet valued at $174,147 was produced in New Brunswick, 12,475 million feet valued at $2,055,768 in Ontario, and 7,174 million feet valued at $1,079,466 in Alberta.

These values represent as closely as can be ascertained the value received by the owners or operators of the wells for gas produced and sold or used. The values do not represent what consumers have to pay, since, in cases where transmission is by separately operated pipe line companies, such cost is not included.

CEMENT.

The year 1914 has witnessed a very large falling off in the production of nearly all materials of construction. This situation while possibly aggravated by the war was due primarily to conditions which had already begun to show their effects during the latter part of 1913.

The total quantity of Portland cement, including slag cement and natural Portland, made in 1914 was 8,727,269 barrels of 350 net pounds each as compared with 8,886,333 barrels made in 1913, a decrease of 159,064 barrels, or about 2 per cent.

The total quantity of Canadian-Portland cement sold or used during 1914 was 7,172,480 barrels, valued at $9,187,924, or an average of $1.28 per barrel, as compared with 8,658,805 barrels valued at $11,019,418 or an average of $1.27 per barrel in 1913, showing a decrease of 1,486,325 barrels, or 17 per cent.

The total imports of cement in 1914 were 343,076 cwt., equivalent to 98,022 barrels of 350 pounds, valued at $147,158, or an average of $1.50 per barrel, as compared with imports of 254,093 barrels valued at $409,303, or an average of $1.61 in 1913.

The total consumption of cement therefore, neglecting a small export, was 7,270,502 barrels, as compared with a consumption of 8,912,898 barrels in 1913; a decrease of 1,642,396 barrels, or 18·4 per cent.

Detailed statistics of production during each of the past four years are shown as follows:—

——	1911.	1912.	1913.	1914.
	Bl.	Bl.	Bl.	Bl.
Portland Cement sold	5,692,915	7,132,732	8,658,805	7,172,480
Portland Cement manufactured	5,677,539	7,141,404	8,886,333	* 8,727,269
Stock on hand Jan. 1st	918.965	894,822	862,067	* 1,074,610
Stock on hand Dec. 31st	903,589	903,094	1,089,595	* 2,629,399
Value of cement sold	$ 7,644,537	$ 9,106,556	$11,019,418	$ 9,187,924
Wages paid	2,103,838	2,623,902	3,466,451	2,271,006
Men employed	3,010	3,461	4,276	2,977

* Partially estimated.

The average price per barrel at the works in 1914 was $1.28 as compared with $1.27 in 1913, $1.28 in 1912, and $1.34 during 1911 and 1910.

The imports of cement in 1914 included 26,774 barrels valued at $35,517 from Great Britain, 69,117 barrels valued at $108,487 from the United States, and 2,131 barrels valued at $3,154 from other countries.

The consumption of Portland cement during each of the past five years was as follows:—

Annual Consumption of Portland Cement.

Calendar Year.	Canadian.		Imported.		Total.
	Barrels.	Per cent.	Barrels.	Per cent.	Barrels.
1910	4,753,975	93	349,310	7	5,103,285
1911	5,692,915	90	661,916	10	6,354,831
1912	7,132,732	83·3	1,434,413	16·7	8,567,145
1913	8,658,805	97·1	254,093	2·9	8,912,988
1914	7,172,480	98·7	98,022	1·3	7,270,502

Exports of Products of the Mine and Manufactures of Mine Products, Calendar Year, 1914.

(Compiled from Trade and Navigation Monthly Statements.)

Products.		Quantity.	Value.
			$
Arsenic	cwt.	37,519	132,567
Asbestos	tons.	81,081	2,298,646
Asbestos sand	"	18,991	108,548
Coal	"	1,423,126	3,880,175
Feldspar	"	18,072	74,100
Gold	$	....	15,242,200
Gypsum	tons.	345,830	404,234
Copper, fine, in ore, etc	lb.	68,830,059	7,130,778
" black or coarse and in pigs	"	6,581,564	908,201
Lead, in ore, etc	"	246,100	2,681
" pig, etc	"	510,573	19,507
Nickel, in ore, etc	"	46,528,327	5,149,427
Platinum	oz.	43	2,161
Silver	"	28,020,069	15,584,813
Mica	lb.	669,163	178,940
Mineral pigments	cwt.	35,549	22,311
Mineral water	gal.	2,287	599
Oil, mineral, crude, etc	"	3,996	362
Oil, refined	"	3,922	826
Ores—			
Antimony	tons.	....	....
Corundum	"	947	87,740
Iron	"	135,451	360,974
Manganese	"	30	750
Other ores	"	12,770	782,437
Phosphate	"	247	677
Plumbago	cwt.	18,375	50,528
Pyrites	tons.	89,909	377,985
Salt	cwt.	9,527	5,229
Sand and gravel	tons	952,370	802,358
Stone, ornamental	"	231	5,607
" building	"	63,009	46,198
" crushed	"	25,130	18,153
" for manufacture of grindstones	"	51	294
Other products of the mine		....	101,096
Total mine products		....	53,781,102
MANUFACTURES.			
Agricultural Implements—			
Mowing machines	No.	21,457	725,831
Cultivators	"	6,030	146,668
Reapers	"	3,919	223,228
Drills	"	3,961	259,701
Harvesters and binders	"	19,474	2,015,996
Ploughs	"	12,896	324,349
Harrows	"	6,252	92,556
Hay rakes	"	6,524	196,519
Seeders	"	32	1,810
Threshing machines	"	1,965	799,307
All other	$	....	290,520
Parts of	"	....	712,414
Asbestos, manufactures of	"	....	94,538
Bricks	M	1,486	11,871
Cement	$	....	2,223
Clay, manufactures of	"	....	26,866
Coke	tons	67,838	306,117
Drugs—			
Acetate of lime	lb.	16,052,255	282,146
Acid sulphuric	"	7,485,509	45,612
Calcium carbide	"	15,447,014	470,387
Phosphorus	"	610,350	92,303

Exports of Products of the Mine and Manufactures of Mine Products, Calendar Year, 1914—*Concluded.*

(Compiled from Trade and Navigation Monthly Statements.)

Products.		Quantity.	Value.
MANUFACTURES—*Concluded.*			$
Earthenware and all manufactures of	$		9,336
Fertilizers	"		2,390,494
Grindstones, manufactured	"		24,113
Gypsum and plaster ground	"		35,490
Iron and Steel and manufactures of—			
Stoves	No.	4,198	25,149
Gas buoys and parts of	$		21,009
Castings, n.o.p.	"		24,218
Pig-iron	tons.	14,198	201,145
Ferro-Silicon and Ferro-Compounds	"	4,865	285,221
Wire and wire nails	cwt.	193,255	355,781
Linotype machines and parts of	$		5,562
Machinery, n.o.p.	"		344,689
Sewing machines	No.	2,109	31,392
Washing machines	$		33,986
Typewriters	No.	3,055	200,441
Scrap iron and steel	cwt.	708,107	446,337
Hardware, viz.: tools, etc	$		95,497
" n.op.	"		190,763
All other, n.o.p.	"		2,931,908
Lime	"		16,927
Metals—			
Aluminium, in bars, etc	cwt.	145,108	2,364,907
" manufactures of	$		5,571
Brass, old and scrap	cwt.	21,209	196,710
Copper, old and scrap	"	19,871	231,710
Metallic shingles, etc	$		105,663
Metals, n.o.p.	"		393,829
Mineral and aerated water (in bottles)	"		1,768
Oil, gasoline and naphtha	gal.	43,023	11,607
" n.o.p.	"	455,867	104,179
Plumbago, manufactures of	$		72,718
Stone, ornamental	"		1,752
" building	"		370
Tar	"		36,719
Tin, manufactures of	"		24,531
Vehicles—			
Automobiles	No.	5,621	3,011,327
" parts	$		384,428
Bicycles	No.	111	10 021
" parts	$		3,973
Total manufactures			21,752,203
Grand total			75,533,305

APPENDIX

(*Reprint.*)

4-5 GEORGE V.

CHAP. 31.

An Act to regulate the Manufacture, Testing, Storage and Importation of Explosives.

[*Assented to 12th June, 1914.*]

HIS Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

SHORT TITLE.

1. This Act may be cited as *The Explosives Act*. Short title.

INTERPRETATION.

2. In this Act, unless the context otherwise requires,— Definitions.

(*a*) "Department" means the Department of Mines; "Department."

(*b*) "Minister" means the Minister or Acting Minister of Mines; or such Minister as the Governor in Council may designate to administer this Act; "Minister."

(*c*) "authorized explosive" means any explosive the manufacture or importation of which has been authorized under this Act; "Authorized explosive."

(*d*) "explosive" means gunpowder, blasting powder, nitroglycerine, gun cotton, dynamite, blasting gelatine, gelignite, fulminates of mercury, or other metals, coloured fires, and every other substance whether chemical compound or mechanical mixture, used or manufactured with a view to produce a violent effect by explosion, or a pyrotechnic effect, and includes fire works, fuses, rockets, percussion caps, detonators, cartridges, ammunition of all descriptions, fog and other signals, and every other adaption or preparation of an explosive as above defined; "Explosive."

"Factory." (*e*) "factory" means and includes any building, structure or premises in which the manufacture, or any part of the process of manufacture of an explosive, is carried on, and any building or place where any ingredient of an explosive is stored during the process of manufacture;

"Inspector." (*f*) "inspector" means and includes the chief inspector of explosives, an inspector of explosives, a deputy inspector of explosives, and any other person who is directed by the Minister to inspect an explosive or explosive factory or magazine, or to hold an inquiry in connection with any accident caused by an explosive;

"Magazine." (*g*) "magazine" means and includes any building, storehouse, structure or place in which any explosive is kept or stored, other than at or in and for the use of a mine or quarry in a province in which provision is made by the law of such province for the efficient inspection of mines and quarries and explosives used in connection therewith; but does not include the place in which an authorized explosive is kept for the purposes of conveyance when the same is being conveyed or kept in accordance with the provisions of this Act, nor the structure or place in which is kept for private use, and not for sale, an authorized explosive to an amount not exceeding that allowed by regulation under this Act, nor any store or warehouse containing authorized explosives to an amount not exceeding that allowed by regulation under this Act or authorized by any provincial or local authority;

"Operator." (*h*) "operator" means any person who operates a factory for manufacturing explosives, or is the manager of or in charge of such factory, or who is the occupant of or uses a magazine for the storage of explosives;

"Regulations." (*i*) "regulations" means any regulations made by the Governor in Council under the authority of this Act;

"Safety cartridges." (*j*) "safety cartridges" means cartridges for guns, rifles, pistols, revolvers and other small arms, of which the case can be extracted from the small arm after firing, and which are so closed as to prevent any explosion in one cartridge being communicated to other cartridges.

Departments exempted. **3.** This Act shall not apply to the Department of Militia and Defence or the Department of the Naval Service.

IMPORTATION, MANUFACTURE AND USE.

Explosives prohibited unless authorized. **4.** Except as herein provided, no person shall have in his possession, or import, store, use or manufacture, whether wholly or in part, or sell, any explosive unless such explosive has been declared by the Minister to be an authorized explosive.

5. Nothing in this Act shall apply to the making of a small quantity of explosive for the purpose of chemical experiment, and not for practical use or sale. Small quantities excepted.

6. Except in so far as may be permitted by regulations made under this Act, no person, except in licensed manufacturing factories, shall carry on any of the following processes, namely:—of dividing into its component parts, or otherwise breaking up or unmaking, any explosive; of making fit for use any damaged explosive; or of remaking, altering or repairing any explosive: Provided that this section shall not apply to the process of thawing explosives containing nitro-glycerine, if a proper apparatus or thawing-house is used in accordance with regulations made under this Act or any Provincial law. Certain process prohibited.

LICENSES AND PERMITS.

7. The Minister may issue licenses for factories and magazines, and no one shall manufacture, either wholly or in part, or store explosives except in licensed factories and magazines. Licenses

2. Notwithstanding any provisions contained in this Act the Governor in Council, upon the recommendation of the Minister, based upon the report in writing of the deputy minister, accompanied by certificates from the chief inspector and chief chemist of explosives approving of the nature of the components and of the final explosive product, may allow the inexplosive component parts of an authorized explosive from licensed factories and magazines to be assembled and blended at or near the point of use, and such place of blending shall not be deemed a factory or magazine within the meaning of this Act. Blending of explosives.

8. The Minister may issue permits for the importation of authorized explosives, and no one shall import any explosive into Canada, other than safety cartridges, without such permit: Provided, however, that nothing in this section shall prevent any explosive from being transported through Canada by railway in bond, if such transportation is made in a manner authorized by the *Railway Act* or any regulation or order made thereunder. Permits for importation. Transport in bond.

9. The Minister may, on application, and on payment of the prescribed fees, issue a special permit to import, for the purpose of chemical analysis or scientific research, an amount not exceeding two pounds of any explosive specified in such permit. Special permits.

10.

Application for license.

10. Applications for factory or magazine licenses shall be made in such form and manner as are prescribed by regulation, and the application shall be accompanied by,—

Plan of factory and premises.

(*a*) a plan, drawn to scale, of the proposed factory or magazine and of the land on which such factory or magazine is situated, and also of the lands adjacent thereto on which buildings are erected, with the uses to which such lands and buildings are now put. Such plan to have the exact distances between the several buildings marked thereon;

Description.

(*b*) a description of the situation, character and construction of all buildings and works connected with the factory or magazine, and the maximum amount of explosive to be kept in each building;

Statement of employees.

(*c*) a statement of the maximum number of persons to be employed in each building in the factory or magazine;

Required information.

(*d*) any information or evidence which the Minister may require;

Statement of maximum amount and ingredients.

(*e*) in the case of an application for a factory license, a statement of the maximum amount of explosive, and of ingredients thereof wholly or partially mixed, to be allowed at any one time in any building, machine, or process of the manufacture, or within the distance from such buildings or machine which is limited by regulation;

Statement of processes and position of explosives.

(*f*) a statement of the nature of the processes to be carried on in the factory and in each part thereof, and the place at which each process of the manufacture, and each description of work connected with the factory is to be carried on, and the places in the factory at which explosives and anything liable to spontaneous ignition, or inflammable or otherwise dangerous, are to be kept.

Permits for experiments, and testing new explosives.

11. The Minister may, on application and on payment of such fees as are prescribed by regulation, issue a permit to manufacture for experimental or testing purposes only, and not for sale, any new explosive, upon such conditions and subject to such restrictions as are fixed by the Minister.

Permit for alteration or addition to factory.

12. The owner or operator of a factory or magazine shall not make any material alteration or addition to a licensed factory or magazine, or rebuild any part thereof, until he has obtained a permit from the Minister; and before such permit may be granted he shall submit such plans and other information and evidence as the Minister may require.

Change of owner or occupier.

13. A factory or magazine license shall not be affected by any change in the persons who own or operate the factory or magazine; but notice of such change with the

the address and calling of the new owner or operator shall be sent to the Minister by the former owner forthwith, and by the new owner within one month after such change, and in default thereof each such owner or operator shall be liable to a penalty not exceeding one hundred dollars for each week during which such default continues, and if the occupier is not himself the owner he shall also be liable to the same penalty.

Notice to Minister.

Penalty.

14. In the case of a factory now in operation or a magazine now in existence, no license shall be required until the first day of January, one thousand nine hundred and sixteen: Provided, however, that if the owner or operator of such factory or magazine desires to make any material alteration in or addition to such factory or magazine, or to rebuild the same or any part thereof, he shall comply with the provisions of section 12 of this Act.

License for factory now in operation.

Proviso.

2. The owner or operator of any such factory or magazine shall, within three months after the passing of this Act, make application to the Minister for a continuing certificate, stating in such application his name and address and the situation of the factory or magazine, and shall supply such particulars and information respecting the same as the Minister may require; and the applicant shall thereupon be granted a continuing certificate in such form as may be prescribed by the Minister, and such factory or magazine shall thereupon be deemed to be duly authorized to manufacture and store explosives.

Application for continuing certificate.

Particulars.

3. Notwithstanding anything in this section, the Minister may require the owner or operator of any factory or magazine to stop using, or to use only under and subject to conditions to be specified by the Minister, any building, structure or premises which, from its situation or from the nature of the processes carried on therein, constitutes, in his opinion, a special danger.

Powers of Minister in case of special danger.

INSPECTORS.

15. The Governor in Council may appoint a chief inspector of explosives, one or more inspectors of explosives, one or more deputy inspectors of explosives, and one or more chemists of explosives.

Appointment of inspectors.

16. An inspector may, at any time, visit and inspect any factory, magazine and premises where any explosive is being manufactured or stored, or where he has reason to suspect any explosive is being manufactured or stored, and may open and examine any package that he may there find; and the owner and operator of such factory, magazine and

Powers of inspectors.

and premises shall afford such inspector every facility to make such inspection full and complete, and shall supply the inspector with any information that he may require, other than information relating to the cost of manufacturing an explosive.

May require samples.

2. An inspector may require the owner or operator of any factory or magazine, where any explosive is manufactured or stored, or any person employed in any such place, to give him such samples as he may require of any substance therein, whether in the state of raw material, material in course of manufacture, or manufactured material, which the inspector believes to be an explosive, or to be an ingredient from which an explosive may be manufactured.

May open packages.

3. An inspector may, at any time, open or cause to be opened any package or store of material of whatsoever nature, which he believes to contain explosives or ingredients for the manufacture of explosives.

INQUIRIES INTO ACCIDENTS.

Inquiry into accidents.

17. The Minister may direct an inquiry to be made whenever any accidental explosion of any explosive has occurred, or when any accident has been caused by an explosive, and the person authorized by the Minister to conduct such inquiry shall have all the powers and authority of a commissioner appointed under Part I of the *Inquiries Act.*

Exemption where covered by provincial legislation.

2. This section shall not apply, however, where an accident has been caused by an explosion of an explosive occurring in any mine or quarry or metallurgical work in any province in which provision is made by the law of such province for a proper and thorough investigation and inquiry into the cause of such accident.

REGULATIONS.

Regulations.

18. The Governor in Council may make regulations,—

Classify explosives.

(*a*) for classifying explosives, and for prescribing the composition, quality and character of explosives;

Licenses, permits, and certificates.

(*b*) prescribing the form and duration of licenses, permits and certificates issued under this Act, the terms and conditions upon which such licenses, permits and certificates shall be issued, and the fees to be paid therefor;

Importation, packing and transportation.

(*c*) for regulating the importation, packing and handling of explosives, and the transportation of explosives otherwise than by railway;

Inquiries into accidents.

(*d*) for inquiries into the accidental explosion of explosives, and any accident caused by explosives;

(*e*)

Samples. Testing.

(*e*) for the taking of samples of explosives required for examination and testing, and for the establishing of testing stations, and of the tests and other examinations to which explosives shall be subjected;

Authorized explosives.

(*f*) prescribing the manner in which an explosive shall be tested and examined before it is declared to be an authorized explosive, and for determining to what examinations and tests authorized explosives shall be subject;

Inspectors and officers.

(*g*) to be observed by inspectors and other officers and employees charged with any duty under this Act, or under any regulations made thereunder;

Factories.

(*h*) relating to the construction, and management and licensing of factories and magazines;

Safety of public and employees.

(*i*) for the safety of the public and of the employees at any factory or magazine, or any person engaged in the handling or packing of explosives, or the transportation of explosives otherwise than by railway;

Location and manufacture.

(*j*) governing the establishment, location and maintenance of factories and magazines, and the manufacture and storage of explosives;

Blending.

(*k*) for blending the inexplosive components of an authorized explosive;

Limiting amounts stored.

(*l*) limiting the amount of authorized explosives that may be kept in places other than licensed factories and magazines, and prescribing the manner in which it shall be handled and stored in such places;

Thawing.

(*m*) regarding the thawing of explosives;

Operation of Act.

(*n*) for the more effective carrying out of this Act.

Publication of regulations.

2. All regulations made under this Act shall be published in *The Canada Gazette*, and upon being so published they shall have the same force as if they formed part of this Act.

OFFENCES AND PENALTIES.

Obstruction of entry and examination by inspector.

19. Every person who fails to permit an inspector to enter upon any property, and to inspect, examine or make inquiries in pursuance of his duties, and every person who fails to comply with any order or direction of such inspector, in pursuance of the requirements of this Act or any regulation made thereunder, or who, in any manner whatsoever, obstructs such inspector in the execution of his duties under this Act, shall be liable to a penalty not exceeding five hundred dollars and costs, or to imprisonment for a term not exceeding six months or to both fine and imprisonment.

Penalty.

Manufacturer's objection to inspector's ruling.

2. Any owner or operator who takes exception to the ruling of an inspector, before such ruling or before the penalty provided for in subsection 1 of this section is enforced as the case may be, may have the facts upon which such ruling is based submitted to the Minister for his consideration and decision.

Reference to Minister.

20.

Trespassing upon premises.

Penalty.

20. Every person who enters without permission or lawful authority or otherwise trespasses upon any factory or magazine shall, for every offence, be liable to a penalty, not exceeding fifty dollars and costs, and may be forthwith removed from such factory or magazine by any constable or by any person employed at such factory or magazine.

Causing explosion or fire.

Penalty.

21. Every person who commits any act which is likely to cause an explosion or fire in or about any factory or magazine, shall be liable to a penalty not exceeding five hundred dollars and costs, or to imprisonment not exceeding six months, or to both such fine and imprisonment.

Possession, sale, manufacture or importation of unauthorized explosive.

Penalty.

22. Every person who, by himself or his agent, has in his possession, sells, offers for sale or manufactures or imports any unauthorized explosive within the meaning of this Act shall, for a first offence, be liable to a penalty not exceeding two hundred dollars and costs, or to imprisonment for a term not exceeding three months, or to both fine and imprisonment, and for each subsequent offence shall be liable to a penalty not exceeding five hundred dollars and costs and not less than fifty dollars and costs, or to imprisonment for a term not exceeding six months, or to both fine and imprisonment.

Contravention of Act.

Penalty.

23. Every person who violates any provision of this Act for which a penalty has not been provided, or any regulation made thereunder, shall, for the first offence, incur a penalty not exceeding two hundred dollars and costs, and for each subsequent offence a penalty not exceeding five hundred dollars and costs.

Disclosing confidential information.

Penalty.

24. Any official employed under this Act who without due authority from the Department discloses any confidential information shall on summary conviction be liable to a penalty not exceeding two hundred and fifty dollars or to imprisonment for a term not exceeding three months and shall not thereafter be eligible for employment in the service of His Majesty.

Recovery of penalties.

25. Every penalty and forfeiture may be recovered in a summary manner under the provisions of Part XV of the *Criminal Code.*

Provincial and municipal laws not affected.

26. Nothing in this Act shall relieve any person of the obligation to comply with the requirements of any license law, or other law or by-law of any province or municipality, lawfully enacted, with regard to the storage, handling, sale or other

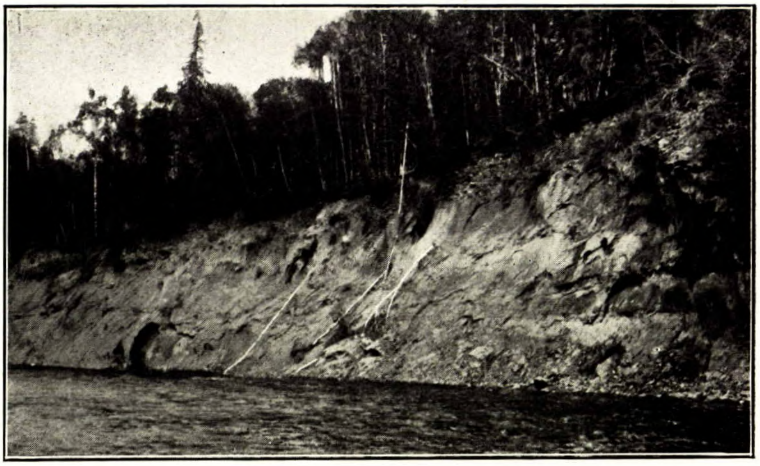
other dealing with explosives, nor of any liability or penalty imposed by such law or by-law for any violation thereof.

COMMENCEMENT OF ACT.

27. This Act shall come into force on a day to be fixed by proclamation of the Governor in Council. Commencement of Act.

INDEX

PLATE I.

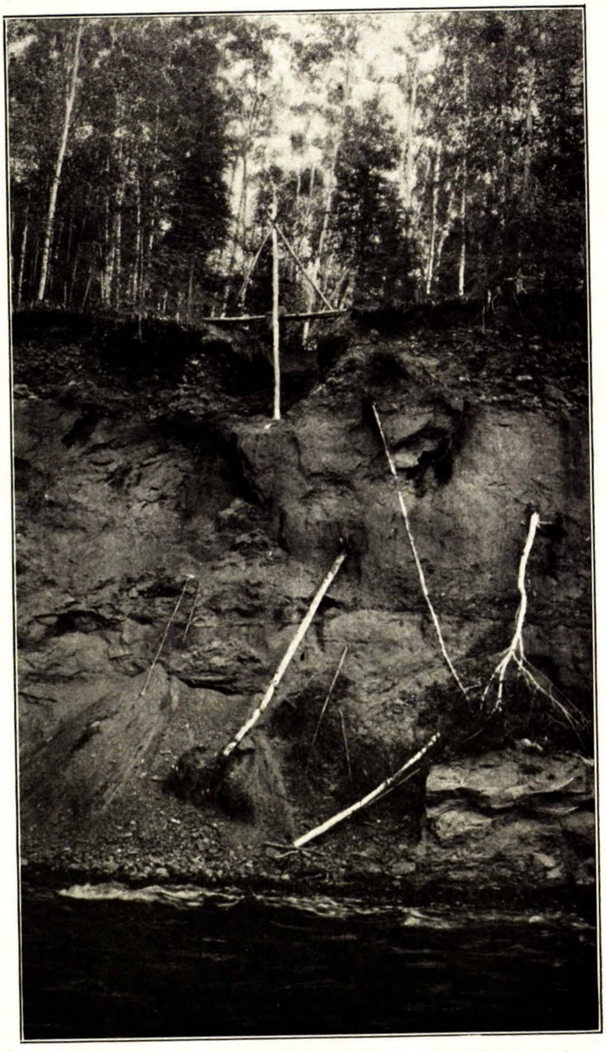


Typical outcrops of bituminous sand on Horse creek.

PLATE II.

Preliminary excavation of outcrop of bituminous sand on Horse creek.

PLATE III,

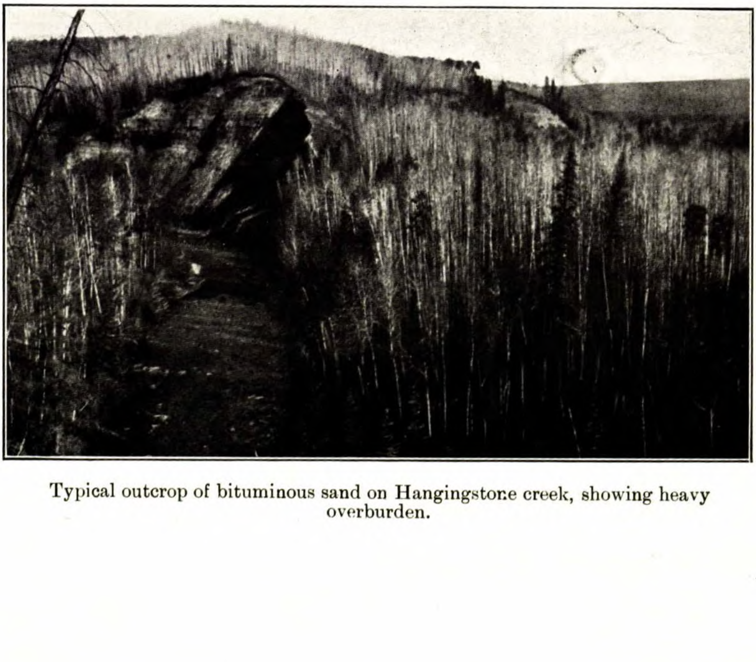


Typical massive structure of bituminous sand on Horse creek.

PLATE IV.

Outcrop of bituminous sand on Hangingstone creek, showing light overburden.

PLATE V.



Typical outcrop of bituminous sand on Hangingstone creek, showing heavy overburden.

PLATE VI.

Outcrop on Athabaska river, showing bituminous sand under light overburden.

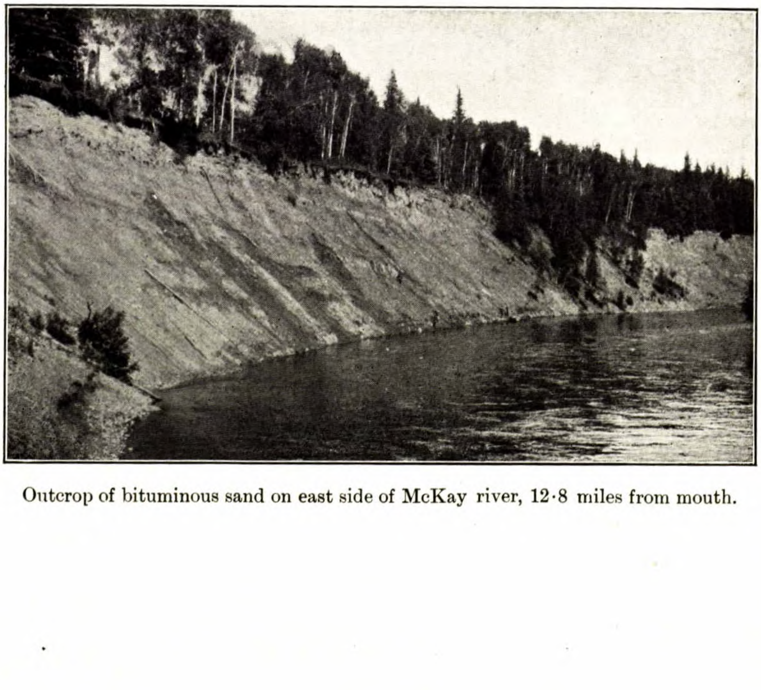
PLATE VII.

Typical outcrop on Horse creek, showing bituminous sand under light overburden.

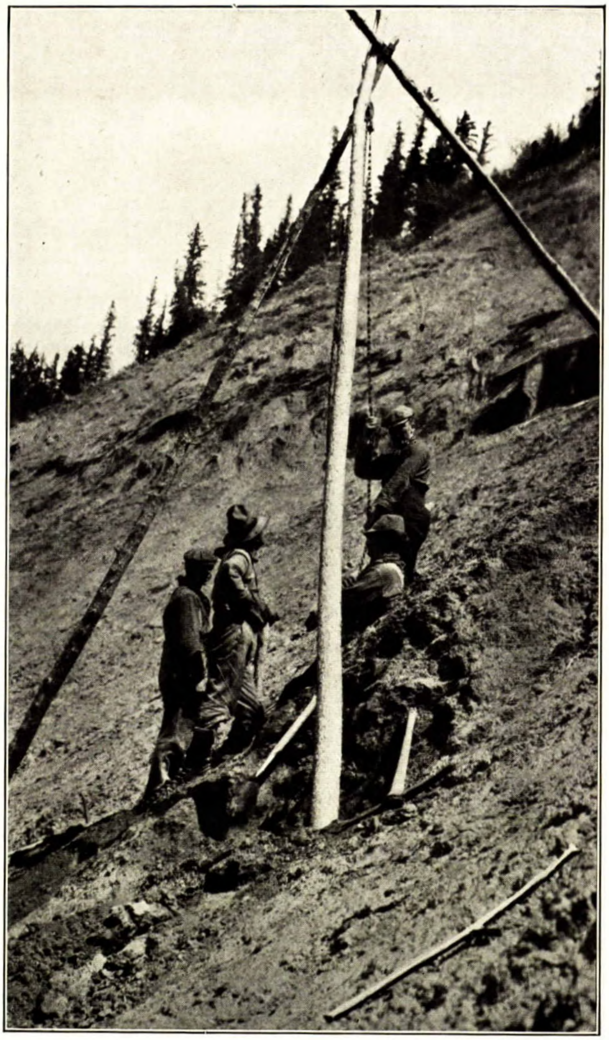
PLATE VIII.

Loading trial shipment of bituminous sand from point on east side Athabaska river, 5 miles below McKay.

PLATE IX.



Outcrop of bituminous sand on east side of McKay river, 12·8 miles from mouth.



Taking core samples of bituminous sand.

PLATE XI.

West side of Upper Narrows, Buffalo lake, Saskatchewan.

PLATE XII.

Typical outcrop of bituminous sand on west side of Horse creek, 2·3 miles from mouth.

622.19

Mines Branch Report
1914

DATE	ISSUED TO
~~21/6/72~~	~~D. Mansell~~
~~2/11/72~~	~~Mulligan~~

1160 LOWE MARTIN CO. LTD.

ERRATA:

On pages 93 and 96 for "Canmore Coal Co., Ltd., Canmore, Alberta," read, "Georgetown Collieries Ltd., Canmore, Alberta."

On page 7, line 17 from bottom of page, for "G" read, "B".

Mines Branch Report No. 331, on—
Results of the Investigation of Six Lignite Samples obtained from the Province of Alberta.

FRONTISPICE.

Source salée C, district de Winnipegosis, Manitoba.