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TECHNICAL REVIEW OF ORE DRESSING INVESTIGATIONS ON CANADIAN TITANIFEROUS ORES CONDUCTED AT CANMET FROM 1950 TO 1975

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MINERAL SCIENCES LABORATORIES REPORT, MRP/MSL 76-157 (IR)

TECHNICAL REVIEW OF ORE DRESSING INVESTIGATIONS ON CANADIAN TITANIFEROUS ORES CONDUCTED AT CANMET FROM 1950 to 1975*

by

D. Raicevic**

ABSTRACT

This report gives summaries of investigations related to the mineralogy and concentration of ores and sands from Canadian titaniferous deposits, conducted at the Mines Branch (presently CANMET) between 1950 and 1975. The mineralogy of each ore sample received and the mineral dressing methods applied for preparation of a separate iron concentrate, a separate titanium concentrate, or a combined iron-titanium concentrate suitable for production of iron and titania slag, are outlined in general terms. Only a summary of the results from each investigation is recorded because details of the mineralogy, the methods applied and the results obtained can be found in the individual reports of the original investigations.***

The possibility of bringing some of the more promising titaniferous deposits into production is also discussed.

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* Mineral Research Program, Processing Contribution No. 32

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*** Photostats of the original MD and IR Investigations can be obtained from CANMET Library at a nominal cost.

LABORATOIRES DES SCIENCES MINERALES MRP/MSL 76-157 (IR)

UNE REVUE TECHNIQUE DES RECHERCHES SUR LE TRAITEMENT DES MINERAIS TITANIFERES CANADIENS EFFECTUEES A CANMET ENTRE 1950 ET 1975

par

D. Raicevic*

RESUME

Ce rapport présente les sommaires d'études effectuées à la Direction des Mines (maintenant CANMET) entre 1950 et 1975, portant sur la minéralogie et la concentration de minerais et de sables provenant des gisements titanifères canadiens. On y donne un aperçu général de la minéralogie de chaque échantillon de minerai reçu et des méthodes de préparation de concentrés distincts de fer, titane ou fer-titane combiné, propre à la production de fer et de scorie de titane oxydé. Seuls les sommaires des résultats des différentes études sont rapportés, étant donné que la minéralogie, les méthodes de traitement et les résultats obtenus sont détaillés dans chacun des rapports originaux.

On invoque la possibilité d'amener à la production certains des gisements titanifères les plus prometteurs.

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INTRODUCTION

Titanium Minerals and their Uses

Titanium is a major constituent of about twenty minerals listed in the table below[1] along with their chemical composition, outstanding physical properties, nature of occurrence and abundance.

Mineral	Chemical composition	Physical properties	Nature of occurrence	Abundance
Rutile ilmeno-rutile strüverite	TiO_2;Ti 60%, Fe impurity as much as 10%, also V Ferriferous rutile with Nb, Ta	Hard, reddish brown crystals, tetragonal	In ilmenite, in veins, as accessory grains, and in placer deposits	Widespread but not abundant
Brookite	$TiO_2(Fe_2O_3.TiO_2)$; Ti 60%	Like rutile, but orthorhombic	Veins and placer deposits	Rare
Anatase (octahedrite)	TiO_2;Ti 60%	Like rutile but of secondary origin, tetragonal	In altered titanium-bearing rocks	Rare
Arizonite	$Fe_2O_3.3TiO_2$; Ti 36%	Hard, dark steel grey, brown streaks	With gadolinite in pegmatite, Mojave County, Arizona	Rare
Ilmenite ferrian ilmenite magneto-ilmemite hemo-ilmemite geikielite, högbomite, pyrophanite, senaite, silicoilmenite?	$FeTiO_3$; Ti 31.6%, Fe 36.8%; 6-13% Fe_2O_3 in solid solution Intergrowths of magnetite Ferrian ilmenite with intergrowths of titanhematite (Mg,Fe) TiO_3, with Al, Fe, Mn,Pb Si	Hard, black, weakly magnetic, will cling to magnet when powdered, rhombohedral	In massive vein-dykes and disseminations in anorthosite and gabbroic anorthosite; also in placers	Abundant
Perovskite niobian perovskite (Oka) and other multiple oxide minerals(brannerite, davidite, etc.)	$CaTiO_3$; Ti 35.3% 25-56.2% TiO_2; Ti 15-30%	Hard, cubic crystals perfect cleavage, isometric	In chlorite, talc, and serpentine rocks, and in alkaline rocks	Not abundant
Sphene (titanite)	$CaTiSiO_5$; Ti 24.5%	Hard, brownish wedge-shaped crystals, good cleavage, monoclinic	Common accessory mineral, also in pegmatite, alkaline rocks, and contact deposits	Not abundant
Ulvöspinel mogensite	$Fe_2TiO_4(2FeO.TiO_2)$; Fe 44%, Ti 16.8% Intergrowth of ulvöspinel in magnetite	Hard, dark, magnetic, isometric	Intergrown with titanomagnetite, forms solid-solution series	Rare
Pseudobrookite	Fe_2TiO_5; Ti 12%	Dark brown tabular crystals, streak ochre yellow	In lavas of Europe, as at Vesuvius, and in artificial melts	Rare
Titanomagnetite ilmeno-magnetite	$(FeTi_3O_4)$; Fe 40-71%, Ti 1-15%; Titanomagnetite with intergrowths of ilmenite or ferrian ilmenite	Hard, dark, strongly magnetic, isometric	Forms solid-solution series	Abundant
Titanhematite ilmeno-hematite	$(FeTi)_2O_3$;Ti 1-10%; Titanhematite with intergrowths of ferrian ilmenite or hemo-ilmenite	Hard, dark, weakly magnetic, rhomobohedral	Forms solid-solution series with ilmenite	Widespread but not abundant
Leucoxene brown creamy white	A mixture of rutile, hematite and pseudobrookite, etc. A mixture of sphene (titanite) altered feldspar, etc.	Hard, dark films Soft, creamy films	Alteration products and coatings on titanium-bearing ores and sands Alteration products and coatings on titanium-bearing rocks	Widespread but not abundant

The main economic titanium-bearing minerals are rutile (TiO_2) and ilmenite ($FeO.TiO_2$). Rutile is the major source for production of titanium metal, often called 'wonder metal' because of its high strength-to-weight ratio and high resistance to corrosion. Ilmenite, which is more abundant than rutile, has been used mainly for production of titania slag and TiO_2 pigment.

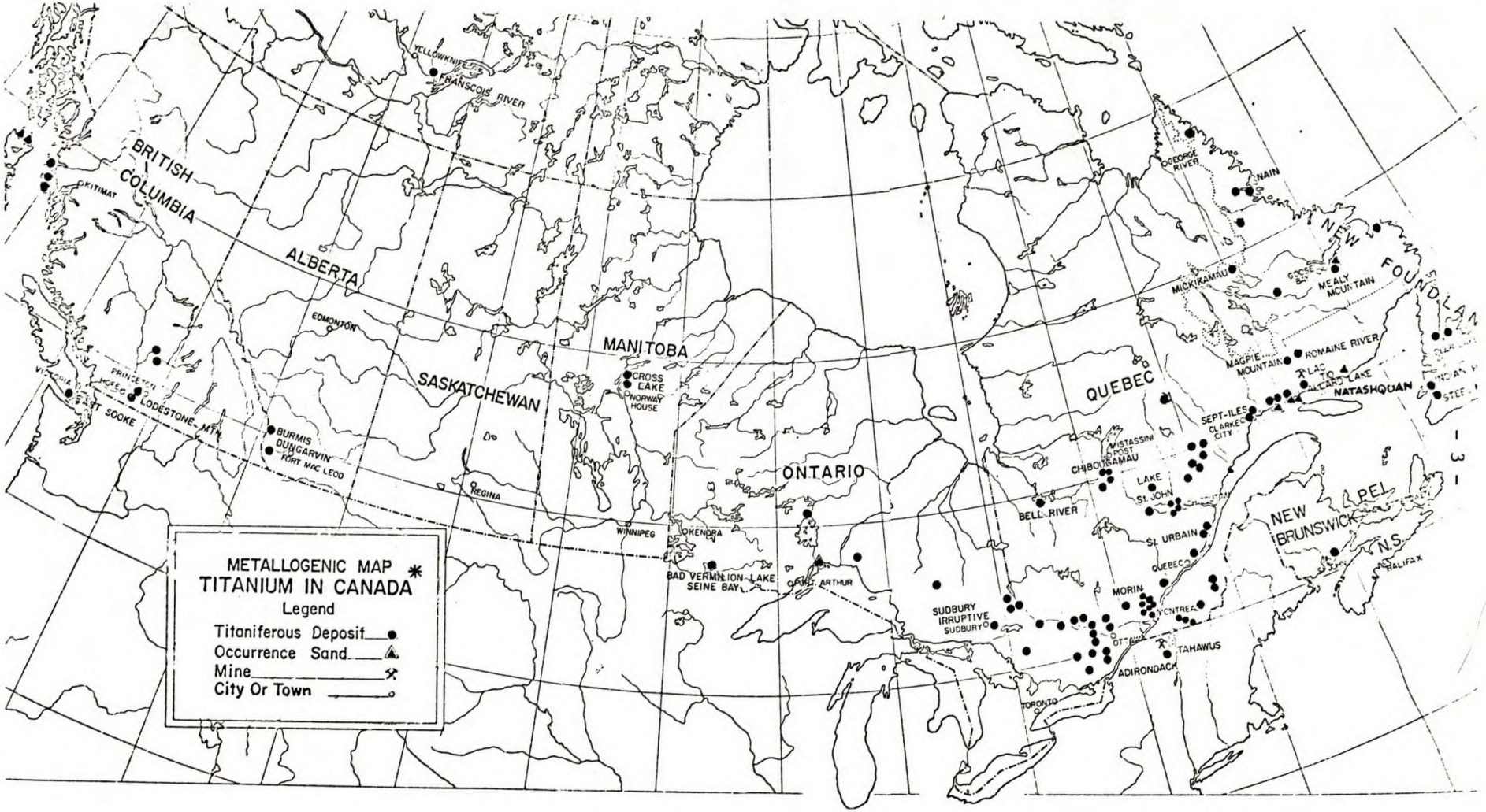
For an economic pigment-manufacturing bisulphate process which is the main process presently used in Canada, pigment manufacturers require a titania slag containing between 70 and 72% TiO_2. To produce a titania slag of this grade or higher, it is essential to have a furnace feed in which the TiO_2/gangue ratio is in excess of 4:1. The gangue = SiO_2 + Al_2O_3 + MgO + CaO. It is also important for the pigment producers that impurities such as phosphorus, sulphur, iron and particularly chromium and vanadium, be as low as possible. Iron content in the furnace feed is not of particular concern in the production of titania slag.

Titanium Occurrence in Canadian Deposits

Canada has enormous resources of titanium-bearing ores and titanium-bearing sands (map). In both, ilmenite is the only titanium-bearing mineral of economic interest as little or no rutile is present. Canada's reserves of medium-grade titanium-bearing ores containing 35% TiO_2 are measurable in hundreds of millions of tons, while low-grade deposits are available in billions of tons. Together these deposits form an immeasurable source of iron and titanium of great potential value to the economy and industrial importance of the country(1). In most deposits, the ilmenite is accompanied by hematite (Fe_2O_3) and/or magnetite (Fe_3O_4) and by various impurities all adversely affecting the titanium grade.

Major characteristics of the Canadian titaniferous deposits, can therefore, in general, be summarized as follows:

(1) low titanium grade,



* Detailed map "Titanium in Canada" (MP 1243A) was issued in 1968 by the Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa.

(2) fine intergrowth of hematite and magnetite with ilmenite, making separation of these minerals difficult and often impossible,

(3) relatively large amounts of impurities such as gangue, sulphur, phosphorus, chromium, vanadium, etc., some of them very difficult to reject or recover.

As a result, all Canadian titaniferous ores and sands must be upgraded to meet specifications of the pyrometallurgical and hydrometallurgical processes for production of iron, titania slag and TiO_2 pigment.

Mines Branch Investigations

Ores and sands from the Canadian titaniferous deposits were upgraded by rejecting as much gangue and other impurities as possible by applying:

- gravity concentration (jigging, spiraling, tabling, etc.)
- low and high intensity magnetic separation
- flotation.

In early investigations, most of the companies requested separate iron (magnetite and/or hematite) and ilmenite concentrates. In some cases, an iron concentrate alone was requested, ignoring the ilmenite.

In later investigations, research was mainly directed towards obtaining a suitable combined ilmenite-iron concentrate rather than separate concentrates.

Objective and Outline of the Report

The objective of this report is to summarize and evaluate each ore dressing investigation carried out at the former Mines Branch between 1950 and 1975 on titanium-bearing samples of Canadian titaniferous deposits. Each summary contains the following points of investigation:

- Number and title of investigation,

- Estimated tonnage of the area,
- Mineralogy and analysis of the ore sample tested,
- Purpose of the investigation,
- Methods of concentration,
- Summary of results and conclusions.

A reference regarding other types of investigations such as pyrometallurgical, hydrometallurgical or others, done on the ores and/or products from the deposits, are recorded in this report but not summarized.

The summaries of investigations are grouped by the political provinces.

Through information on mineralogy of the deposits and their amenability to beneficiation, this report will be of help for resource evaluation. It will also indicate areas where new or improved methods of beneficiation would be required to help bring some of the more promising deposits into production.

SUMMARY OF MINERALOGY AND CONCENTRATION RESULTS

Mineralogy

Canada has an enormous resource of titanium-bearing ores and some sands in which ilmenite ($FeO.TiO_2$) is the titanium-bearing mineral of economic interest. Ilmenite in these deposits is always accompanied by the iron-bearing minerals, magnetite (Fe_3O_4) and/or hematite (Fe_2O_3), which are considered of secondary economic interest. In most cases, a relatively large amount of impurities is also present. As a result, the Canadian titaniferous ores and sands have a low titanium grade and cannot be utilized in their natural state. The valuable minerals present must therefore be concentrated and the concentrates processed.

The ilmenite in most deposits is finely intergrown with magnetite and hematite, making it difficult and often impossible, to make a separation so that preparation of a combined iron-titanium concentrate is usually necessary.

Concentration Results

A. The only titaniferous ore deposit from which iron and titanium are being recovered on a commercial scale is that of the Allard Lake area in Quebec. Proven reserves of this deposit in 1970 was about 350,000,000 tons averaging 36% Fe and 32% TiO_2.

The average assay of the portion of the deposit owned by the Quebec Iron and Titanium Corporation (QIT) of Sorel (Tracy), Quebec, is 40% Fe and 34.5% TiO_2. The gangue content is about 11% and consists of MgO + Al_2O_3 + SiO_2 + CaO. A typical ilmenite-hematite concentrate, which is actually slightly upgraded ore, assays about 41% Fe and 35% TiO_2 with a gangue content of about 6.3%. The TiO_2/gangue ratio in the concentrate is therefore about 4.6:1. The iron and titanium recoveries in the concentrate are about 95% each.

The ilmenite-hematite concentrate is kiln-roasted to reduce sulphur content and then electrically smelted to produce pig iron and titania slag containing 71% TiO_2. QIT is the only producer of titania slag in Canada.

B. A potential magnetite-ilmenite ore deposit, presently not exploited, is in the Temagami area of Ontario, with estimated reserves of 140,000,000 tons. It contains 38.5% Fe, 18.7% TiO_2, 14.3% gangue and small amounts of sulphur and phosphorus.

The combined magnetite-ilmenite concentrates produced from this deposit assayed from 47% to 48.7% Fe and 21.2% to 21.6% TiO_2 with gangue ratios from 4:1 to 7:1. These tests were described in Mines Branch Investigation Report IR 69-32, March 1969. The iron recovery in the concentrates ranged between 82% and 89% Fe, while titanium recovery ranged between 77% and 85% TiO_2.

Based on operation of the QIT plant, titania slags of 70% to 85% TiO_2 can be produced from the above concentrates respectively with the pig iron of similar quality to that of QIT.

C. The pertinent results from less known but possibly worth-while deposits, presently unexploited, from which reasonable iron concentrates have been obtained, are recorded in the following table:

Investigation Number	Ore Deposit			Iron Concentrate				
	Location and tonnage	Assays %		Assays %			Dist'n %	Ratio of conc'n
		Fe	TiO_2	Fe	TiO_2	SiO_2	Fe	
IR 62-113 Nov. 28,1962	Bob's Lake, Ont. 50 million tons	41	0.37	68.9	0.24	0.72	89.1	2:1
IR 59-100 Dec.17,1959	Lanark area, Ont. "Large" tonnage	54 "	3.51 "	70.85 70.63	0.27 0.30	0.24 n.a.	68.8 91.6	2:1 1.5:1

D. Canada has two large deposits of titaniferous beach sands; the Natashquan River sands in Quebec, estimated at about 1,500,000,000 tons and the beach sands of Graham Island in British Columbia (Queen Charlotte Islands) "spread over 250 square miles". Both these deposits contain magnetite, hematite, ilmenite and zircon; the Graham Island deposit also contains some gold and platinum.

The concentration results from a large number of samples from these deposits are recorded in the following table:

Investigation Number	Sand Samples		Iron-Titanium Concentrate				
	Assays %		Assays %		Dist'n %		Ratio of conc'n
	Fe	TiO_2	Fe	TiO_2	Fe	TiO_2	
MD 3066, MD 3114 MD 3162, IR 59-40*	42.26	11.63	56.6	15.5	91.3	92.5	2.35:1
MD 3177 **	42.55 40.4	8.26 8.50	60.1 60.5	14.8 12.05	71.2 72.0	95.6 68.6	1.85:1 2.1:1

* Natashquan River ** Graham Island

As chromium, vanadium, phosphorus, sulphur and other impurities were not determined it could not be concluded if the concentrates were suitable for production of pig iron and titania slag by the electric smelting process.

Some gold and platinum values were also recovered from the samples of Graham Island.

CONCLUSIONS

1. Due to the fine intergrowth of ilmenite with the iron-bearing minerals in the deposits, a separate iron concentrate suitable for steel manufacturing, could not be produced because titanium content could not be lowered to the 0.1% TiO_2 required by the steel industry. If this specification remains, it seems unlikely that a separate iron concentrate, acceptable to the steel industry, can be produced from Canadian titaniferous deposits. As a result, exploitation of these deposits has to be directed towards concentrating the iron, titanium and other valuable minerals in a combined (bulk) concentrate and then recovering the individual metals by suitable processes.

2. A combined hematite-ilmenite concentrate is being produced on an operating scale by QIT at Sorel, Quebec, from a 350,000,000-ton titaniferous deposit at Allard Lake, Quebec. From this concentrate the company produces pig iron and titania slag, the latter used for manufacturing pigment.

3. A combined magnetite-ilmenite concentrate, suitable for production of pig iron and titania slag, was prepared at CANMET, the former Mines Branch, on a laboratory scale from a 140,000,000-ton titaniferous deposit located in the Temagami area, Ontario, owned by Titan Iron Mines Ltd., but no commercial operation has so far been realized.

4. If the present specification of 0.1% TiO_2 in iron concentrate, is increased to 0.3% TiO_2, and indications are that it will be, separate iron concentrates could be produced from some presently unexploited deposits in the Lanark and Leeds areas of Ontario.

5. The 22,000,000-ton ilmenite-hematite-rutile deposit of St. Urbain area in Quebec, the only one in Canada with an appreciable rutile content, also warrants further investigation: Efforts should be directed to prepare a bulk ilmenite-hematite-rutile concentrate suitable for pig iron and titania slag production rather than trying to produce separate concentrates as in earlier investigations.

6. It appears that concentration of magnetite and ilmenite as a bulk concentrate, or as separate concentrates, from a 260-square mile area of beach sands on Graham Island in the Queen Charlotte Islands in British Columbia and from 1,500,000,000 tons of sand along the Natashquan River in Quebec, deserve further investigation to improve the quality of concentrates and to find out if those concentrates could become a source of iron and titania slag.

APPENDIX

SUMMARY OF INVESTIGATIONS

Approximate location of deposits (●)
in Alberta

Investigation Report No. MD3034, May 10, 1954

MAGNETIC AND GRAVITY CONCENTRATION TESTS ON A SAMPLE OF IRON ORE FROM THE WEST CANADIAN COLLIERIES LIMITED, BLAIRMORE, ALBERTA

BY R. W. BRUCE.

Tonnage of the area:

Tonnage estimated by EMR in 1969 was 8,000,000. Diamond drilling indicated a potential of approximately 15,000,000 tons (Investigation Report No. MD3187).

Ore sample tested: About 70 lb of magnetite ore with some ilmenite and hematite.

Mineralogy: (Min Rep No. M-1461-E, Sept. 20, 1956)

Magnetite was the predominant mineral in the ore sample but small amounts of ilmenite and hematite were also visible with some ilmenite intergrown with magnetite.

Gangue consisted mainly of quartz scattered through massive granular magnetite and some fine-grained carbonate material.

Analysis: The ore assayed: 50.76% Fe, 7.20% TiO_2, 0.24% Mn, 0.23% P and 0.017% S.

Purpose of investigation: To determine if an iron concentrate suitable for steel production could be made from this ore.

Methods of concentration: Low-intensity magnetic separation and tabling.

Summary of results and conclusions: Magnetic and table concentrates produced from a minus 200-mesh grind were as follows:

Magnetic concentrate			Table concentrate	
Constituent	Assay %	Recovery %	Assay %	Recovery %
Fe	65.7	62.7	64.5	16.56
TiO_2	3.52	23.7	4.55	9.13
SiO_2	1.59		1.66	
Insol	4.44		5.84	

The iron (magnetite) concentrates obtained were not suitable for steel production due to high TiO_2 content and low iron recoveries.

Investigation Report No. MD3187, April 8, 1957

CONCENTRATION AND MAGNETIC ROASTING TESTS ON THREE SAMPLES OF IRON ORE FROM WEST CANADIAN COLLIERIES LIMITED, BLAIRMORE, ALBERTA

by R.W. BRUCE

Ore samples tested: Three samples together weighing 179 lb. containing magnetite, ilmenite and gangue.

Mineralogy: (Min Rep No. M-1461-E, Sept. 20, 1956)

Ore samples were composed of finely disseminated magnetite occurring in matrix of carbonates. The only other iron-bearing minerals identified in appreciable amounts were limonite, anatase, hematite, goethite and ilmenite.

The gangue minerals were quartz, calcite, dolomite and chlorite. No siderite was present and the calcite and dolomite proved to be almost completely iron-free. Since the amount of

chlorite, a hydrous iron-magnesium silicate, was very small, the only mineral which could account for high tailing losses from magnetic concentration was limonite.

Analysis: The three samples assayed:

Constituent	Percent		
	No.1	No.2	No.3
Total Fe	39.25	47.10	33.75
TiO_2	5.78	6.20	6.19
Mn	0.28	0.32	0.21
SiO_2	17.33	10.17	25.46
CaO	4.39	2.29	4.70
MgO	1.66	1.36	2.82
P	0.18	0.22	0.17
S	0.053	0.030	0.049
Al_2O_3	6.70	3.84	5.18
ZrO_2	0.10	0.24	0.12
V_2O_5	0.29	0.38	0.28
Insol	19.0	12.1	29.2
L.O.I.	7.20	7.06	5.09

Purpose of investigation: To obtain a magnetite concentrate with iron recovery higher than that given in Investigation Report No. MD3034.

Methods of concentration: Low-intensity magnetic concentration, tabling and roasting.

Summary of results and conclusions: Little or no improvement in the iron recovery was achieved by the methods applied, mainly due to the presence of limonite.

M.D. Test Report No. 913-OD, October 31, 1957

HEAVY-MEDIA SEPARATION TESTS ON A SAMPLE OF IRON ORE FROM WEST CANADIAN COLLIERIES LIMITED, BLAIRMORE, ALBERTA

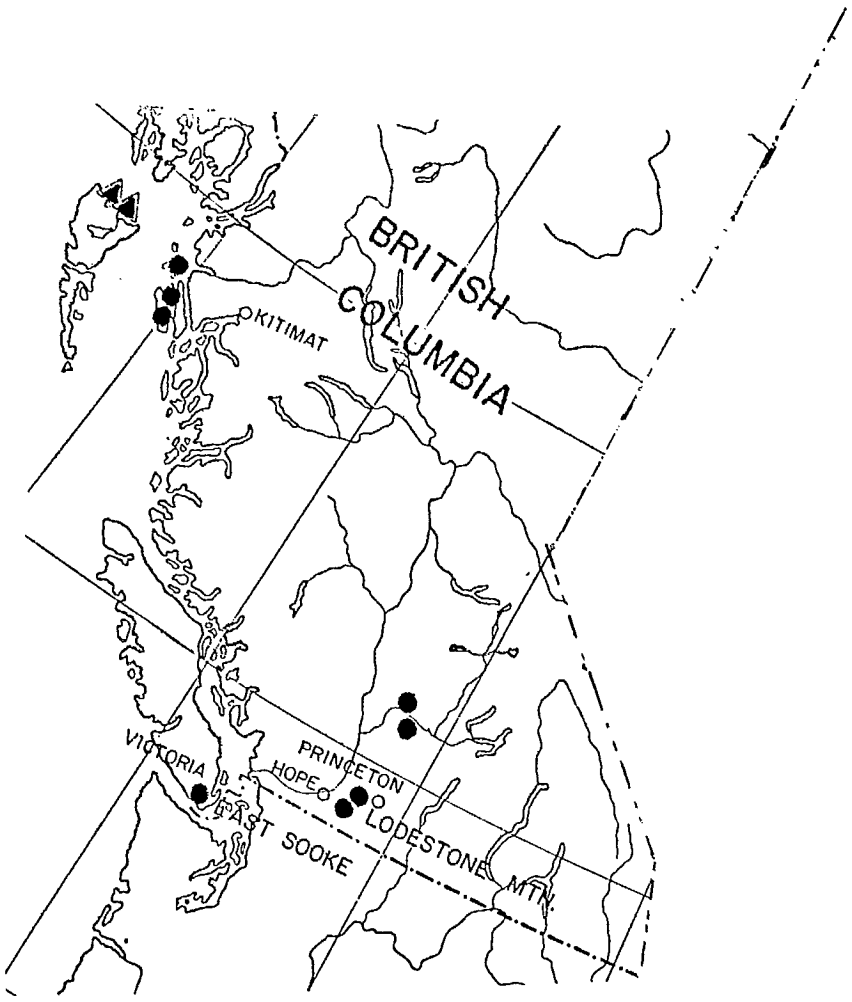
BY R. W. BRUCE.

Ore sample tested: About 286-lb composite sample from Investigation Report No. MD 3187.

Analysis: The following assays were obtained: 37.3% total Fe, 21.62% SiO_2, 6.09% TiO_2 and 46.07% magnetic iron (determined by Davis Tube separation).

Purpose of investigation: To determine if gangue, low in iron, could be rejected from the sample by means of heavy-media separation, and to compare the results of these tests with those of magnetic cobbing as described in Investigation Report MD 3187, April 8, 1957.

Summary of results and conclusions: The sink and float results were similar to those of magnetic cobbing. The heavy-media method was therefore not suitable for rejecting gangue material from the ore.



Approximate location of deposits (●)
in British Columbia

Mines Branch Investigation Report IR 63-37, February 6, 1963

INVESTIGATION OF IRON ORE FROM LODESTONE MOUNTAIN AREA, B. C.
SUBMITTED BY IMPERIAL METALS AND POWER LIMITED, N.P.L.,
VANCOUVER, B. C.
BY W. S. JENKINS

Tonnage: Tonnage estimated by EMR in 1966 was 260,000,000.

Ore sample tested: About 500-lb sample in five bags, of magnetite-ilmenite-gangue lumps.

Mineralogy: MB Investigation IR 62-114, December 8, 1962

The iron ore consisted of magnetite in a pyroxene-rich rock. The magnetite contained minute blebs and lamellae of ilmenite and possibly spinel, and some of the gangue minerals contained needle-shaped inclusions of magnetite.

The ilmenite occurred in magnetite as both irregular grains and tiny grains and lamellae. The tiny grains and lamellae ranged from nearly sub-microscopic sizes to blebs that were up to 3 microns in diameter and lamellae that ranged up to 3 microns in width and 50 microns in length.

Some of the gangue minerals contained fine needle-like magnetite inclusions. These minerals were therefore somewhat magnetic.

Analysis: 29.09% total Fe, 1.06% TiO_2, 0.022% P_2O_5, 0.067% S, 29.76% SiO_2, 11.48% CaO and 10.59% MgO.

Purpose of investigation: To determine grade and recovery of the iron concentrate.

Methods of concentration: Low-intensity magnetic separation (cobbing and upgrading after fine regrinding) and gravity concentration.

Summary of results and conclusions: The iron concentrate assayed 66.54% Fe, 2.22% TiO_2, 0.025% S and 1.44% SiO_2. Iron recovery from the ore was 83.8%. The high TiO_2 content makes this concentrate unacceptable to the steel industry.

Investigation Report No. MD3177, October 28, 1957

CONCENTRATION TESTS ON BEACH SANDS FROM GRAHAM ISLAND OF THE QUEEN CHARLOTTE ISLANDS GROUP, B.C., SUBMITTED BY THE MOGUL MINING CORPORATION, LIMITED, TORONTO, ONTARIO

BY W.S. JENKINS

Tonnage: The total reserves are said to be large in an area of 250 square miles, containing a large percentage of heavy minerals.

Sand samples tested: Three samples in two shipments of sand containing magnetite, ilmenite, rutile, zircon and gold.

Mineralogy: (Min Rep No. M-1496-E, Jan. 24, 1957)

Minerals and their percentage content in sands are given in the following table:

Mineral	% Weight in Shipment 1	% Weight in Shipment 2
Ilmenite and hematite	33.0	38.8
Garnet	26.0	15.0
Magnetite	18.8	23.9
Quartz (+ feldspar)	6.6	11.2
Altered silicates	6.5	3.6
Epidotes	4.2	2.0
Amphibole	2.6	Hornblende 3.0
Zircon	0.8	1.2
Staurolite	0.7	0.9
Titanite	0.5	0.3
Rutile	0.2	0.1
Gold	less than 0.1	-
	100.0	100.0

Considerable hematite and ilmenite are finely intergrown. The magnetite, on the other hand, is mostly free in the sands. Most of the gold is also free. Fe, TiO_2, Zr and Au values are contained in the minus 10 mesh portion of the sand.

Analysis: The following constituents were determined:

Sample	% Fe	% TiO_2
Cyanide tailing*	44.0	9.57
Shipment 1	42.55	8.26
Shipment 2	40.4	8.50

*The origin of the sample was not explained.

Purpose of investigation: To produce separate iron and titanium concentrates and to investigate the possibility of recovering gold and zircon from sands.

Methods of concentration: Gravity concentration, low- and high-intensity magnetic separation and electrostatic separation.

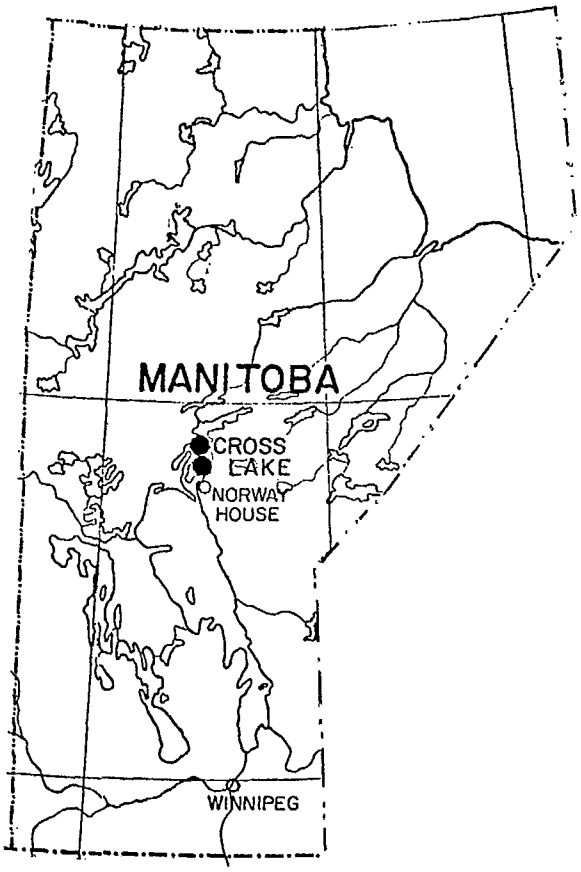
Summary of results and conclusions:

(a) Concentration of magnetite and ilmenite:

Product	Weight, per cent	Assays, per cent		Recovery, per cent		Ratio of concentration
		Fe	TiO_2	Fe	TiO_2	
Test No. 1 - Cyanide Tailing, Shipment No. 1						
Magnetite conc	19.4	70.1	1.18	30.9	2.4	5.2:1
Ilmenite conc	48.1	56.2	19.23	61.4	96.6	2.1:1
Test No. 7 - Sands of Shipment No. 1						
Magnetite conc	17.6	70.1	0.90	27.1	1.9	5.7:1
Ilmenite conc	36.4	55.2	21.48	44.1	93.7	2.7:1
Test No. 8 - Sands of Shipment No. 2						
Magnetite conc	22.1	69.35	1.85	38.0	4.8	4.5:1
Ilmenite conc	26.0	52.9	20.85	34.0	63.8	3.8:1

The gangue constituent (insol) was not determined as the objective of the investigation was the production of separate concentrates.

(b) Concentration of gold and zircon: All the gold seen in the various products was free. After concentration by jigging, it was recovered by amalgamation. Gold recovery was not reported. Zircon was recovered in gravity concentrates from non-magnetic tailings of several sand samples. The concentrates varied in grade from 50 to 59% ZrO_2 (pure zircon contains 67.2% ZrO_2). Although zircon recovery was not reported, it was expected to range between 70 and 75% of the zircon in the sands. The zircon concentrate assayed 3.5% hafnium (Hf).



Approximate location of deposits (●)
in Manitoba

Mines Branch Investigation Report IR 59-33, March 19, 1959

MAGNETIC CONCENTRATION OF TITANIFEROUS MAGNETITE ORE FROM A PROPERTY OF NORANDA MINES LIMITED, TORONTO, ONTARIO, AT CROSS LAKE, MANITOBA
BY W. S. JENKINS

Ore samples tested: Six small magnetite-ilmenite samples with a combined weight of 123 lb.

Mineralogy: (Min Rep No. M-1636-E, January 22, 1959)

Constituents present in order of abundance were magnetite, ilmenite and gangue with small amounts of hematite and a minor amount of sulphides, mainly pyrite and chalcopyrite. Considerable amounts of ilmenite and magnetite were finely intergrown.

Main gangue minerals in the sample were chlorite and amphibole scattered erratically through the metallic minerals as small inclusions and irregular masses.

The sulphide minerals were unevenly disseminated in gangue as well as in the other metallic minerals.

Analysis: The composite sample assayed: 49.4% Fe, 16.34% TiO_2, 0.87% V_2O_5, 0.09% S, 0.009% P, 5.46% SiO_2 and 15.36% Insol.

Purpose of investigation: (1) To determine grade and recovery of concentrates from the ore; (2) to determine if the deposit could be exploited economically by existing or new processes in which titanium-bearing concentrates could be used as smelter feed.

Methods of concentration: Dry and wet low- and high-intensity magnetic separation and tabling.

Summary of results and conslusions:

A minus 100-mesh magnetite concentrate had the following results:

Constituent	Assays	Recovery
Fe	62.7%	69.9%
TiO_2	5.22%	21.4%
V_2O_5	1.68%	77.0%
SiO_2	0.24%	-

A minus 100-mesh ilmenite concentrate assayed 47% TiO_2 with 30% TiO_2 recovery. High TiO_2 and V_2O_5 content in the magnetite concentrate and the low TiO_2 recovery in the ilmenite concentrate made these concentrates unsuitable for iron and TiO_2 production. It was recommended that vanadium recovery be investigated.

Mines Branch Investigation Report IR 60-81, December 30, 1960

CONCENTRATION OF TITANIFEROUS MAGNETITE ORE FROM CROSS LAKE, MANITOBA, FOR NORANDA MINES LIMITED

BY W. S. JENKINS

Ore sample tested: A 685-lb sample for pilot plant investigation.

Mineralogy: Same as in Investigation IR 59-33

Analysis: This pilot plant sample assayed: 33.1% of total Fe, 29.9% soluble Fe (by bisulphate fusion) 27.8% HCl soluble Fe, 21.76% SiO_2, 8.90% TiO_2, 1.05% V_2O_5, 0.15% S, trace P, <0.02% WO_3.

Purpose of pilot plant investigation: To investigate the separation of vanadium from the ore by pyrometallurgical methods. The Mineral Processing Division was asked to magnetically concentrate the ore and send the concentrate to the Extraction Metallurgy Division for the extraction investigation.

Method of concentration: Low-intensity magnetic separation.

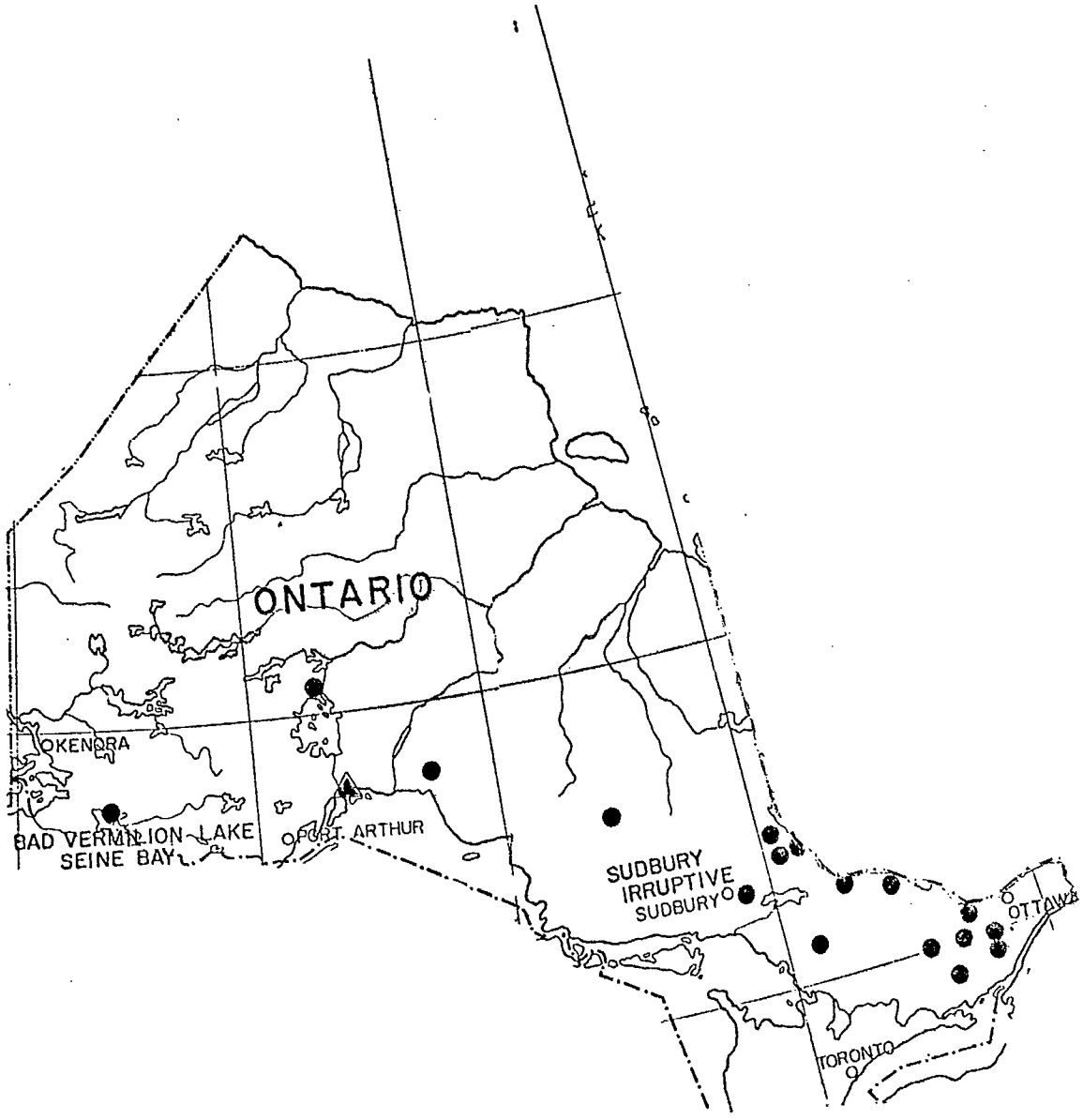
Summary of results and conclusions: The following iron (magnetite) concentrate was produced:

Constituent	Assays %	Recovery %
Fe	66.3	66.8
TiO_2	3.95	16.1
V_2O_5	1.74	95.2

Excellent vanadium recovery (95.2%) was obtained from this ore sample by pilot plant tests.

Other investigations conducted on this deposit by Mines Branch

M B Investigation IR 62-100, November 28, 1962, (Removal of vanadium from pilot plant ore concentrate by Extraction Metallurgy Division).



Approximate location of deposits (•)
in Ontario

Investigation Report No. MD2996, November 5, 1953

MAGNETIC CONCENTRATION OF AN IRON ORE FROM THE FARADAY TOWNSHIP PROPERTY OF TRENT RIVER IRON LIMITED, OTTAWA, ONTARIO

by W. S. JENKINS

Ore samples tested: Two ore samples weighing 20 lb and 80 lb, respectively.

Mineralogy: Sample No. 1 - Magnetite was the predominant ore mineral with lesser amounts of ilmenite, pyrrhotite, and possibly pentlandite. A considerable quantity of ilmenite occurred with the magnetite, but not as fine intimate graphic intergrowths. Grains of ilmenite substituted for grains of magnetite here and there and in a few places, were locally common. A small amount of pyrrhotite was visible in the polished sections as uneven disseminated particles whose average size was smaller than that of magnetite and ilmentite. Sample No. 2 - was taken from the same location as No. 1 so that no mineralogical examination of this sample was carried out.

Analysis:

Constituent	Sample No. 1	Sample No. 2
	Assay %	Assay %
Fe (soluble	27.98	11.7
Fe (total)	-	17.5
TiO_2	4.25	3.12
Insol (gangue)	54.00	74.3
SiO_2	28.30	36.9
S	-	0.8
P	-	0.01
Ni	-	N.D.
Co	-	N.D.

Purpose of investigation: To determine fineness of grind necessary to separate ilmenite from magnetite; to determine grade of concentrates and recovery of iron obtainable.

Methods of concentration: Low-intensity magnetic separation on grinds of minus 10, 20, 48, 100, 150 and 200 mesh. Flotation was applied to recover pyrrhotite to determine the amount of nickel contained.

Summary of results and conclusions: The minus 100-mesh grind gave the best results, as shown in the following table:

Magnetic Concentrates

Constituent	From Sample 1		From Sample 2	
	Assay %	Distn %	Assay %	Distn %
Fe	63.73	66.4	66.9	63.0
TiO_2	1.12	3.9	0.13	1.3
SiO_2	2.88		4.14	
S	0.74		2.47	
Insol	9.48		N. A.	
Ni & Co	Trace		N. D.	

A very low nickel content (0.132%) was present in the flotation (pyrrhotite) concentrate. No Ni or Co was found in Sample No. 2.

Investigation Report No. MD3103. June 4, 1956

CONCENTRATION TESTS ON A SAMPLE OF TITANIFEROUS MAGNETITE FROM A PROPERTY IN WOLLASTON TOWNSHIP, ONTARIO SUBMITTED BY MR. E. H. ISLAND, COLBORNE. ONTARIO

BY W. S. JENKINS

Ore sample tested: About 583 lb of magnetite-ilmenite-apatite ore.

Mineralogy: (Min Lab Report No. M-1419-E, November 5, 1955)

Gangue minerals predominated and consisted mostly of ferromagnesium silicates containing small scattered grains of apatite. Major metallic minerals were magnetite and ilmenite but a small quantity of sulphides (mostly pyrite, pyrrhotite and chalcopyrite) were also present.

Magnetite and ilmenite occurred as coarse to very fine isolated grains and small aggregations disseminated through gangue, with the coarser sizes predominant. These two minerals were usually associated as mixed granular masses and both contained occasional-to-rare small inclusions of gangue and sulphides. Although magnetite and ilmenite were often associated with each other, none was seen in the nine polished surfaces enclosed in the other as tiny eutectic intergrowths.

Analysis: 19.4% soluble Fe, 4.57% insoluble Fe, 6.86% TiO_2, 0.48% S, 4.16% P_2O_5, 26.68% SiO_2, 0.30% Mn.

Purpose of investigation: To determine the grades of magnetite, ilmenite and apatite concentrates that could be produced from the ore.

Methods of concentration: Low- and high-intensity magnetic separation, electrostatic separation, tabling and flotation.

Summary of results and conclusions: The best magnetite concentrate produced, after regrinding to minus 100 mesh, assayed 67.3% Fe, 0.97% TiO_2, and 0.15% P_2O_5. The iron recovery was 62.6%.

The ilmenite concentrates obtained by electrostatic separation assayed between 35 and 48% TiO_2 with 23-25% TiO_2 recovery. The ilmenite concentrate obtained by tabling assayed 38.8% TiO_2 with a 38.6% TiO_2 recovery.

The apatite concentrate produced by flotation assayed 40.4% P_2O_5, 0.66% TiO_2, 0.52% Fe. Recovery was 36.6% of P_2O_5 in the ore.

Mines Branch Investigation Report IR 59-100, December 17, 1959

MAGNETIC CONCENTRATION TESTS OF IRON ORE FROM LANARK COUNTY, ONTARIO, SUBMITTED BY W. K. STRONG

BY W. S. JENKINS

Ore sample tested: About 91½ lb of predominately magnetite ore with some ilmenite.

Mineralogy: (Internal Report MS-59-16, date not marked)

Magnetite was the most abundant mineral with minor amounts of ilmenite, hematite and a negligible amount of sulphides, mainly pyrite. The metallic minerals were mostly coarse grains without fine intergrowing.

Gangue material was a mixture of biotite, calcite and spinel in order of decreasing abundance. Gangue was more prevalent in the polished sections than in unmounted fragments. These minerals were distributed erratically through metallics as coarse to fine, smooth, rounded grains and small irregular particles.

Analysis: 53.98% total Fe, 52.08% soluble Fe, 15.48% insoluble, 6.28% SiO_2, 3.51% TiO_2, 0.070% P, 0.010% S.

Purpose of investigation: To produce a commercial grade iron concentrate.

Method of concentration: Low-intensity magnetic separation at various fineness of grinds.

Summary of results and conclusions: The iron concentrate produced at the minus 200-mesh grind and minus 325-mesh regrind, assayed 70.85% Fe, 0.27% TiO_2, 0.24 SiO_2 with 68.8% iron recovery.

The concentrate and middlings combined assayed 70.63% Fe, 0.30% TiO_2 with 91.6% iron recovery.

Mines Branch Investigation Report IR 58-158, September 16, 1958

CONCENTRATION TESTS ON A SAMPLE OF MAGNETITE ORE FROM NEWBORO, ONTARIO, SUBMITTED BY NEW MYLAMAQUE EXPLORATIONS LTD.

BY J. D. JOHNSTON

Tonnage: Tonnage estimated by EMR in 1969 was 53,000.

Ore sample tested: About 390 lb of magnetite-ilmenite ore.

Mineralogy: (Min Rep. No. M-1585-E, April 25, 1958)

Massive magnetite predominated with considerable ilmenite as fine inclusions as well as inclusions of gangue and some sulphides "to make it very doubtful that a satisfactory iron concentrate can be economically made by standard methods of treatment".

Gangue minerals occupied only a small portion of the ore and consisted chiefly of coarse-to-fine particles of pyroxene, plagioclase feldspar and chlorite scattered unevenly through the ore.

Analysis: 48.40% Fe, 11.50% TiO_2, 6.6% SiO_2, 3.09% S, 1.55% P, 3.82% MgO, 6.10% Al_2O_3.

Purpose of investigation: To produce a marketable iron concentrate (magnetite).

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: The best iron concentrate produced assayed 63.8% Fe, 6.27% TiO_2, 4.72% insol with 44.50% Fe recovery. Due to low Fe grade and recovery, and the high TiO_2 content, a marketable iron concentrate from this ore sample could not be produced.

Mines Branch Investigation Report IR 60-118, December 30, 1960

INVESTIGATION OF IRON ORE FROM NORTH CROSBY TOWNSHIP, LEEDS COUNTY, SUBMITTED BY W. H. STRONG, PERTH, ONTARIO

BY W. S. JENKINS

Ore sample tested: About 395 lb of large fragments of rock.

Mineralogy: (Internal Report MS-60-117, December 1, 1960)

Microscopic examination showed that the ore minerals present were magnetite, ilmenite, hematite and pyrite. Magnetite was most abundant but was associated with a considerable amount of ilmenite. These two minerals commonly formed mixed granular aggregates containing scattered particles of pyrite and gangue. In some places, however, ilmenite transected magnetite as narrow parallel lamellae and some grains of ilmenite contained numerous minute exsolved plates and blebs of hematite. Although magnetite and ilmenite occurred largely as moderately coarse granular masses, small proportions of them were disseminated through gangue in very fine particle sizes. Pyrite, the only sulphide observed in the sections, occurred as small irregular grains in gangue and in metallic oxides. While most particles of pyrite were between grains of magnetite and ilmenite, some appeared to be entirely within grains of these two minerals.

Amphibole, the only gangue mineral identified in the polished sections, is decidedly subordinate in quantity to the ore minerals. Coarse-to-fine particles of gangue are scattered erratically through the granular aggregates of magnetite and ilmenite, and, like those of pyrite, are both interstitial to, and entirely within grains of the two iron oxides .

Analysis: 47.2% total Fe, 44.5% HCl soluble Fe, 6.65% SiO_2, 11.21% TiO_2, 0.020% P, 1.48% S, 0.006% Cu.

Purpose of investigation: To determine the grind necessary to obtain a commercial grade of iron concentrate with rejection of

titanium dioxide to specifications; and to determine the recovery and grade of ilmenite from the tailing.

Methods of concentration: Low- and high-intensity magnetic separation and tabling.

Summary of results and conclusions: To obtain reasonable results it was necessary to grind the ore to minus 100 mesh.

The concentrates from ore ground to minus 48 mesh assayed 67.8% Fe and 0.66% Tio_2. The minus 65 mesh and minus 100 mesh grinds produced concentrates assaying 69.1% Fe, 0.29% TiO_2 and 69.7% Fe, 0.28% TiO_2, respectively, with no additional elimination of TiO_2 at finer grinds. The recoveries of iron were 69.9% at minus 48 mesh, 69.1% at minus 65 mesh and 66.4% at minus 100 mesh. The minus 100 mesh concentrate also contained 0.62% SiO_2, 0.144% S, and less than 0.005% P.

An ilmenite concentrate, assaying 35.65% TiO_2, was obtained by gravity concentration of minus 65 mesh tailing. The recovery of TiO_2 was 62.3%. This was reconcentrated to 41.46% titanium dioxide by a high-intensity dry magnetic separator.

Mines Branch Investigation Report IR 62-113, November 28, 1962

INVESTIGATION OF IRON ORE FROM FRONTENAC AND LEEDS COUNTIES, SUBMITTED BY W.H. STRONG, PERTH, ONTARIO

BY W. S. JENKINS

Tonnage: An area of about two square miles at Bob's Lake was surveyed by magnetometer and pits and trenches dug. Two anomalies were surveyed. One was about one mile long by a half mile wide and the other is smaller. The anomalies are estimated to contain about 50 million tons of iron ore.

Ore samples tested: Four ore samples of a total weight of 301 lb were investigated.

Mineralogy: No mineralogical examination was carried out on any of the four samples.

Analysis of the Head Samples

Sample	Weight lb	Sol Fe %	TiO_2 %	P_2O_5%	S %
Black Lake	75	44.75	0.56	<0.02	0.69
Bob's Lake	41	40.81	0.37	<0.01	0.072
Aaron's Lake	74	63.19	0.88	<0.02	0.28
Troy Lake	116	33.18	7.31	3.12	0.84

Purpose of investigation: To determine the amount of iron and titanium in the four samples and to run magnetic separation tests on each head sample by the Davis tube separator. The main investigation was to be made on the Bob's Lake sample to ascertain the grade and recovery of iron and the amounts of titanium dioxide in the concentrates by various grinds.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: Cobbing at minus 20 mesh, regrinding of the concentrate to minus 150 mesh and reconcentration produced an iron concentrate assaying 69.8% Fe, 0.24% TiO_2, 0.72% SiO_2, 0.002% P_2O_5, 0.010% S, <0.001% Cr_2O_3, 0.02% V_2O_5, 0.003% Cu, 0.07% Mn. The iron recovery was 89.1% Fe at a 2:1 ratio of concentration.

M. D. Test Report No. 773-OD, November 16, 1955

DIFFERENTIAL MAGNETIC CONCENTRATION TESTS TO REDUCE THE TITANIUM CONTENT OF A SAMPLE OF MAGNETITE ORE FROM AIRY TOWNSHIP, ONTARIO, SUBMITTED BY W. W. DAVIS, 69 SPARKS STREET, OTTAWA, ONTARIO

BY J.D. JOHNSTON

Ore sample tested: About 35 pounds of magnetite-ilmenite ore.

Mineralogy: Magnetite was the main constituent while gangue and ilmenite were minor constituents. A small quantity of hematite was visible as minute inclusions in both magnetite and ilmenite.

Magnetite was present in massive form and mostly in coarse grains, some containing inclusions of gangue minerals but no fine inclusions of ilmenite were observed by the mineralogical examination.

Gangue was represented largely by mica and zircon both unevenly scattered through the metallic minerals.

Analysis: 63.55% Fe, 5.82% TiO_2, 0.46% SiO_2, 0.35% Mn, trace S, trace P.

Purpose of investigation: To determine whether or not a magnetite concentrate could be produced that would contain 1% or less of titanium dioxide.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: With the ore crushed through 20 mesh it has not been possible to reduce the titanium dioxide content below 1.5%. However, when the ore was ground to minus 100 mesh the titanium dioxide content was reduced to 0.72%.

The iron concentrate assayed 70.3% Fe with 75.0% Fe recovery.

M. D. Test Report No. 683-OD, November 17, 1954

MAGNETIC CONCENTRATION TESTS ON A SAMPLE OF IRON SANDS FROM MARATHON, ONTARIO, SUBMITTED BY D. W. TULLY, DOBIE, ONTARIO
BY W.S. JENKINS

Sand sample tested: About 16½ lb of sand.

Mineralogy: Major metallic mineral was magnetite, but some hematite and a small amount of ilmenite and sulphides were also present.

Analysis: 48.25% Fe, 12% SiO_2 and 26% Insol. No TiO_2 was determined.

Purpose of investigation: To determine the response of the sand to magnetic concentration, the grade of concentrate and any undesirable constituents in the concentrate.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: The iron concentrate produced assayed 68.35% Fe, 2.08% TiO_2 etc., with a recovery of 77.7% of the Fe in the sand.

Due to high TiO_2 content, the iron concentrate produced was not suitable for steel production.

Mines Branch Investigation Report IR 60-104, November 24, 1960

MAGNETIC CONCENTRATION OF VANADIUM-BEARING TITANIFEROUS MAGNETITE FROM PROSPECTORS AIRWAYS COMPANY, LIMITED, IN PAPINEAU TOWNSHIP, ONTARIO

BY W. S. JENKINS

Ore samples tested: Two drill-core samples designated as Sample 180 and 181 of about 5½ and 11 lb, respectively, were investigated.

Mineralogy: (Internal Report MS-60-107, November 8, 1960)

Mineralogy of both samples was similar. Magnetite and ilmenite were the major metallic minerals. The magnetite was relatively pure, but the ilmenite contained roughly 12 to 16% hematite. The ratio of magnetite to ilmenite in the ore was fairly constant, and was estimated at 1.6:1 and 1.9:1 for Samples 181 and 180, respectively,

The vanadium occurred in both magnetite and ilmenite, but spectrochemical analysis indicated it showed a slight preference for magneite. Spectrochemical analysis indicated that the magnetite contained around 1% vanadium accounting for approximately 65% of the vanadium in the head sample.

Analysis:

	Sample 180	Sample 181
Total Fe	- 32.85%	42.0 %
TiO_2	- 8.28%	10.55%
V_2O_5	- 0.41%	0.63%
S	- 0.91%	0.30%
P	- None detected	None detected

Purpose of investigation: To determine grade and recovery in concentrates, and to determine if the deposit could be exploited economically by present or new processes in which titanium-bearing concentrates could be used as smelter feed.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions:

Results of Magnetic Concentration of -100 Mesh Ore by the Jeffrey-Steffensen 3-drum Separator

Test No. 3; Feed -100 mesh, Ore Sample 180

Product	Weight %	Analysis %			Distribution %			Ratio of concentration
		Fe	TiO_2	V_2O_5	Fe	TiO_2	V_2O_5	
Feed*	100.0	32.9	8.43	0.48	100.0	100.0	100.0	
Conc	24.2	68.1	0.14	1.45	50.1	0.4	73.7	4.0:1
Midds	2.8	52.15	3.00	1.05	4.5	1.0	6.3	
Tailing	73.0	20.5	11.4	0.13	45.4	98.6	20.0	
	Test No. 4; Feed -100 mesh Ore Sample 181							
Feed*	100.0	40.5	11.6	0.64	100.0	100.0	100.0	
Conc	32.1	69.6	0.17	1.50	55.1	0.5	75.0	3.0:1
Midds	3.6	55.05	5.33	1.07	4.9	1.7	6.1	
Tailing	64.3	25.18	17.7	0.19	40.0	97.8	18.9	

*Calculated

The vanadium in the ore was not eliminated by magnetic concentration at minus 200 mesh.
Concentration of titanium from tailings was not carried out due to low TiO_2 and high V_2O_5 contents in the tailings.

Mines Branch Investigation Report IR 59-109, December 14, 1959

INVESTIGATION OF IRON ORE FROM CALVIN TOWNSHIP, ONTARIO, SUBMITTED BY PEERLESS CANADIAN EXPLORATIONS LTD., TORONTO

BY W. S. JENKINS

Tonnage: A company director stated that the property had a potential tonnage of 100 million.

Ore sample tested: 161 lb of magnetite-ilmenite ore.

Mineralogy: (Internal Report No. MS 59-26, December 15, 1959)

Gangue minerals are predominant constituents and consist essentially of a medium-grained assemblage of pyroxene, plagioclase, phlogopite and calcite transected by rare narrow veinlets of quartz and siderite. The numerous tiny inclusions of gangue in marcasite are apatite.

Magnetite and ilmenite occur alone and associated with each other as coarse to fine disseminated grains and small granular aggregates up to 3 mm (-6 + 8 Tyler mesh) in size. The coarser grain sizes predominate in both minerals but small proportions of each are also present in very fine sizes. Minor quantities of sulphide minerals are present as small erratically scattered particles of marcasite, pyrrhotite and chalcopyrite.

Analysis: 24.03% total Fe, 12.22% soluble Fe, 5.58% TiO_2, 0.43% Mg, 1.65% P, 0.3% S.

Purpose of investigation: To produce separate magnetite and ilmenite concentrates.

Methods of concentration: Low-and high-intensity magnetic separation.

Summary of results and conclusions: The magnetic concentrate assayed 59.9% Fe, 2.83% TiO_2 with only 8.4% Fe recovery. The ilmenite concentrate assayed 6.38% TiO_2 with 91.9% TiO_2 recovery. These concentrates were too low grade for commercial use.

M.D. Test Report No. 649-OD, April 8, 1954

MAGNETIC CONCENTRATION TESTS ON A SAMPLE OF MAGNETIC SANDS FROM THE PATRICIA DISTRICT OF ONTARIO, SUBMITTED BY THE KENNCO EXPLORATION (CANADA) LIMITED, 25 KING STREET, WEST, TORONTO, ONTARIO

BY W. S. JENKINS

Sand sample tested: 7½ lb of magnetite-hematite-ilmenite sand.

Mineralogy: Magnetite, hematite and ilmenite were major metallic minerals in the sands which also contained a small amount of sulphides. Considerable magnetite and hematite were finely intergrown. Some ilmenite was finely intergrown with hematite. Gangue minerals, quartzose in character, were mostly free but some were present as small inclusions in ore minerals.

Analysis: 48.45% Fe, 5.54% SiO_2 and 18.44% TiO_2.

Purpose of investigation: To produce separate iron and titanium concentrates.

Method of concentration: Low-intensity magnetic separation. No grinding was applied.

Summary of results and conclusions: The following concentrates were produced:

Constituent	Mag Conc	Non-mags (TiO_2 conc)
Fe	64.44%	35.64%
TiO_2	3.81%	29.36%
SiO_2	0.98%	9.34%

The iron recovery in the magnetic concentrate was 56.6%; 91.7% of TiO_2 was left in the titanium concentrate.

The high TiO_2 content in the iron concentrate made it unacceptable to the industry.

M.D. Test Report No. 522-OD, May 31, 1951

MAGNETITE FROM PORT COLDWELL, ONTARIO

BY A.K. ANDERSON

Ore sample tested: A two-pound sample from outcroppings.

Mineralogy: A mineralogical examination was not carried out.

Analysis: The following components were determined: 39.46% Fe, 3.74% TiO_2, 0.39% P and 0.028% S.

Purpose of investigation: To determine what grade and recovery of concentrate could be expected.

Method of concentration: Low-intensity magnetic separation (fineness of grind not reported).

Summary of results and conclusions: The magnetic and non-magnetic portions were as follows:

Product	Weight %	Assays%				Distribution%	
		Fe	TiO_2	P	S	Fe	TiO_2
Mag conc	9.0	55.16	23.48	0.04	0.018	12.6	52.5
Non-mags	91.0	37.80	2.10	N.A.	N.A.	87.4	47.5
Feed (calcd)	100.0	39.36	4.02	0.39	0.028	100.0	100.0

The magnetic concentrate contained a high percentage of titanium and as such would be unsuitable as an iron ore.

Mines Branch Investigation Report IR 69-32, March, 1969

CONCENTRATION OF IRON AND TITANIUM FROM AN ORE OF TITAN IRON MINES LIMITED, TEMAGAMI, ONTARIO

BY D. RAICEVIC

Tonnage: Information regarding the size of deposit and tonnage potential were supplied by A.S. Bayne, consulting engineer, for Titan Iron Mines Ltd. His reports entitled "Potential Feasibility of Titan Iron Mines Ltd." of November 15, 1967, March 10, 1972 and November 30, 1974, were made available to the Departmental files. These two sections of the 1974 Abstract are recorded from the report in the original form:

Size of Deposit: "Surface bulk sampling and core drilling has outlined a deposit 1,050 ft long by 586 ft average width. The core drilling was done by light equipment to 200 ft with the bottom of holes still in ore. Magnetic surveys indicate

the length extends to at least 1,400 ft with an average width over 900 ft."

Tonnage potential: "Calculations based on a volume/weight factor of 8 cu ft per short ton (8.96 cu ft per long ton), from sampling analyses of cross-sectional rock trenches and drill cores, show that open pit mining can readily yield over 50,000,000 long tons of ore to 750-feet depth." The estimated tonnage: 140,000,000.

Ore sample tested: About 700 lb sample.

Mineralogy: (Investigation Report IR 68-46, June 1968)

"The results of the mineralogical investigation showed that this complex ore is composed largely of feldspar and granular magnetite intimately intergrown with what appears to be ulvospinel (Fe_2TiO_4). Also present are appreciable quantities of ilmenite, which occur as inclusions in gangue and as inclusions and intergrowths with the magnetite-ulvospinel. The ore also contains a small amount of hercynite ($FeOAl_2O_3$) as fine-grained inclusions in magnetite and to a lesser degree in the ilmenite, as well as a small quantity of hematite, geothite, anatase, chalcopyrite, pyrite and pyrrhotite and traces of bornite and violarite. The gangue minerals, in addition to plagioclase feldspar, include relatively coarse grains of olivine and pyroxene, and small amounts of apatite, chlorite, amphibole, biotite and graphite".

Analysis:

Constituent	Per cent
TiO_2	18.76
Total Fe	38.56
Soluble Fe	38.18
Insol (Gangue)	14.26
V_2O_5	0.36
Cr_2O_3	0.032
S	0.05
P_2O_5	0.05

Purpose of investigation: To investigate possibilities of producing two types of concentrates:

(a) an iron-titanium bulk concentrate suitable for production of pig iron and titanium slag by a smelting process as used by QIT, or

(b) separate iron and titanium concentrates suitable for the steel industry and for production of titania slag.

Methods of concentration: Low- and high-intensity magnetic separation, flotation and tabling.

Summary of results and conclusions:

(a) Bulk iron-titanium concentrates

The following bulk iron-titanium concentrates with various TiO_2 / gangue ratios were produced from this ore sample:

	Assay	Recovery
(i) Bulk conc:	47.05% Fe 21.02% TiO_2 5.34% gangue	89.9% Fe 85.0% TiO_2
TiO_2/gangue ratio = 4:1		
(ii) Bulk conc:	48.70% Fe 21.58% TiO_2 3.1% gangue	81.8% Fe 77.% TiO_2
TiO_2/gangue ratio = 7:1		

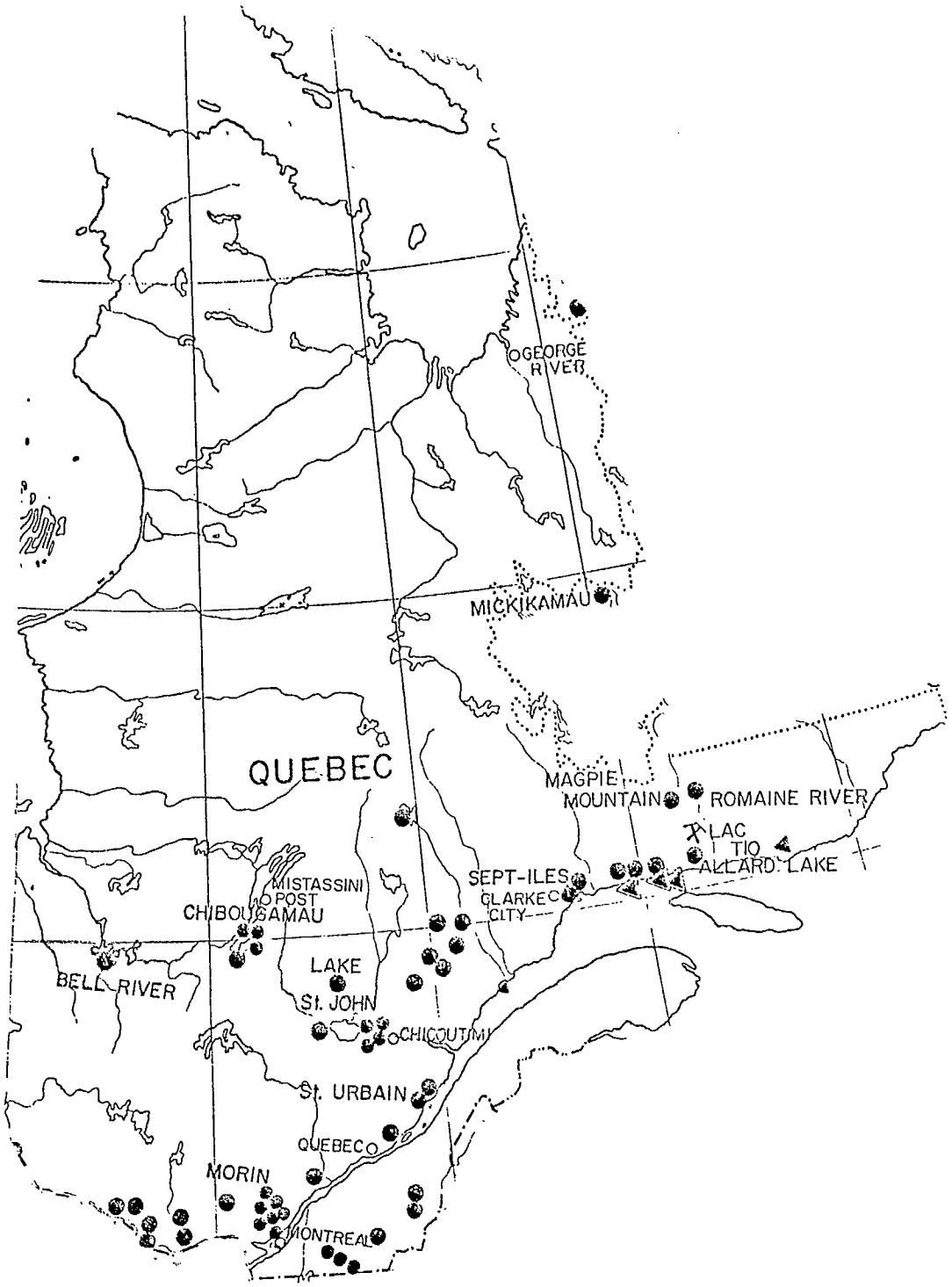
As the TiO_2/gangue ratio of the bulk concentrate, presently being produced by QIT is about 4.6:1, and results in titania slag containing 71% TiO_2, the two bulk concentrates produced from the Titan iron ore sample could, therefore, theoretically produce titania slags of about 70% TiO_2 and 85% TiO_2 grades, respectively. The respective TiO_2 recoveries would be 85% and 77%, while the iron recoveries would be 89% and 82% Fe respectively.

It is expected that the pig iron produced from the Titan Iron Mines bulk concentrates would be of a quality similar to that of QIT.

(b) Separate iron and titanium concentrates

Iron concentrate was produced from this ore sample containing 53.4% Fe, 19.16% TiO_2, 0.86% gangue. The recoveries were 69.0% Fe and 52.7% TiO_2.

Due to intimate intergrowth of the titanium-bearing minerals with the magnetite, the separation of these minerals to obtain a separate iron and titanium concentrates could not be achieved by conventional mineral-dressing methods from this ore sample.



Approximate location of deposits (●)
in Quebec

ALLARD LAKE AREA, QUEBEC; ILMENITE-HEMATITE AND ILMENITE-MAGNETITE DEPOSIT

Tonnage estimated by EMR in 1970: 350,000,000

Location: This deposit is located in the Allard Lake area, Romaine River Valley, Saguenay County, 27 miles from Havre St. Pierre, on the north shore of the St. Lawrence River, Quebec. The smelter is at Sorel, Quebec.

Mineralogical Characteristics of Deposit in General:

A description of the ore was given in Investigation Report No. MD2791 and reviewed in MD3024 along with other observations that were made during the test work.

Polished sections of mineralized samples of the ore appeared to the unaided eye to consist entirely of massive granular ilmenite with a few small inclusions of gangue and pyrite. Under the microscope, however, the ilmenite was seen to contain innumerable needles and spindles of hematite in parallel arrangement intergrown with the ilmenite. The largest of the hematite bodies was about 60 microns in width and from this they ranged down to minute particles just visible under a high power objective. The grains of ilmenite varied in size and had an average nominal diameter of 5 to 6 millimeters.

Most of the pyrite grains occurred in the occupied space between the grains of ilmenite. A grain count of 23 grains of pyrite showed that 97.1% by volume of the pyrite occurred interstitially to ilmenite grains. The major constituent of the gangue was a feldspar identified as labradorite. A minor amount of brown mica was present and a few grains of spinel were also observed.

The gangue was liberated from the mineral at coarse sizes and high grade concentrates can be obtained at sizes as coarse as 1/4 in.

Pyrite concentrate made during the flotation tests was found to contain an appreciable amount of copper and nickel. A sample of cleaned pyrite made from the mill flotation tests was submitted to the mineragraphic laboratory to determine, if possible, the mode of occurrence of the contained nickel. Two polished sections were prepared from the sample and examined under a reflecting microscope.

Each polished surface contained numerous small particles of pyrite set in the mounting medium (bakelite). Particles of other ore minerals visible in comparatively minor amounts were chalcopyrite, magnetite, ilmenite, hematite, and millerite. The last mineral was so similar in appearance to pyrite that it could only be differentiated under crossed nicols, and was identified by means of an X-ray powder pattern. All particles of millerite seen in the sections were free of pyrite but a few were associated with chalcopyrite.

Because millerite did not seem sufficiently abundant in the two polished sections to account for all the nickel present in the concentrate, it was thought that the pyrite might be nickeliferous. A small amount of what appeared to be pure pyrite under a binocular microscope was picked out for a spectographic analysis. The spectographic laboratory reported 7% nickel in this sample, as well as 0.5% cobalt.

The above analysis did not prove that the pyrite contained nickel because the similarity in appearance of pyrite and millerite particles made it impossible to be sure that no nickel sulphide was selected for the spectographic sample. For the same reason more millerite might be present in the polished sections than was observed, and as millerite contains 65% nickel, there was a possibility that all the nickel in the concentrate occurred as this mineral.

Analysis: Several ore samples used for mineralogical examinations and testing were analyzed, with results as follows:

Constituent	Percent				
	A	B	C	D	E
TiO_2	15	31.3	31.3	32.4	35.6
Fe	28	36.1	35.8	37.4	40.5
FeO		25.0	24.9	24.3	
Fe_2O_3		23.8	23.5	26.47	
Grade*	65	80.6	79.7	83.17	90.5
SiO_2		8.66	8.07	6.44	
Al_2O_3		5.45	5.65	4.74	
CaO		1.44	1.58	0.96	
MgO		3.94	4.06	3.30	
Cr_2O_3		0.14	0.13	0.106	
V_2O_5		0.24	0.24	0.303	
MnO		0.12	0.06	0.161	
S	0.4	0.85	0.87	0.91	0.34

*Term "grade" = Amount of ilmenite ($FeO.TiO_2$) + amount of hematite (Fe_2O_3). A short formula for calculating "grade" from the TiO_2 and total Fe assays of an ilmenite-hematite ore is given below:

$$\%\ TiO_2 \times 0.9 + \frac{\%\ \text{total Fe}}{0.7} = \text{Grade}$$

Example: TiO_2 = 35%, total Fe = 40.0%

$$\text{Grade; } 35.0 \times 0.9 + \frac{40.0}{0.7} = 31.5 + 57.1 = 88.6$$

As approximately 4% of the FeO in the ilmenite is replaced in solid solution by MgO, the maximum grade of QIT ore that can be produced is 96%.

Investigation Report No. MD2843, May 30, 1952

GRAVITY CONCENTRATION TESTS ON AN ILMENITE ORE FROM QUEBEC IRON AND TITANIUM CORPORATION, LAKE ALLARD, QUEBEC

BY R. A. ELLIOTT

Ore sample tested: Seven-ton sample of a low-grade ilmenite-hematite ore.

Mineralogy: The ore characteristics of the low-grade sample are, in general, similar to the high grade ore described in "Mineralogical Characteristics of Deposit in General" in the preceding entry.

There was much more gangue in this lower grade sample, with the ilmenite-hematite containing massive to small pieces disseminated throughout gangue. Pyrite also appeared in larger amounts, and the distribution of this mineral throughout the sample tended to be erratic. A few scattered grains of chalcopyrite were also observed. The gangue minerals appeared to consist mainly of feldspars, and an appreciable percentage of brown mica was also present.

Analysis: This ore assayed 15% TiO_2, 28% Fe, 65% "grade", 0.42% S.

Purpose of investigation: To produce highest grade possible of ilmenite-hematite concentrate with maximum recovery.

Methods of concentration: Gravity concentration: jigging, tabling, spiraling and heavy media separation.

Summary of results and conclusions: The combined ilmenite-hematite concentrates of 85 to 90 grade were made from this ore by heavy media separation at a specific gravity of 3.2 and by jigging and tabling of the sizes too small for sink-float separation. An overall recovery of about 90% of the combined ilmenite-hematite was obtained.

Investigation Report No. MD3024, March 15, 1955

SULPHUR ELIMINATION AND BENEFICIATION TESTS ON THE ILMENITE-HEMATITE ORE AND MINUS 14 MESH FINES FROM THE QUEBEC IRON AND TITANIUM CORPORATION, SOREL, QUEBEC

BY R.A. ELLIOTT

Ore samples tested: Five-ton, ten-ton and one hundred-ton samples of ilmenite-hematite ore.

Analysis of samples: The analyses of these ore samples, designated as E, D, C and B respectively, are given in the table on page 52.

Purpose of investigation: Sulphur rejection and ilmenite-hematite concentration by various ore dressing methods.

Methods of concentration: Flotation (anionic and cationic), high-intensity magnetic separation, tabling and electrostatic separation.

Summary of results and conclusions: The average results from the beneficiation methods applied on all samples is shown in the following table:

Method	Preparation	Sulphur Elimination	Recovery, Per cent	Grade of Conc, Per cent
Flotation	Grinding	Excellent	50-75	86-90
Magnetic Separation	Drying	Good	85-90	90-92.5
Tabling	None	None	90-95	87-89

High-intensity magnetic separation gave good rejection of sulphur, good grade of the ilmenite-hematite concentrate and a very good recovery of these two minerals as indicated in the above table.

Mines Branch Investigation Report IR 62-85, October 30, 1962

CONCENTRATION OF TITANIFEROUS MAGNETITE ORE FROM ROMAINE RIVER VALLEY, QUEBEC, FOR QUEBEC IRON AND TITANIUM CORPORATION, SOREL, QUEBEC
BY W. S. JENKINS & D. E. PICKETT

Ore samples tested: Two samples of ilmenite-magnetite and some hematite weighing 250 lb and 275 lb were tested.

Purpose of investigation: To determine whether suitable grades of magnetite and ilmenite concentrates for commercial applications could be made. The second shipment was made to determine the capacity of the Jones high-intensity pilot plant separator for use in ilmenite concentration.

Since the concentrates were to be used by QIT for a special smelting process, certain specifications were required before a concentrate would be considered acceptable.

Mineralogy: (Internal Report MS 61-75, August 21, 1961)

The metallic minerals present in the ore were magnetite, ilmenite, hematite and pyrite. The non-metallic minerals were feldspar, pyroxene, and a small amount of apatite.

Ilmenite and magnetite were the principal metallic minerals present. They occur in masses and irregular shaped grains that ranged between 0.10 and 1.0 mm in diameter. The ilmenite grains contained parallel hematite lamellae up to 0.04 mm wide. Some of the magnetite grains contained a few very narrow lamellae or veinlets of a non-metallic mineral that could not be identified.

Analysis: The two ore samples assayed:

Constituent	Sample 1,%	Sample 2,%
Total Fe	20.94	15.24
TiO_2	8.58	6.80
P_2O_5	6.27	3.97
S	-	0.55

Methods of concentration: Low- and high-intensity magnetic separation, tabling and flotation of apatite.

Summary of results and conclusions: Sample 1 - Ore ground to minus 150 m produced magnetite concentrate assaying 70.50% Fe, 0.38%TiO_2, 0.06%P_2O_5, 0.105%S and 0.24%SiO_2. The recovery of iron was 34.3% at a ratio of concentration of 11.1:1.

Ilmenite concentrate at minus 150 m assayed 36.19% TiO_2, 0.03% P_2O_5, 0.125% S, 6.34% SiO_2. The recovery of TiO_2 was 62.09% at a ratio of concentration of 6.9:1.

Sample 2 - Magnetite concentrate was similar to that from Sample 1 but the ilmenite concentrate contained 0.11% P_2O_5.

Mines Branch Investigation Report IR 63-99, September 30, 1963

FURTHER CONCENTRATION TESTS ON MAGNETITE-ILMENITE FROM ROMAINE RIVER VALLEY, P.Q., FOR QUEBEC IRON AND TITANIUM CORPORATION

BY W.S. JENKINS

Ore sample tested: About 1550 lb of ilmenite-magnetite ore.

Mineralogy: Purpose of Investigation and Methods of Concentration were the same as in IR 62-85.

Analysis: This sample assayed 19.19% total Fe, 15.14% soluble Fe, 7.18% TiO_2, 4.18% P_2O_5, 0.47% S, 34.06% SiO_2, 59.16% Insol.

Summary of results and conclusions: The magnetite in the sample was concentrated by low-intensity magnetic methods to produce a high iron (70% Fe) concentrate at minus 150 m containing about 0.30% TiO_2 and less than 0.01% P_2O_5. The ilmenite was recovered from the non-magnetic cobber tailing by gravity and/or high-intensity

wet magnetic concentration. Cleaning of this ilmenite concentrate by apatite flotation and high-intensity wet magnetic separation, after regrinding to minus 150 m, produced finished ilmenite concentrate containing 39 to 40% TiO_2 and 0.05% P_2O_5. However, recovery of ilmenite was low.

The results of the investigation show that the required grade of magnetite concentrate can be made at minus 150 m after cobbing at 35 m. The ilmenite can be recovered from the non-magnetic tailing by gravity concentration or high-intensity magnetic concentration followed by grinding to minus 150 mesh and reconcentrating. Either high-intensity magnetic concentration of ilmenite or flotation of apatite from ilmenite concentrate could be used to obtain an acceptable grade of ilmenite.

Mines Branch Investigation Report IR 63-93, September 25, 1963

PILOT PLANT CONCENTRATION OF MAGNETITE-ILMENITE FROM ROMAINE RIVER VALLEY, P.Q., FOR QUEBEC IRON AND TITANIUM CORPORATION
BY P.D.R. MALTBY AND W.S. JENKINS

Ore sample tested: 53-ton sample of ilmenite-magnetite ore.

Mineralogy, Purpose of investigation and Methods of concentration the same as in IR-62-85.

Analysis: This pilot-plant sample assayed: 14.84-15.13% total Fe, 6.74-6.95% TiO_2 and 3.76% P_2O_5.

Summary of pilot-plant results and conclusions: The investigation demonstrated that production of high grade magnetite and ilmenite concentrates meeting the specifications of Quebec Iron and Titanium Corporation was feasible. This was carried out by conventional magnetic concentration of the magnetite and using an

ilmenite concentration process employing gravity and high-intensity magnetic concentration followed by apatite flotation to reduce the phosphorus content of the final ilmenite concentrate to less than 0.05% P_2O_5.

From a shipment of 53 tons, approximately 5 tons each of magnetite and ilmenite concentrates were produced and shipped to Sorel. The magnetite concentrate contained 10.7% of the original feed weight and assayed 69.26% Fe, 0.43% TiO_2, and 0.011% P_2O_5. A screen test showed it to be 63.8% minus 325 mesh. The ilmenite concentrate contained 11.0% of the original feed weight and assayed 38.9% TiO_2. Due to production difficulties, the phosphorus content of the shipment exceeded 0.09% P_2O_5, but it was believed this could have been reduced by flotation if it had been detected before shipment. Apatite flotation concentrates assaying 36.7% P_2O_5 were produced from the tailing. A 350-lb shipment of recleaned apatite concentrate was sent to Sorel.

Other investigations conducted on these deposits at Mines Branch.

Investigation Report No. MD2791, May 28, 1951 Sintering and Flotation Tests on Ilmenite Ore from QIT, Lake Allard, Quebec.

Investigation Report No. MD3027, April 9, 1954 - Grinding Tests on Ilmenite Ores of Different Grades from QIT, Sorel, Quebec.

CIM Bulletin, February, 1957 - Experimental Smelting of Ores and Related Materials at the Department of Mines and Technical Surveys, Ottawa.

Mines Branch Investigation - IR 64-26, March 6, 1964 - An Investigation of Products Resulting from the Pressure Leaching of Titanium Ore and Slag.

Technical Bulletin - TB 82, July, 1966 - The Application of Electronic Sorting to Minerals Beneficiation.

CIM Bulletin, February, 1968 - Development of a Combination Shaft and Electric Furnace.

CIM Bulletin, July, 1957 - Experimental Electric Smelting of Ilmenite to Produce High Titanium Slag and Pig Iron.

Mines Branch Investigation (Mineralogical) IR 64-26.

Investigation Report No. MD3222, October 9, 1957

MAGNETIC CONCENTRATION OF A SAMPLE OF TITANIFEROUS IRON ORE FROM BEAR LAKE, QUEBEC, SUBMITTED BY STRATMAT LIMITED
BY W. S. JENKINS

Ore sample tested: About 31 lb of magnetite-ilmenite ore with gangue.

Mineralogy: (Min. Rep. No. M-1539-E, October 7, 1957)

Metallic mineralization was slightly more abundant by volume than gangue. Magnetite was the major metallic mineral. It was scattered through gangue as coarse to fine particles with the large sizes predominating, but contained many gangue inclusions. Ilmenite was present in a minor amount and was intimately intergrown with magnetite. Very small amounts of fine hematite were visible, mostly associated with magnetite. The amount of sulphides, mainly pyrite, was negligible. Gangue material, the second largest constituent of the ore, was of medium to coarse grain. Some gangue was finely disseminated in magnetite.

Analysis: This ore contained 34.93% Fe (total), 15.10% TiO_2, 16.90% SiO_2, 1.88% P.

Purpose of investigation: To produce combined magnetite and ilmenite concentrates with approximately 50% Fe and 20% TiO_2 at grinds of minus 10 mesh, minus 20 mesh and minus 35 mesh.

Methods of concentration: Low- and high-intensity magnetic separation.

Summary of results and conclusions: The highest grade concentrates obtained from the finest grind (minus 35 mesh) were as follows:

	Fe(total) %	TiO_2%	SiO_2%	P%
Magnetite conc	59.1	12.4	2.85	0.64
Ilmenite conc	23.9	19.3	27.0	1.22
Combined conc	50.1	14.1	9.0	0.70

After these results were obtained, the company decided to discontinue further testing of this ore sample.

Investigation Report No. MD3191, May 13, 1957

FURTHER CONCENTRATION TESTS ON MAGNETITE-ILMENITE ORE, GROUND BY THE AEROFALL MILL, FROM DES GROSBOIS, BERESFORD TOWNSHIP, QUEBEC, SUBMITTED BY PERSHING AMALGAMATED MINES LIMITED, MONTREAL, QUEBEC
BY W. S. JENKINS

Ore sample tested: Magnetite-ilmenite-apatite

Mineralogy: (Min. Rep. No. M-1508-E, March 18, 1957)

After concentration of magnetite from the sample identified as "Aerofall Mill Products" a mineralogical examination

was carried out on the Wetherill tailing. The conclusion was as follows:

The product, as received, consisted largely of ilmenite, apatite, plagioclase, and pyroxene, with lesser amounts of garnet and biotite. The ilmenite was relatively free of inclusions and attached grains at a grain size of 48 mesh. The apatite was combined with other minerals to a greater extent than ilmenite and at 65 mesh only about 80% of it was free of inclusions and attached grains. Both ilmenite and apatite were more finely comminuted than the accompanying gangue minerals.

Analysis: This sample assayed 37.2% total Fe, 10.3% TiO_2, 3.76% P_2O_5.

Purpose of investigation: To produce separate magnetite, ilmenite and apatite concentrates.

Methods of concentration: The ore was magnetically concentrated by a Laurila dry magnetic separator. The Laurila concentrate was reground and reconcentrated by the Roche wet belt separator to upgrade the magnetic concentrate. The Laurila tailing was concentrated by a Wetherill dry belt separator to remove remaining magnetite. The Wetherill tailing was concentrated by a Humphreys spiral. The spiral concentrate was upgraded by a Wetherill high-intensity magnetic separator and by a high-tension Carpco electrostatic separator. The spiral tailing was concentrated by flotation to recover apatite.

Summary of results and conclusions: The results of the three concentrates are recorded in the following table:

Constituent	Magnetite Conc		Ilmenite Conc		Phosphorus Conc	
	Assay%	Distn%	Assay%	Distn%	Assay%	Distn%
Fe	64.0	58.1	35.36	7.2	0.85	0.1
TiO_2	3.49	12.1	48.71	36.57	0.74	0.35
P_2O_5	0.10	1.12	0.13	0.46	39.34	56.46
V_2O_5			0.08			
Cr_2O_3			0.10			
CaO			0.42		52.42	
MgO			1.61		Trace	
SiO_2			0.88		0.67	
Al_2O_3			0.60		0.26	
S			0.18			
Mn			0.59			
F					2.92	

The magnetic iron concentrate was of good iron grade with relatively low iron recovery. It had a high TiO_2 content and was thus not suitable as blast furnace feed.

The ilmenite concentrate had a relatively high TiO_2 content with little gangue and would be suitable for production of pig iron and titania slag by a pyrometallurgical process; TiO_2 recovery was low at 36.57%. The phosphorus concentrate had a fairly good phosphorus grade but low phosphorus recovery.

Investigation Report No. MD3131, October 29, 1956

CONCENTRATION TESTS ON AEROFALL MILL PRODUCTS FROM GRINDING TESTS ON A SAMPLE OF MAGNETITE-ILMENTIE ORE FROM DESGROSBOIS, BERESFORD TOWNSHIP, QUEBEC, SUBMITTED BY PERSHING AMALGAMATED MINES LTD., MONTREAL, QUEBEC

BY W.S. JENKINS

Summary of results and conclusions: Similar results to those in Investigation Report MD3191 were obtained from the Aerofall Mill Products.

Investigation Report No. MD2953, June 23, 1953

MAGNETIC CONCENTRATION OF TWO SAMPLES OF TITANIFEROUS MAGNETITE ORE FROM THE GRAND CHIBOUGAMAU MINES LIMITED, CHIBOUGAMAU DISTRICT, QUEBEC

BY W.S. JENKINS

Ore samples tested: Two samples of magnetite-ilmenite ore of which one was 75 lb of surface material and the other was 56 lb of drill core rejects.

Mineralogy: (Reported in the above Investigation)

Main metallic minerals in both samples were magnetite and ilmenite scattered through gangue as moderately coarse (up to 1 mm) to very fine particles often intimately associated. Each mineral also occurred alone in gangue down to very fine sizes.

Small amounts of pyrite, pyrrhotite and chalcopyrite was also present as disseminated grains in gangue, more rarely in magnetite and ilmenite. Gangue consisted mainly of dense grey quartz and a soft light green mineral.

Analysis:

Constituent	Surface Sample %	Drill Core Rejects %
Fe (total)	25.52	24.55
Fe (soluble)	20.50	18.56
TiO_2	5.03	6.41
S	0.26	0.44
P	None detected	None detected
SiO_2	32.80	32.20
Insol	44.80	49.26

Purpose of investigation: To produce separate iron and titanium concentrates.

Methods of concentration: Dry belt and wet belt magnetic separators for the concentration of magnetite, and tabling for ilmenite concentration.

Conclusions: The iron and titanium concentrates produced had low grades and low recoveries. In addition, the iron concentrate contained a large amount of titanium, ranging between 6 and 9% TiO_2.

Mines Branch Investigation Report IR 58-95, June 25, 1958

CONCENTRATION TESTS ON A PONTIAC COUNTY, QUEBEC TITANIFEROUS MAGNETITE ORE FROM MR. J.U. GAUTHIER

BY W.S. JENKINS

Ore sample tested: 9 lb of magnetite-ilmenite ore.

Mineralogy: (Min. Rep. No. M-1580-E, 1958)

Massive pitted magnetite was the main constituent of the ore sample. Ilmenite, which comprised only a small amount of the ore sample, was not finely or intimately intergrown with magnetite but contained numerous small inclusions of hematite. Gangue content was small and consisted of fairly coarse to fine scattered grains of white quartz and apatite.

Analysis: 32.9% Fe, 1.7% TiO_2, 0.025% S, 6.27% P.

Purpose of investigation: To determine the iron grade and the iron recovery of the concentrate produced from various grinds.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: The iron concentrate produced from a minus 200-mesh grind, comprised 86.6% of the iron in the ore sample and assayed:

Constituent	Percent
Fe	71.1
TiO_2	0.50
S	0.014
Insol	1.17
SiO_2	None detected
P	None detected

It was concluded that this 9-lb sample was amenable to magnetic concentration. Recovery of phosphorus was not requested.

Mines Branch Investigation Report IR 61-79, July 27, 1961

MAGNETIC CONCENTRATION OF TITANIFEROUS MAGNETITE FROM SAGUENAY EXPLORATION AND MINING INC., OUTREMONT, QUEBEC
BY R.S. KINASEVICH

Ore sample tested: 300-lb sample of magnetite, ilmenite and gangue.

Mineralogy: Mineralogical examination was not carried out.

Analysis: The ore contained 41.75% total Fe, 40.85% soluble Fe, 11.62% SiO_2, 22.62% Insol, 0.02% P, 0.038% S, 17.1% TiO_2.

Purpose of investigation: To produce a marketable iron concentrate. Ilmenite concentration was not requested.

Methods of concentration: Low-intensity magnetic separation and tabling.

Summary of results and conclusions:

The magnetic concentrate assayed 60.4% total Fe, 1.45% SiO_2 and 9.52% TiO_2. The iron recovery was 64.0%.

A marketable iron concentrate, therefore, could not be produced by the above methods as the amount of TiO_2 in the iron concentrate exceeded the required minimum.

MD Test Report No. 923-OD, February 12, 1958

MAGNETIC CONCENTRATION TESTS ON A SAMPLE OF TITANFEROUS IRON ORE FROM THE COULONGE RIVER AREA OF OUEBEC, SUBMITTED BY J.U. GAUTHIER

BY W.S. JENKINS

Ore sample tested: 4½-lb sample of magnetite-ilmenite ore.

Mineralogy: Examination of hand specimens indicated that the magnetite was coarse and that the gangue consisted largely of quartz and feldspar with some biotite mica.

Analysis: The ore assayed 47.5% Fe (total), 2.70% TiO_2.

Purpose of investigation: To determine the grade of iron concentrate that could be produced from this sample.

Methods of concentration: Stage-grinding followed by a low-intensity magnetic separation.

Summary of results and conclusions:

At a minus 100-mesh grind, this method produced an iron concentrate assaying 70% Fe (total) and 0.35% TiO_2 with 92.8% iron recovery.

Slightly better results were obtained from a minus 200-mesh grind.

Investigation Report No. MD3057, March 31, 1955

MAGNETIC CONCENTRATION TESTS ON A SHIPMENT OF IRON ORE FROM SHEEN TOWNSHIP, PONTIAC COUNTY, QUEBEC, SUBMITTED BY G. J. McILRAITH, M.P. OTTAWA, ONTARIO
BY W. S. JENKINS

Ore samples tested: A shipment of 14 samples with a net weight of 1200 lb.

Mineralogy: Polished sections were prepared from each sample and examined under a reflecting microscope. The major constituent was gangue material composed mainly of white-to-colourless vitreous quartz with some flakes of black mica (biotite).

Magnetite was the major metallic mineral scattered through gangue as coarse-to-fine uneven grains with coarser sizes predominant. In general, the magnetite was free of inclusions but a small amount was associated with ilmenite, gangue and some sulphides (mainly pyrite and some pyrrhotite).

A comparatively small amount of ilmenite was present in all samples. Some hematite and limonite were also observed in polished sections.

Analysis: The iron content in samples varied from 43.61% Fe to 1.98% Fe, averaging 16.04% in a composite sample. Only one sample (1-C) was analyzed for TiO_2, S and P. It assayed 5.26% TiO_2, 0.06% S, N.D.% P.

Purpose of investigation: To determine the iron content in each sample and investigate whether concentrates of suitable grade could be produced.

Methods of concentration: Low-intensity magnetic separation applying cobbing and upgrading procedures.

Summary of results and conclusions: At grinds from minus 48 mesh to minus 150 mesh, the iron concentrate assayed between 68.4 and

69.6% Fe with iron recovery ranging from 80 to 88% Fe. The lowest titanium content in the concentrate was at the minus 150-mesh grind and assayed 1.24% TiO_2, which was too high for steel manufacturing.

Mines Branch Investigation Report IR 60-103, October 11, 1960

CONCENTRATION OF MAGNETITE FROM A SAMPLE OF SANDS SENT BY J.E. ROCHON, LOW, QUEBEC

BY R.S. KINASEVICH

Sand sample tested: About 50 lb of sand.

Mineralogy: Mineralogical examination was not carried out.

Analysis: This sand contained 4.57% soluble Fe, 0.63% TiO_2.

Purpose of investigation: To produce a magnetite concentrate.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: The magnetic concentrate assayed 60.4% soluble Fe and 0.61% TiO_2. The iron recovery was only 30.4% of iron in the sand.

The low iron recovery and the titanium content in excess of the usual acceptable 0.1% TiO_2 makes this concentrate unsuitable for the steel industry.

Investigation Report No. MD3229, November 27, 1957

INVESTIGATION OF AN ILMENITE-MAGNETITE BEACH SAND FROM LAKE NORMAN, SUBMITTED BY MR. J.M. YATES, 545 ST. AUBIN STREET, ST. LAURENT, MONTREAL, QUEBEC

BY T.F. BERRY

Sand sample tested: About 4 lb of magnetite-ilmenite-hematite sand.

Mineralogy: (Min. Rep. M-1510-E, October 16, 1957)

The minerals likely to be of commercial value were all in the heavy fraction with a density greater than 3.62. The magnetite appeared to be relatively free of inclusions of other minerals or attached grains.

Most of the ilmenite appeared to be pure, but some was intergrown with hematite on a microscopic scale. When intergrown, the two minerals consisted of lamellae down to a micron or less in width of one component in the other. There was almost no free hematite.

The zircon occurred as elongated grains, usually showing partly rounded crystal faces. Most of it was white or tan in colour, although some was pink. It is doubtful if the monazite and rutile were sufficiently abundant to warrant an attempt at recovery.

Analysis: This sample assayed 45.8% Fe (total), 29.92% TiO_2, 1.2% Zr, 2.16% SiO_2.

Purpose of investigation: To determine whether or not an economic recovery of iron (magnetite) could be made.

Methods of concentration: A low-intensity magnetic separation for magnetite concentration and a high-intensity magnetic separation (Stearns) for ilmenite-zircon concentration.

Summary of results and conclusions: Results are summarized in the following table:

Results of Test No. 4

Product	Wt, %	Assays, %			Distribution, %		
		Fe	TiO_2	ZrO_2	Fe	TiO_2	ZrO_2
Ball-Norton mag conc	18.7	69.30	2.42	N.D.	27.9	1.5	-
Stearns mag conc	74.7	42.80	39.61	tr.	68.9	97.6	-
middling	1.3	33.10	11.39	tr.	0.9	0.5	-
tailing	5.3	19.70	2.55	19.7	2.3	0.4	100.0
Feed (calcd)	100.0	46.40	30.32	1.04	100.0	100.0	100.0

N.D. - None detected
tr. - trace

By grinding the magnetic concentrate to minus 200 mesh and retreating, TiO_2 content was lowered to only 1.4%, and the iron grade was increased to 70.6% Fe. Due to the high TiO_2 content, the magnetic (iron) concentrate was not suitable for steel production.

Mines Branch Investigation Report IR 58-22, April 14, 1958

CONCENTRATION TESTS ON A SAMPLE OF TITANIFEROUS-MAGNETITE ORE FROM THE LAKE ST. JOHN DISTRICT, QUEBEC, SUBMITTED BY M. ZAOURSKI, MONTREAL, QUEBEC

BY T.F. BERRY

Ore sample tested: About 27 lb of magnetite-ilmenite ore.

Mineralogy: (MB Mineralogical Report No. M-1559-E, Jan. 20, 1958)

Magnetite was the most abundant ore mineral and occurred mainly as coarse granular masses but a small amount was also present as fine disseminated particles. Many grains of magnetite contained

numerous inclusions of gangue.

Ilmenite was common in coarse grain sizes but some was finely intergrown with magnetite. Inclusions of gangue in ilmenite were not nearly as numerous as in magnetite.

Hematite was visible but in negligible quantity.

Sulphide minerals (mostly pyrite) were present in trace amounts. Gangue, comprising only a minor portion of the ore, was made up of coarse and fine grains and some finely disseminated in magnetite but rarely in ilmenite.

Analysis: The following components were determined: 49.50% total Fe, 45.20% soluble Fe, 18.02% TiO_2, 2.97% SiO_2 , 0.025% P_2O_5 and 0.033% S.

Purpose of investigation: To determine amenability of the minerals to concentration.

Methods of concentration: Low- and high-intensity magnetic separation.

Summary of results and conclusions: Although a fair grade iron concentrate (64.1% Fe) was produced, its TiO_2 content (6.68%) was too high for the steel industry. Attempts to reduce the TiO_2 content in the magnetic concentrate were not successful.

The titanium concentrate assayed 33.7% TiO_2 and comprised 52.6% of the TiO_2 in the ore.

The separate concentrates produced were therefore not suitable for industrial uses.

Mines Branch Investigation Report IR 66-82, October 20, 1966

CONCENTRATION TESTS ON A TITANIFEROUS ORE FROM TITANIUM PRODUCTS CORPORATION, ST. CHARLES, BOURGET TOWNSHIP, QUEBEC

BY D. RAICEVIC

Ore sample tested: About 15 lb of magnetite-ilmenite ore.

Mineralogy: (MB Investigation IR 66-70, August 15, 1966)

The ore sample consisted mainly of magnetite, ilmenite and gangue. The magnetite was massive and contained inclusions of ilmenite, spinel, gangue, graphite and goethite. The ilmenite was present as small masses and inclusions in the magnetite, and also contained inclusions of spinel, graphite, gangue and goethite. The gangue which was composed of apatite, amphibole, mica and olivine, contained a few grains of magnetite, pyrrhotite and goethite.

Analysis: The ore sample contained 47.9% soluble Fe, 20.68% TiO_2, and 0.52% P_2O_5.

Purpose of investigation: To produce separate iron, titanium and phosphorus concentrates.

Methods of concentration: Low- and high-intensity magnetic separation.

Summary of results and conclusions: The best iron and titanium concentrates obtained were as follows:

Product	Analysis %			Distn %	
	Sol Fe	TiO_2	P_2O_5	Sol Fe	TiO_2
Iron conc, low intensity	62.45	9.22	<0.01	65.7	16.1
Titanium conc, low intensity	23.5	40.27	1.5	16.1	63.7
Titanium conc, high intensity	29.53	38.16	0.22	25.4	71.6

The high TiO_2 content in the iron concentrate and the high P_2O_5 content in the titanium concentrates make these products unacceptable to the steel, pig-iron and titania slag producers.

The unsatisfactory separation of magnetite, ilmenite and apatite is the result of the fine intergrowth of these minerals.

Recovery of phosphorus did not seem feasible due to the low P_2O_5 content and the association of apatite with the other minerals.

Investigation Report No. MD3079, April 29, 1955

MAGNETITE SEPARATION AND FLOTATION TESTS ON AN ILMENITE-ORE FROM LAURENTIAN TITANIUM MINES LIMITED, MONTREAL, QUEBEC

BY R. A. ELLIOTT

Ore sample tested: Ilmenite-hematite-gangue drill cores

Mineralogy: (Reported in the above investigation)

Ilmenite and hematite were the most abundant ore minerals. The ilmenite occurred in gangue as coarse to fine disseminated particles and small granular masses up to about 1 cm in size. Numerous inclusions of hematite were visible in every grain of ilmenite. Small scattered grains of sulphides in gangue and ilmenite were common in the two polished sections. Pyrite predominated, but rare small particles of pyrrhotite and chalcopyrite were also present. Where sulphide occurred in ilmenite aggregates, it was usually along grain boundaries.

A few small grains of magnetite were visible in gangue in one of the six fragments of ore, and, unlike those of ilmenite, they contained no hematite but were dense and homogeneous in

appearance. In the polished sections of the ore fragments, gangue was quite prevalent and consisted of an assemblage of medium coarse to fine grains of plagioclase and pyroxene with a little erratically distributed calcite and mica.

Analysis: The following composition was determined: 24.88% total Fe, 20.65% TiO_2, 0.69% S and 22.2% SiO_2.

Purpose of investigation: To determine the highest grade of concentrate that could be obtained by ore dressing methods. (Based on the treatment applied, "concentrate" means ilmenite-hematite concentrate).

Methods of concentration: (1) Low-intensity magnetic separation of ore at 14 mesh after heating to 1100-1600°F. (2) Anionic flotation of ilmenite and hematite materials.

Summary of results and conclusions: (1) Magnetic concentrates containing over 35% TiO_2, representing a recovery of 78% of the TiO_2 in the ore, were obtained. (2) In a flotation test using fatty acid to float the ilmenite-hematite, the concentrate contained only 27% TiO_2. Since the maximum grade of concentrate obtained from this ore will certainly be under 40%, it will not be possible to produce marketable concentrates for the pigment industry from this ore according to a statement by company president E.R. Rowley in 1955.

Mines Branch Investigation Report IR 62-21, May 2, 1962

CONCENTRATION OF ILMENITE FROM TITANIFEROUS MAGNETITE ORE FROM LAURENTIAN TITANIUM MINES, LIMITED, WEXFORD TOWNSHIP, QUEBEC
BY W.S. JENKINS

Tonnage: Estimated tonnage by EMR in 1969: 15,000,000.

Ore samples tested: Three samples of ilmenite-magnetite ore.

Mineralogy: (Mines Branch Investigation Report IR 60-78)

Ilmenite and magnetite were distributed unevenly through the gangue as coarse-to-fine irregular grains and aggregates. Magnetite and ilmenite were not intimately and finely intergrown and both minerals were largely free of small inclusions of gangue. Gangue minerals were plagioclase and dark pyroxene with minor amounts of apatite, sulphides and garnet as small scattered grains. Although hematite was not reported in the examination of this shipment, it was intimately associated with the ilmenite in some samples from shipments 2 and 3. Since complete liberation would be impossible, any ilmenite concentrate would contain some hematite altering the magnetic properties of the mineral and lowering the TiO_2 grade obtainable.

Analysis: The following composition was determined: 24.06% total Fe, 19.86% soluble Fe, 9.48% TiO_2, 30.74% SiO_2, 1.63% P_2O_5, 0.36% S. Tungsten manganese, vanadium and copper were present in minor or trace amounts.

Purpose of investigation: To determine (1) the recovery and grade of ilmenite concentrate that could be obtained from the non-magnetic tailing after concentrating the magnetite in the ore, (2) if the ilmenite concentrate would have the required specification of less than 0.05% P_2O_5 for a commercial grade of titanium concentrate.

Methods of concentration: After concentrating the ore magnetically to recover magnetite, the tailings were concentrated by gravity and by high-intensity magnetic separation to recover a finished ilmenite concentrate. The gravity concentrate was reconcentrated by a Stearns high-intensity dry separator. In three tests, this concentrate was reground to minus 150 mesh and concentrated by the Jones high-intensity wet separator. In Test 4,

flotation was used to concentrate the apatite remaining in the minus 150 mesh ilmenite concentrate from the Stearns separator.

Summary of results and conclusions: The results indicated that grinding to minus 65 mesh was best for magnetite concentration and gravity concentration of the ilmenite. A magnetic concentrate of 65.26% Fe grade with 54% Fe recovery was produced but TiO_2 and P_2O_5 contents were high at 2.53% and 0.28% respectively. Grinding of the rougher ilmenite concentrate to minus 150 mesh was necessary to liberate the apatite. At this grind the Jones high-intensity wet magnetic separator produced an ilmenite concentrate of 37.54% TiO_2 grade with only 49.0% recovery and less than 0.05% P_2O_5. The ilmenite concentrate from flotation assayed 27.72% TiO_2, 9.02% P_2O_5 , 20.16% SiO_2. The recovery of TiO_2 was 48.1%

The concentrates were not suitable for industrial use.

Mines Branch Investigation Report IR 60-78, December 13, 1960

CONCENTRATION OF TITANIFEROUS MAGNETITE ORE FROM LAURENTIAN TITANIUM MINES LIMITED, WEXFORD TOWNSHIP, P.Q.
BY W.S. JENKINS

Tonnage: Estimated tonnage by EMR in 1969: 15,000,000.

Ore samples tested: Three ore samples were investigated.

Mineralogy: (Internal Report MS-60-64, July 4, 1960)

Shipment No.1

The sample was taken from the surface of the deposit, as evidenced by its severely oxidized condition. Magnetite was the chief iron mineral with a small amount of ilmenite. Magnetite

and ilmenite, alone and mutually combined, were distributed unevenly through gangue and were not intimately and finely intergrown. Both minerals were largely free of gangue inclusions. Small amounts of sulphide minerals, pyrite, chalcopyrite and pyrrhotite, occurred as small erratically scattered grains. Gangue material consisted largely of rather coarse white to brown plagioclase and dark green-to-black pyroxene with minor amounts of apatite and garnet as small scattered grains.

Shipment No. 2

Ilmenite, being the major metallic mineral, occurred largely as small granular aggregates up to one centimeter or more in diameter, but a small proportion of this mineral was disseminated through gangue as coarse-to-fine irregular particles. Each grain of ilmenite contained numerous inclusions of hematite which, for the most part, were narrow, parallel, exsolved lamellae ranging from one micron or less up to one hundred microns or more in width. Pyrite was fairly common as small grains and narrow sinuous veinlets in gangue and ore minerals. Chalcopyrite and pyrrhotite were both present in practically negligible amounts as small grains associated with pyrite.

Shipment No. 3

The ore minerals present in the three polished sections were ilmenite, hematite, magnetite, and pyrite, the magnetite being most abundant. The hematite occurred in ilmenite largely as parallel, exsolved lamellae, some of which, especially the larger ones, exhibited, tiny exsolved needles of ilmenite. These two minerals also contained minute, more equant inclusions of each other with random arrangement. Grains of magnetite were commonly disseminated through gangue with grains of ilmenite. Unlike the hematite, however, the magnetite was not finely intergrown with ilmenite. Grains of magnetite and ilmenite simply adjoined each other and were comparable in size. As in the second shipment, some pyrite was present as small scattered grains and narrow veinlets.

Analysis: The ores contained:

Constituent	Per Cent		
	No. 1	No. 2	No. 3
Total Fe	24.2	24.2	15.2
Soluble Fe	20.35	-	-
TiO_2	9.10	18.7	6.26
SiO_2	31.38	-	-
P	0.66	-	-
S	0.37	-	-

Purpose of investigation: To determine the degree of grinding necessary to produce an iron concentrate suitable for blast furnace feed. Concentration of ilmenite was not requested.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions:

Shipment No. 1

An iron concentrate assaying 69.36% Fe, 0.41% TiO_2 and 0.88% SiO_2 was produced from ore ground to minus 200 mesh. The recovery of iron was 46.5% and the ratio of concentration 7.7:1.

Shipment No.2

Magnetic concentrate obtained by Davis tube at minus 200 mesh assayed 52.6% Fe and 22.1% TiO_2. The recovery of iron was only 9.1% at a ratio of concentration of 23.8:1.

Shipment 3

Magnetite was concentrated at minus 8, minus 100 and minus 200 mesh. The minus 200-mesh magnetite concentrate from the reground minus 8-mesh concentrate assayed 66.5% Fe and 1.60% TiO_2. The recovery of iron was 45.5% at a ratio of concentration of 9.6:1. A minus 200-mesh concentrate made directly from the

ground ore assayed 62.8% Fe and 2.25% TiO_2. The recovery of iron was 51.5% at a ratio of concentration of 7.8:1.

Iron concentrates suitable as a feed for blast furnace operation could not be produced from these samples.

Investigation Report No. MD3067, October 6, 1955

CONCENTRATION TESTS ON A SAMPLE OF TITANIFEROUS MAGNETITE FROM LEMOINE AND RINFRET TOWNSHIPS, QUEBEC, SUBMITTED BY DOMINION GULF COMPANY, TORONTO, ONTARIO
BY W. S. JENKINS

Ore sample tested: About 220 lb of magnetite-ilmenite ore.

Mineralogy: Metallic mineralization in the sample predominated slightly by volume over gangue.

Major metallic minerals were magnetite and ilmenite with a small amount of sulphide minerals, mostly pyrite.

Magnetite occurred in gangue as moderately coarse granular masses. A considerable amount of ilmenite was intimately associated with magnetite.

Gangue material consisted of chlorite, epidote and plagioclase feldspar.

Analysis: The following constituents were determined: 46.5% total Fe, 43.0% soluble Fe, 12.3% TiO_2, 0.08% S, 8.7% SiO_2.

Purpose of investigation: To produce marketable iron and titanium concentrates.

Methods of concentration: Low- and high-intensity magnetic separation, flotation and tabling.

Summary of results and conclusions: A relatively low grade iron concentrate 64.9% Fe with only 66% iron recovery and a high titanium content (8.61% TiO_2) made this product unacceptable to the steel industry.

An ilmenite concentrate assaying 46.5% TiO_2 and 35.0% Fe was obtained by electrostatic separation but the TiO_2 recovery was low (about 42%).

The calculated combined iron-titanium concentrate assayed 58.2% Fe and 16.6% TiO_2. The iron and titanium recoveries were 75.7% and 72.5%, respectively.

Investigation Report No. MD3066, December 30, 1955

MAGNETIC, GRAVITY, AND ELECTROSTATIC CONCENTRATION TESTS ON SIX SAMPLES OF TITANIFEROUS MAGNETITE SANDS FROM NATASHQUAN, QUEBEC, SUBMITTED BY THE ACONIC MINING CORPORATION, MONTREAL, QUEBEC
BY W. S. JENKINS

Tonnage: Estimated tonnage by EMR in 1967: 1,500,000,000.

Sand samples tested: Six samples were submitted for this investigation.

Mineralogy: The major metallic minerals in these samples were magnetite, hematite and ilmenite while quartz, feldspar, garnet and pyroxene were the major non-metallic minerals. Some sphene, hornblende, zircon, rutile and epidote were also present.

Analysis: Assays of the samples were as follows:

Sample No.	Fe %	TiO_2 %	Zr %
203-B	24.83	8.18	0.2
206-B	59.96	2.64	0.08
208-B	4.06	1.05	0.06
209-B	3.57	0.90	0.01
305-B	42.26	11.63	0.2
306-B	3.18	0.84	-

Purpose of investigation: To determine the grade of concentrate obtainable from each sample.

Methods of concentration: Gravity concentration, low- and high-intensity magnetic separation and electrostatic concentration.

Summary of results and conclusions:

The best results were obtained from sample 305-B. A combined magnetite-ilmenite concentrate contained 56.6% iron and 15.5% titanium dioxide. The recoveries were 91.3% of the iron and 92.5% of the titanium dioxide in the sample. The other components were not determined.

Investigation Report No. MD3114, February 28, 1956

RECOVERY OF MAGNETITE-ILMENITE-HEMATITE AND ZIRCON FROM SAMPLES OF NATASHQUAN RIVER BEACH SAND SUBMITTED BY THE ACONIC MINING CORPORATION, MONTREAL, QUEBEC
BY R. A. ELLIOTT

Tonnage: Tonnage estimated by EMR in 1967: 1,500,000,000

Sand samples tested: 10 lb (No. 1) and 6 tons (No. 2) of sands.

Mineralogy: MD Test Report No. 785 - CC, December 30, 1955. This report contained detailed mineralogy of all sand samples sent by Aconic.

The major metallic minerals were magnetite, hematite, ilmenite and ilmenite-hematite intergrowths. Minor minerals were zircon, monazite and rutile. Gangue was represented by feldspar, garnet and quartz.

Analysis: Sample No. 1: 30.7% Fe, 16.5% TiO_2; Sample No. 2: 34.7% Fe, 11.1% TiO_2.

Purpose of investigation: To produce the following concentrates: magnetite, ilmenite-hematite and zircon-monazite.

Methods of concentration: Low- and high-intensity magnetic separation, electrostatic separation and tabling. (Major test work was carried out on Sample No. 2).

Summary of results and conclusions: (Sample No. 2)

Magnetite concentrate: Magnetite cleaner concentrates of 68 to 69% Fe were produced. The iron recoveries were not reported. The TiO_2 in the concentrates assayed 1.6 to 1.8%. These concentrates, therefore, were not suitable for steel production.

Ilmenite-hematite concentrate: The Carpco electrostatic concentrate assayed about 45% Fe and 30% TiO_2. The recoveries were not reported.

Zircon and monazite concentrate: The high-intensity magnetic concentrate assayed 67 to 68% ZrO_2 + HfO_2. The zircon recovery was not reported. The analyses were done by a commercial laboratory and reported only to Dr. Peter Ensio; results were not forwarded to the Mineral Dressing Laboratory. The final recoveries were not calculated and thus no conclusion was stated in the report.

Investigation Report No. MD3162, November 22, 1956

CONCENTRATION OF HEAVY MINERALS FROM VARIOUS SAMPLES OF CRUDE SAND AND PILOT PLANT PRODUCTS FROM THE NATASHQUAN BEACH SAND DEPOSIT OF THE ACONIC MINING CORPORATION, MONTREAL, QUEBEC
BY R. A. ELLIOTT

Tonnage: Tonnage estimated by EMR in 1967: 1,500,000,000

Sand samples tested: 13 samples from various areas of the deposit ranging from 7 lb to 18 tons were investigated.

Mineralogy: The major metallic minerals in these samples were magnetite, hematite and ilmenite while quartz, feldspar, garnet, and pyroxene were the major non-metallic minerals. Some sphene, hornblende, zircon, rutile and epidote were also present.

Analysis: Recorded in each progress report.

Purpose of investigation: To determine the grade of concentrate obtainable from each sample, i.e. no recoveries were requested.

Methods of concentration: Gravity concentration, low- and high-intensity magnetic separation and electrostatic concentration.

Summary of results and conclusions: Based on the average figure from all ten progress reports the assays of the concentrates obtained were summarized as follows:

Magnetite concentrates: These concentrates assayed 67 to 69% Fe and 3.5 to 2.0% TiO_2 and would not be suitable for steel production.

Ilmenite-hematite concentrates: These concentrates assayed about 48% Fe, and 29% TiO_2. The zircon concentrates produced were not analyzed.

Mines Branch Investigation Report IR 59-40, May 6, 1959

CONCENTRATION TESTS ON A SAMPLE OF BEACH SANDS FROM THE MOUTH OF THE NATASHQUAN RIVER, QUEBEC, SUBMITTED BY SOGEMINES CONSULTANTS LTD. MONTREAL, QUEBEC

BY J. D. JOHNSTON

Tonnage of the Area:

Tonnage: Estimated tonnage by EMR in 1967: 1,500,000,000

Sand samples tested: Two samples were tested: 1465 lb on a laboratory scale and 24 tons on a pilot plant scale.

Mineralogy: (Min. Rep. No. M-1615-E, October 7, 1958)

The major constituents in the gravel were quartz and feldspar followed by magnetite, ilmenite and hematite, hornblende, pyroxene, garnet and sphene. Zircon, rutile and monazite were also present but in very small amounts. Most of the metallic minerals were in the minus 65-mesh portion of the sand while most of the quartz and feldspar were in the plus 65-mesh fraction.

The magnetite occurred largely as individual grains and was not appreciably intergrown with other minerals except with some hematite. This was probably the result of partial oxidation of some of the magnetite grains. The ilmenite and hematite were intimately intergrown. All the other minerals present in the sample occurred essentially as free grains.

Analysis: The following composition was determined: 18.5% total Fe, 4.97% TiO_2, 0.08% P, 0.069% S, 66.43% Insol and 46.14% SiO_2.

Purpose of investigation: It was requested that a magnetite concentrate of as good grade as possible be produced with maximum recovery.

Methods of concentration: Low- and high-intensity magnetic separation.

Summary of results and conclusions: Laboratory tests indicated that 53 to 54% of the iron in the form of magnetite could be recovered without grinding in a concentrate assaying about 65% Fe and 2.56% TiO_2. Grinding the sands to 60% finer than 200 mesh produced a concentrate assaying 70% Fe and 1.21% TiO_2, containing about 48-49% of the iron present in the sand.

The ilmenite-hematite concentrate assayed 34.06% Fe, 17.60% TiO_2 and 28.72% Insol, and contained 36.2% of the iron and 75.6% of the TiO_2 in the sand.

The pilot plant results were slightly inferior to those of the laboratory testing.

Investigation Report No. MD3107, June 1, 1956

CONCENTRATION TESTS ON A SAMPLE OF TITANIFEROUS MAGNETITE FROM PINNACLE MOUNTAIN, SUTTON TOWNSHIP, QUEBEC, SUBMITTED BY GRAVIMETRIC SURVEYS LIMITED, OTTAWA, ONTARIO

BY W. S. JENKINS

Samples tested: Two samples, 310 lb and 18 lb, were received for this investigation and combined.

Mineralogy: (Min. Lab. Report No. M-1714-E, October, 1955)

Gangue material consisted of soft fine clay minerals together with scattered grains of quartz and zircon. Clay formed the matrix in which the metallic mineral particles and the hard non-metallic mineral grains were embedded. The metallic minerals present in order of decreasing abundance in the combined sample were hematite, magnetite, ilmenite and rutile. Hematite and magnetite grains occurred alone and intimately associated with ilmenite and with gangue. Rutile was present in gangue as occasional free grains some of which are well rounded in shape

Analysis: The following constituents were determined: 26.3% Fe, 20.49% TiO_2, 1.32% Zr. Determination of the rutile content in the sample and products was also done and is reported in the Min. Lab. Report No. M-1430-E, January 1956 and summarized in Investigation Report No. MD3107. The non-magnetic fraction of the low-intensity magnetic separation contained practically all of the ilmenite of the crushed ore and most of the rutile was in the minus 48-plus 325-mesh portion of the crushed ore.

Purpose of investigation: To produce a commercial grade iron concentrate and to determine the grade and recovery of rutile (TiO_2) concentrate which could be produced by mineral dressing methods.

Methods of concentration: Low and high intensity magnetic separation, tabling and flotation.

Summary of results and conclusions: At minus 100-mesh grind and minus 200 mesh regrind, the iron concentrates assayed 63.3% Fe and 6.77% TiO_2, and 68.5% Fe and 2.29% TiO_2 respectively. The respective iron recoveries in the iron concentrates were only 25.5% and 17.2%. The TiO_2 concentrate produced assayed 33.3% TiO_2 and 37.1% Fe. It was concluded that commercial exploitation of this deposit did not look promising.

Mines Branch Investigation Report IR 60-51, November 25, 1960

MAGNETIC CONCENTRATION OF IRON ORE FROM TAMARA MINING LIMITED, WEXFORD TOWNSHIP, P.A.

BY W.S. JENKINS

Tonnage: Tonnage estimated by EMR in 1969: 230,000,000

Ore samples tested: Four samples of magnetite-ilmenite ores were investigated.

Mineralogy: (Internal Report MS-60-18)

Mineralogical examination was carried out on a 175-lb laboratory sample. This sample consisted predominately of magnetite, ilmenite, pyroxene, feldspar and a very small amount of sulphide minerals, mainly pyrite and pyrrhotite. Most of the magnetite and ilmenite were finely intergrown. Feldspar was coarse grained and almost completely liberated from the other minerals at a minus 65-mesh grind. The pyroxene, dark green in colour and mostly free, contained about 9% chemically combined iron. The apatite, which amounts to about 2% of the ore, was coarse grained and had smooth boundaries with other minerals.

Analysis of laboratory sample: 20.4% total Fe, 17.4% soluble Fe, 8.83% TiO_2, 51.40% Insol, 33.35% SiO_2, 7.73% Al_2O_3, 9.74% MgO, 0.77% P, and 0.32% S. Other components were not analyzed.

Analysis of Pilot Plant Samples

Constituent	"Green" Sample, %	"White" Sample, %	"No Colour" Sample, %
Fe (total)	19.7	20.7	20.8
TiO_2	6.12	7.52	7.76

Other components were not analysed.

Purpose of investigation: To produce separate iron and titanium concentrates of acceptable commercial grades.

Methods of concentration: Low-intensity magnetic separation was applied for magnetite (iron) concentration, and tabling and a high-intensity magnetic separation of the pilot plant tailings were used for the ilmenite (titanium) concentration.

Summary of results and conclusions:

Laboratory investigation: Relatively fine grinding of all four samples was required for a reasonable liberation of magnetite and ilmenite both from each other and from the gangue minerals. From a minus 200-mesh grind the following iron concentrates were produced:

Iron Concentrates	Assay%		Distn%
	Fe (total)	TiO_2	Fe (total)
From laboratory sample	69.0	0.55	25.5
From pilot plant samples	66.2	0.6	50.1

Pilot plant investigation: The best iron concentrate obtained from the minus 200-mesh grind from the three pilot plant samples combined assayed 68.2% total Fe and 0.5% TiO_2 with 50% iron recovery.

The ilmenite concentrates assayed between 27% TiO_2 and 46% TiO_2 but TiO_2 recoveries were low at 30% and 3% TiO_2 respectively.

The iron concentrate was not suitable for steel production due to high TiO_2 content.

The ilmenite concentrate had a good TiO_2 grade but low titanium recovery.

M.D. Test Report No. 828-OD, July 12, 1956

MAGNETIC CONCENTRATION TESTS ON A SAMPLE OF BEACH SAND FROM THE NORTH SHORE OF THE GULF OF ST. LAWRENCE, SAGUENAY COUNTY, QUEBEC, SUBMITTED BY E. J. OLIVIER, PEBBLE BEACH, CALIFORNIA, U.S.A.
BY S. CHWASTIAK

Sand sample tested: About 80 lb of magnetite-hematite-ilmenite

sands representing about one square mile of beach.

Mineralogy: (Min. Rep. No. M-1433-E, March 8, 1956)

About 80% by weight of the sand was coarser than 65 mesh. Most of the metallic minerals were in the minus 100-mesh portion of the sand.

Major constituents of the sand were quartz and feldspar. The other non-metallic minerals present were orthopyroxene, amphibole, garnet, sphene, zircon, and monazite. The metallic minerals in the sand were magnetite, hematite, ilmenite, rutile and zircon. It was reported that magnetite was mostly free from other minerals, while hematite and ilmenite were extremely finely intergrown.

Analysis: This sand contained: 10.80% total Fe, 8.77% soluble Fe, 3.04% TiO_2 and 53.52% SiO_2.

Purpose of investigation: To produce an iron concentrate low in titanium.

Method of concentration: Low-intensity magnetic separation.

Summary of results and conclusions: The best magnetite concentrate obtained assayed 67.8% Fe and 2.78% TiO_2 with only 21.9% iron recovery.

An iron concentrate low in titanium could not be produced from this sand by the method applied.

Mines Branch Investigation Report IR 60-71, August 25, 1960

MAGNETIC CONCENTRATION OF BEACH SANDS FROM NEAR THE JUNCTION OF THE BATISCAN AND ST. LAWRENCE RIVERS, P.Q.

BY W. S. JENKINS

Sand sample tested: About 2 lb of beach sand composed of grab samples taken along 1000 feet of the beach.

Mineralogy: (MB Internal Report MS-60-60, January 23, 1960)

The non-metallic minerals in the sand were quartz, feldspar, hornblende and pyroxene. The metallic minerals were magnetite, plus small amounts of ilmenite, hematite and zircon. Some ilmenite was finely intergrown with magnetite.

Analysis: This sample assayed 28.6% Fe (total), 22.6% soluble Fe and 8.86% TiO_2.

Purpose of investigation: To investigate the separability of metallic minerals.

Methods of concentration: Low-and high-intensity magnetic separation.

Summary of results and conclusions: The magnetite concentrate produced from non-ground sand assayed 68.82% Fe (total), 2.12% TiO_2 with 54.7% Fe recovery. The titanium content in this concentrate could not be lowered below 1.54% TiO_2 even after a minus 200-mesh grind of the concentrate and thus this concentrate was not suitable for steel production. The ilmenite concentrate produced assayed 36.30% Fe (total), 31.28% TiO_2 with 31.0% Fe and 86.1% TiO_2 recoveries. Only negligible amounts of zircon and rutile were present in the high intensity tailing.

Tonnage: Tonnage estimated by EMR in 1969: 230,000,000

M.D. Test Report No. 857-OD, November 29, 1956

PRELIMINARY CONCENTRATION TESTS ON A SAMPLE OF IRON-TITANIUM ORE FROM CONTINENTAL IRON AND TITANIUM MINING LIMITED, MONTREAL, QUEBEC
BY W. S. JENKINS

Tonnage: Tonnage estimated by EMR in 1969: 22,000,000

Ore sample tested: Sample No. 1. Ilmenite-hematite ore.

Mineralogy: (Min. Rep. M-1486-E, December 17, 1956)

Ore sample No. 1 consisted mainly of metallic minerals and a small amount of gangue. Main metallic minerals were ilmenite, hematite and a very small amount of pyrite. Ilmenite predominated in each section as massive granular aggregates, in which individual grains ranged up to 3 mm across with average size about 1.5 mm (-10 + 14 mesh) and almost every grain contained numerous inclusions of hematite. In some grains of ilmenite, however, hematite also occurred in larger, more or less irregular blebs showing no regular pattern. Gangue consisted largely of plagioclase feldspar with minor amounts of associated serpentine and spinel. These minerals occurred in ilmenite as occasional small rounded inclusions and irregular masses up to 3 or 4 mm across the longest direction.

Analysis: This ore assayed: 38.68% total Fe, 41.48% TiO_2, 1.15% SiO_2.

Purpose of investigation: To produce an ilmenite-iron concentrate containing not less than 43.5% titanium dioxide from crushed ore.

Methods of concentration: Roasting in air, low-intensity magnetic separation, high-intensity magnetic separation and electrostatic concentration of crushed ore. Concentration of ground ore was not carried out.

Conclusion (laboratory investigation): The methods applied on Sample No. 1 failed to produce an ilmenite-iron concentrate of 43.5% TiO_2 or higher.

M.D. Test Report No. 863-OD, January 5, 1957

PRELIMINARY CONCENTRATION TESTS ON A TABLE CONCENTRATE FROM BIGNELL LEAN ORE AND DIAMOND DRILL CORES FROM BIGNELL NOS. 2 AND 3 IRON-TITANIUM ORE, SUBMITTED BY CONTINENTAL IRON AND TITANIUM MINING LIMITED, MONTREAL, QUEBEC

BY W.S. JENKINS

Tonnage:

Tonnage estimated by EMR in 1969: 22,000,000

Ore samples tested: Diamond drill samples No. 2 and No. 3, ilmenite-hematite ore.

Analysis: These samples contained:

	Per Cent	
Constituent	Sample No. 2	Sample No.3
Fe (total)	39.90	34.70
TiO_2	39.96	33.03
SiO_2	3.06	10.73
CaO	0.8	2.05
MgO	3.25	3.13
Al_2O_3	4.55	8.20
V_2O_5	0.31	0.20
Cr_2O_3	0.21	0.14
P_2O_5	0.01	0.18
S%	1.01	0.94

Purpose of investigation: To produce an ilmenite-iron concentrate containing not less than 43.5% titanium dioxide from crushed ore.

Methods of concentration: Roasting in air, low- and high-intensity magnetic separation and electrostatic concentration of crushed ore.

Summary of results and conclusions from No. 2 and No. 3 Samples

Sample	Concentrate	
	TiO_2%	Recovery%
Bignell No.2	42.4	81.4
Bignell No.3	41.9	62.2

The methods applied failed to produce an ilmenite-iron concentrate of 43.5% TiO_2 or higher.

M.D. Test Report No. 895-OD, September 9, 1957

PRELIMINARY CONCENTRATION TESTS ON SAMPLES OF RUTILE-ILMENITE ORE SUBMITTED BY CONTINENTAL IRON AND TITANIUM MINING, LIMITED, MONTREAL, QUEBEC
BY W. S. JENKINS

Tonnage: Tonnage estimated by EMR in 1969: 22,000,000

Ore samples tested: Ilmenite-rutile ore samples No. 1 and No. 2

Mineralogy: Not reported.

Analysis:

Constituent	Per cent	
	Sample No.1	Sample No.2
Fe (total)	31.0	30.64
TiO_2	46.5	45.36
Rutile	9.25	8.24

Purpose of investigation: To determine the grind necessary to recover rutile and ilmenite in separate concentrates of commercial grade and to determine if standard methods of grinding and concentration can be applied to this type of ore.

Methods of concentration: High-intensity magnetic separation and tabling from dry and wet grind (35 mesh and 48 mesh).

Summary of results and conclusions: An ilmenite concentrate assaying up to 48% TiO_2 and a rutile concentrate assaying up to 91.6% TiO_2 were obtained. However, the indicated recoveries were low. Since the wet concentration method appeared to give better results, it was decided to make pilot-plant runs on 25 tons of ore using wet grinding by rod mill followed by wet concentration methods. (See Investigation Report No. MD3218, September 10, 1957).

Investigation Report No. MD3218, September 10, 1957

RESULTS OF PILOT PLANT RUNS ON A SHIPMENT OF TWENTY-FIVE TONS OF ORE FROM THE ST. URBAIN (CHARLEVOIX COUNTY, QUEBEC) PROPERTY OF CONTINENTAL IRON AND TITANIUM MINING LIMITED, MONTREAL, QUEBEC
BY W. S. JENKINS

Tonnage: Tonnage estimated by EMR in 1969: 22,000,000

Ore sample tested: 20-ton sample of rutile ore.

Mineralogy: Not reported.

Analysis: The pilot plant sample assayed: 46% TiO_2, 10% rutile.

Purpose of investigation: To determine the grades and recoveries of ilmenite and rutile concentrates.

Methods of concentration: Gravity concentration, high intensity and electrostatic magnetic separations of the ore ground to minus 30 mesh.

Summary of results of pilot plant investigation: Pilot plant operation produced about the same TiO_2 grade of ilmenite concentrate and slightly higher TiO_2 grade of rutile than reported in M.D. Test Report No. 895-OD, but the TiO_2 recoveries in both pilot plant concentrates were low (43.9% and 41.7%, respectively).

Other investigations conducted on this deposit at Mines Branch:

MB Investigation IR 60-101, November 11, 1960 (Grinding Tests)

MB Investigation IR 61-21, March 10, 1961 (Selective Reduction of Ilmenite)

MB Internal Report, EMI 60-7, September 21, 1960 (Mineralogical)

Mines Branch Investigation Report IR 59-115, December 30, 1959

MAGNETIC CONCENTRATION OF TITANIFEROUS-MAGNETITE ORE FROM PONTIAC COUNTY, QUEBEC, SUBMITTED BY CHARLES I. LYNCH

BY W.S. JENKINS

Ore sample tested: About 210 lb of magnetite-ilmenite ore.

Mineralogy: The ore sample consisted largely of coarse-grained magnetite and ilmenite, both ranging between 1 and 10 millimeters in diameter. Magnetite contained no visible inclusions of ilmenite or other titanium minerals. Although it seemed that separation of magnetite and ilmenite would be accomplished without difficulty, the results showed that the magnetite concentrate contained 1.85% TiO_2 at a minus 200-mesh grind. This suggested that the titanium content of the concentrate (magnetite) could

probably be attributed to titanium chemically combined with the magnetite.

Analysis: The ore assayed: 44.5% Fe (total) and 14.6% TiO_2.

Purpose of investigation: (Not recorded in the report)

Based on the kind of testwork done and the product obtained, the objective was to reject ilmenite and produce an iron (magnetite) concentrate suitable for steel production (maximum 0.1% TiO_2).

Method of concentration applied: Davis tube.

Summary of results and conclusions: The magnetic concentrate from minus 200 mesh ore assayed:

Constituent		Per cent
Total iron	-	68.42
Titanium dioxide	-	1.85
Silica	-	1.06

The recovery of iron was 62.8% and TiO_2 loss was 4.5%.

The non-magnetic tailings assayed 26.6% TiO_2 and contained 95.5% of the TiO_2 in the ore.

Due to high TiO_2 content in the magnetic (iron) concentrate this concentrate was not suitable for steel production.

The concentration of ilmenite was not carried out.

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