M. M. Farnham

O T T A W A January 29th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1350.

Concentration of Manganese Ore from Brigus, Newfoundland.

IR 1350

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BUREAU OF MINES
DIVISION OF METALLIC MINERALS
ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Concentration of Manganese Ore from Brigus, Newfoundland.

Shipment:

A shipment of 22 bags of ore, net weight 2,590 pounds, was received on September 8th, 1942, from the Brigus Manganese Limited, 774 Notre Dame Street West, Montreal, Quebec. This sample was submitted by Fernand Roy, of the same address, and by R. M. Macaulay, Consulting Mining Engineer, 598 Grosvenor Avenue, Westmount, Quebec, supervisor for the Brigus Manganese Limited.

Location of the Property:

The shipment was stated to be from a property at Brigus, Newfoundland.

Purpose of the Investigation:

The investigation was made to determine the grade and character of the concentrate that could be obtained from the ore.

Character of the Ore:

Polished and thin sections, made from selected specimens of the ore, were studied microscopically in conjunction with microchemical and spectral analysis.

Non-Metallic Minerals -

The non-metallic minerals, which predominate in the polished surfaces, consist essentially of two distinct types. One appears to be a weathering product. It is soft, grey to dull buff-coloured, and spectrographic analysis and microchemical tests prove that it contains only very slight traces of manganese. The other is comparatively hard reddish-brown material which is soluble in hydrochloric acid (HCl) and gives strong tests for manganese. This is the portion which tends to sink in the sink-and-float tests, and which shows considerable loss of weight on ignition, with consequent rise in the manganese content of the product. In thin sections the transparent minerals are so extremely finely crystalline as to defy identification but it would appear that the soft type largely consists of earthy and friable silicates, and that the harder reddish-brown type is essentially manganese carbonate (rhodochrosite). Rare, narrow, irregular stringers of quartz are visible, transecting both the non-metallic and metallic assemblages.

(Continued on next page)

(Character of the Ore, cont'd) -

Metallic Minerals -

Metallic mineralization is represented almost entirely by a mixture of manganese oxides, probably largely pyrolusite. For the most part those occur as small, fine-grained masses which contain narrow veinlets and numerous small inclusions of non-metallic minerals. Small amounts are present also as tiny ragged grains unevenly disseminated through non-metallic assemblages and as narrow irregular stringers transecting it.

Pyrite is visible in practically negligible amount, as very rare small grains in the transparent minerals.

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Sampling and Analysis:

The shipment was crushed to pass a $\frac{1}{2}$-inch screen and sampled by standard methods. The head sample was found to contain:

			Per cent
Manganese	(Mn)	=	33.35
Iron	(Fe)	=	3.60
Silica	(SiO_2)	=	18.69
Phosphorus	(P)	=	0.06
Carbon dioxide	(CO_2)	=	6.69
Sulphur	(S)	=	0.13
Calcium oxide	(CaO)	=	Trace.

Investigative Procedure:

A screen analysis of the head sample was made.

Roasting tests of the various screen products at different temperatures were made.

Several concentration tests were made using straight flotation, jigging and tabling at various sizes.

Sink-and-float tests were made on various sizes with mediums of varying densities.

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Results of Investigative Tests:

The sink-and-float process shows the best results, giving a concentrate assaying 42.7 per cent manganese, which on roasting at 1700° F. assays Mn, 57.1 per cent and SiO_2, 8.10 per cent.

Roasting raw ore resulted in raising the grade of the manganese from 33.5 per cent to 40.5 per cent.

The ore in this shipment was not amenable to treatment by flotation, jigging, or table concentration, the oxide and carbonate minerals being so close to the soft silicate mineral in specific gravity that gravity separation is not practicable.

DETAILS OF TESTS:

Screen Analysis of the Head Sample.

A portion of the head sample was screened on ½ inch, 8 mesh, 14, and 35 mesh screens and the products of each size were sampled and assayed. The balance of each size was used in subsequent roasting tests.

Results of Screen Analysis.

Screen	Mn assay, per cent
-½+¼ inch	34.74
-¼ inch +8 mesh	33.54
-8 mesh +14 "	32.89
-14 " +35 "	33.59
-35 mesh	31.40

(Continued on next page)

(Details of Tests, cont'd) -

The samples of ore were roasted one hour at indicated temperatures in a muffle furnace.

Results of Roasting Tests on Screened Products.

Test No.	Size Feed	Temp. of Roast, °C.	Assays, per cent FEED Mn	ROASTED ORE Mn	ROASTED ORE CO_2	ROASTED ORE SiO_2	Loss in weight, per cent
1	-½+¼ inch	400	34.74	39.11	4.16	-	14.7
2	"	600	34.74	41.29	0.14	-	20.3
3	"	800	34.74	41.95	0.10	-	21.0
4	"	1000	34.74	43.82	0.0	-	23.1
5	"	1100	34.74	41.19	0.12	22.96	27.1
6	-¼+8	600	33.54	39.94	0.075	-	18.7
7	"	800	33.54	40.54	0.05	-	20.0
8	"	1000	33.54	40.54	0.075	22.67	22.3
9	"	1100	33.54	39.49	0.127	-	23.3
10	-8+14	600	32.89	39.48	0.16	-	16.3
11	"	800	32.89	39.90	0.0	-	16.8
12	"	1000	32.89	39.69	0.05	-	17.3
13	-14+35	600	33.59	38.62	0.09	-	15.0
14	"	800	33.59	39.45	0.03	-	16.2
15	"	1000	33.59	39.52	0.0	-	17.6

Several roasting tests were made on unsized ore, crushed minus ½ inch.

Roasting Tests on Unsized Ore.

Test No.	Size Feed	Temp. of Roast, °C.	Assays, per cent FEED Mn	ROASTED ORE Mn	ROASTED ORE CO_2	ROASTED ORE SiO_2	Loss in weight, per cent
16	-½ inch	600	33.35	40.65	0.06	-	18.8
17	"	800	33.35	40.27	0.0	-	19.2
18	"	1000	33.35	39.75	0.09	-	20.4

Several selected lumps of ore varying in size from 1½ to 2½ inches in diameter were roasted at 800° C. and finished at 1030° C. The calcined lumps were found to contain 55.9 per cent Mn, 8.2 per cent SiO_2. A loss in weight of 27.1 per cent was recorded.

(Details of Tests, cont'd) -

Flotation.

The microscopic examination indicates that the character of the ore will preclude successful concentration of manganese and elimination of the gangue minerals, both of which are extremely small.

Fifteen flotation tests were made on samples of the ore, using various degrees of grinding and various combinations of reagents, without producing a suitable concentrate or elimination of gangue minerals.

Flotation tests were abandoned.

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Concentration by Jigging.

A sample of the ore was crushed minus $\frac{1}{4}$ inch and screened on various screens to give uniformly sized products for jigging. The following screen sizes were jigged and the jig products sampled and assayed for manganese, -$\frac{1}{4}$"+4 mesh, -4+8 mesh, -8+10 mesh, -10+14 mesh. The minus 14 mesh material was reserved for concentration on a Wilfley table.

Results:

Jigging, -$\frac{1}{4}$"+4 Mesh Ore.

Product	Weight, per cent	Assays, per cent Mn	Distribution, per cent Mn	Ratio of concentration
Feed	100.0	35.12	100.0	
Jig	80.3	35.71	81.7	1.25:1.
" middling	12.6	34.36	12.3	7.9:1.
" tailing	7.1	29.84	6.0	

Jigging, -4+8 Mesh Ore.

Feed	100.0	33.10	100.0	
Jig concentrate	16.2	37.67	18.4	6.2:1.
" middling	59.1	32.70	58.4	1.7:1.
" tailing	24.7	31.04	23.2	

(Continued on next page)

(Concentration by Jigging, cont'd) -

Jigging, -8+10 Mesh Ore.

Product	Weight, per cent	Assays, per cent Mn	Distribution, per cent Mn	Ratio of concentration
Feed	100.0	35.46	100.0	
Jig concentrate	44.5	37.52	47.1	2.25:1.
" middling	36.9	34.81	36.2	2.7:1.
" tailing	18.6	31.80	16.7	

Jigging, -10+14 Mesh Ore.

Feed	100.0	35.85	100.0	
Jig concentrate	26.7	40.39	30.0	3.75:1.
" middling	38.5	36.77	39.5	2.6:1.
" tailing	34.8	31.35	30.5	

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Table Concentration.

These tests were made on minus 14 mesh ore reserved from the jig tests. The ore was sized -14+28 mesh and -28+48 mesh. The minus 48 mesh ore was rejected.

Results:

-14+28 Mesh Ore.

Product	Weight, per cent	Assays, per cent Mn	Distribution, per cent Mn	Ratio of concentration
Feed	100.0	35.61	100.0	
Table concentrate	73.1	37.37	76.7	1.4:1.
" middling	17.9	29.84	15.0	5.6:1.
" tailing	9.0	32.85	8.3	

-28+48 Mesh Ore.

Feed	100.0	35.10	100.0	
Table concentrate	63.2	36.77	66.2	1.6:1.
" middling	21.6	31.80	19.6	4.6:1.
" tailing	15.2	32.70	14.2	

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(Details of Tests, cont'd) -

SINK-AND-FLOAT.

Preliminary tests were made on samples of the ore. For purposes of obtaining a representative head sample, the shipment had been crushed to $\frac{1}{2}$ inch. This produced considerable fine ore which is not amenable to treatment by the sink-and-float method. The tests indicate that the fine ore cannot be treated by flotation or gravity methods to obtain a satisfactory grade of concentrate or recovery.

The sink-and-float tests were made on screened samples, $-\frac{1}{2}"+3$ mesh and $-\frac{1}{2}"+8$ mesh.

Results of Test No. 1:

Size range of ore treated, $-\frac{1}{2}"+3$ mesh.
Separating density, 2.80.

Product	Weight, per cent	Assays, per cent Mn	Assays, per cent SiO_2	Loss in weight, per cent	Distribution, per cent Mn	Distribution, per cent SiO_2
-3 mesh fines	62.07	35.70	16.22	18.09	60.53	67.14
Float @ 2.80	11.78	27.92	27.98	12.39	8.96	21.98
Sink @ 2.80	26.15	42.67	6.24	15.24	30.49	10.88
S.F. feed	37.93	38.09	12.99		39.47	32.86
Ore	100.00	36.61	15.00		100.00	100.00
Sink product roasted	19.55	57.06	8.10		30.49	10.88

The recovery was low owing to the high percentage of untreatable fines.

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(Sink-and-Float, cont'd) -

Results of Test No. 2:

Size range of ore treated, -$\frac{3}{8}$+8 mesh.
Separating density, 2.70.

Product	Weight, per cent	Assays, per cent Mn	Assays, per cent SiO_2	Loss in weight, per cent	Distribution, per cent Mn	Distribution, per cent SiO_2
-8 mesh fines	39.62	35.30	17.24	14.96	38.93	45.54
Float @ 2.70, calculated	25.17	29.34	22.90	14.24	20.55	38.42
Sink @ 2.70	35.21	41.34	6.83	23.32	40.52	16.04
S.F. feed	60.38	36.34	13.53		61.07	54.46
Ore	100.00	35.95	15.00		100.00	100.00
Sink product roasted	27.00	55.91	8.91			

About 40 per cent of the manganese is in the untreatable fines, and it is hoped that crushing coarser than $\frac{1}{2}$ inch will reduce this figure to 20 per cent or less and that more efficient separation will result from the coarser feed.

SUMMARY AND CONCLUSIONS:

The first tests made on the ore were roasting various-sized samples from -$\frac{1}{2}$ inch to +35 mesh. There was a loss in weight varying from 15 to 27 per cent. This results in a concentration of the values, raising the analysis of manganese and silica.

Roasting of selected lumps of ore from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in diameter resulted in a grade of 55.9 per cent manganese and 8.2 per cent silica. This result is comparable

(Summary and Conclusions, cont'd) -

to the roasted sink-and-float product (sink @ 2.80), manganese 57.06 per cent, silica 8.10 per cent.

Flotation tests were made on several samples of the ore. The results indicate that flotation concentration is unsuitable for this type of ore.

Jig concentration tests were made on several sizes of feed. The recoveries and grades of the jig concentrate were low.

Concentration tests were made on a Wilfley table, with practically the same results as with the jig. The table feed was sized -14+28 and -28+48 mesh.

It was noted that the ordinary methods of flotation and gravity concentration do not apply to this type of ore.

The failure of the ore to respond to the better known methods of gravity concentration is explained by the fact that there is not enough difference in the specific gravities of the manganese-bearing minerals and the silicate minerals. The presence of considerable quantities of water of crystallization brings them much closer together than would be normally expected.

The sink-and-float process was tried on samples sized -$\frac{1}{2}$"+3 mesh and -$\frac{1}{2}$"+8 mesh, with encouraging results. The sink at 2.80 product had a higher grade, 42.7 per cent manganese and 6.24 per cent silica, than any previous test concentrate. When roasted, the concentrates analysed 57.1 per cent manganese and 8.1 per cent silica.

The sink-and-float process cannot be used to treat material finer than 8 mesh. Concentration of ore -1$\frac{1}{2}$ to 1 inch should also be made to determine recoveries at these sizes. The shipment had been crushed minus $\frac{1}{2}$ inch for sampling and no 1$\frac{1}{2}$ inch-sized ore was available.

The recoverable values in the sample under

(Summary and Conclusions, cont'd) -

investigation apparently are rhodochrosite centres with coatings of oxides. Selected nodules larger than 1½ inches in diameter after roasting assayed 55.9 per cent manganese, 8.2 per cent silica.

In crushing to minus ½ inch, about 40 per cent of the ore was finer than 8 mesh. Coarser crushing, 1½ to 1 inch, would reduce the amount of untreatable fines, and if a satisfactory separation can be made at the coarser sizes as much as 75 per cent of the manganese may be recovered as a concentrate.

Roasting at 1700° F. for 2½ hours gave a loss in weight of 23 to 25 per cent for the sink product, the loss being due largely to carbon dioxide and water of crystallization.

This material would require roasting to produce a satisfactory metallurgical product.

The results of this investigation can apply only to ore of similar grade and character as in the shipment submitted. Further work on sink-and-float tests should be made on a representative sample of the proposed concentrator feed, which should include a proportional amount of fines which would result from mining the ore.

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