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

by

W. S. JENKINS

MINERAL PROCESSING DIVISION

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

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W. S. Jenkins*

SUMMARY OF RESULTS

The shipment assayed 47.2% total iron, 44.5% acid soluble (HCl) iron and 11.21% titanium dioxide.

The concentrate from ore ground to -48 M assays 67.8% Fe and 0.55% TiO_2. The -65M and -100 M 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 -48 M, 69.1% at -65 M and 66.4% at -100 M. The -100 M concentrate also contained 0.62% SiO_2, 0.144% S, and less than 0.005% P.

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

* Senior Scientific Officer, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

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INTRODUCTION

Shipment

On November 14, 1960, Mr. W. H. Strong, Perth, Ontario, personally delivered a sample of ore, consisting of six large fragments of rock, net weight 395 lb, to the Mineral Processing laboratories.

Location of Property

In his covering letter, Mr. Strong stated that the sample was taken from properties held under option in North Crosby township, County of Leeds, approximately four miles northwest from the village of Westport, Ontario.

Purpose of Investigation

The investigation was to determine the grind necessary to obtain a commercial grade of iron with rejection of titanium dioxide to specifications; and to determine the recovery and grade of ilmenite from the tailing.

Description of Property

No description of the property was given in the letter.

SAMPLING AND ANALYSIS OF SHIPMENT

After samples were obtained for a mineralogical examination by the Mineral Sciences Division, Mines Branch, the ore was crushed and a head sample was obtained.

Samples for tests were cut out. The remaining ore was bagged and reserved.

TABLE 1

Chemical Analysis of Head Sample

	%
Total iron	47.2
Iron (HCl soluble)	44.5
Silica	6.65
Titanium dioxide	11.21
Phosphorus	0.020
Sulphur	1.48
Copper	0.006

TABLE 2

Semi-Quantitative Spectrographic Analysis of Head Sample

In order of decreasing abundance:

Major constituents - Fe, Ti, Al, Si

Intermediate constituents - Mg, Ca

Minor constituents - Na, Mn, V, Zn

Trace constituents - Co, Ba, Ni, Cr, Cu

MINERALOGICAL EXAMINATION*

Four polished sections were prepared and studied under a reflecting microscope and X-ray analyses were made of powder samples taken from the polished surfaces.

To unaided eyes the four polished sections appear to consist of massive iron oxide(s) containing small scattered particles of sulphide(s) and gangue up to 4 mm in diameter. All sections are strongly magnetic.

Microscopic examination shows that the ore minerals present are magnetite, ilmenite, hematite, and pyrite. Magnetite is most abundant but a considerable amount of ilmenite is associated with it. Commonly these two minerals form mixed granular aggregates containing scattered particles of pyrite and gangue (Figure 1). In some places, however, ilmenite transects magnetite as narrow parallel lamellae, (Figure 2), and some grains of ilmenite contain numerous minute exsolved plates and blebs of hematite, (Figure 3). Although magnetite and ilmenite occur largely as moderately coarse granular masses, small proportions of them are disseminated through gangue in very fine particle sizes, (Figure 4). Pyrite, the only sulphide observed in the sections, occurs as small irregular grains in gangue and in metallic oxides. While most particles of pyrite are between grains of magnetite and ilmenite, some appear to be entirely within grains of these two minerals.

Amphibole, the only gangue mineral identified in the polished

*Internal Report MS-60-117, by W. E. White, December 1, 1960.

sections, is decidedly subordinate to the ore minerals in quantity. 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.

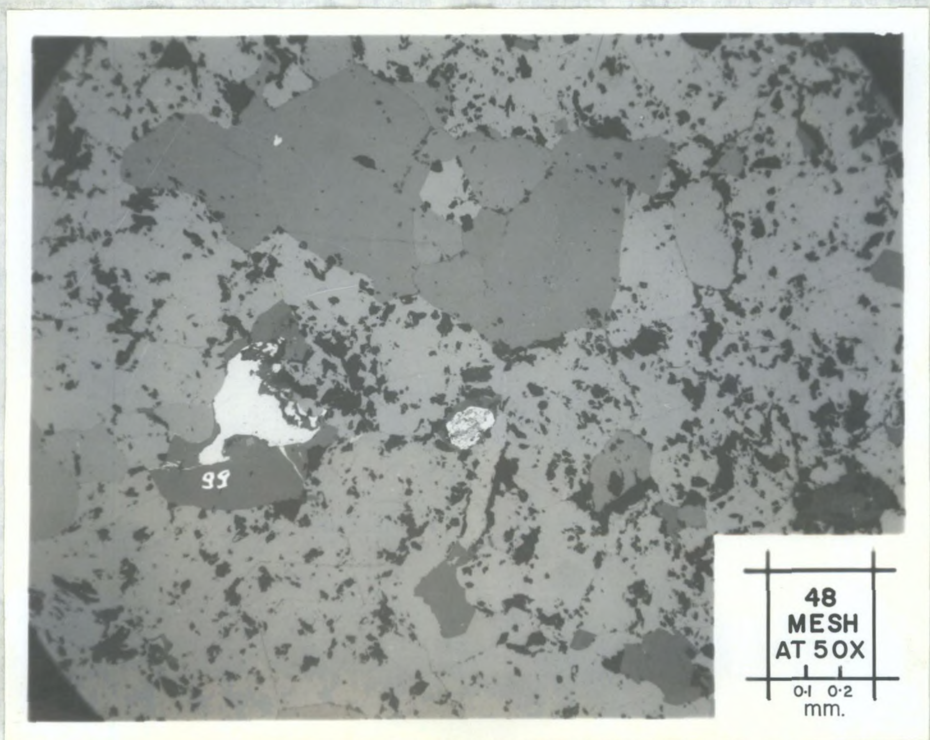

Figure 1. - Typical field in polished section showing mixed granular aggregate of magnetite (light grey, pitted surfaces) and ilmenite (various shades of darker grey); particles of pyrite are white and gangue dark grey (one grain of latter is marked gg); polishing pits are black, crossed polars.

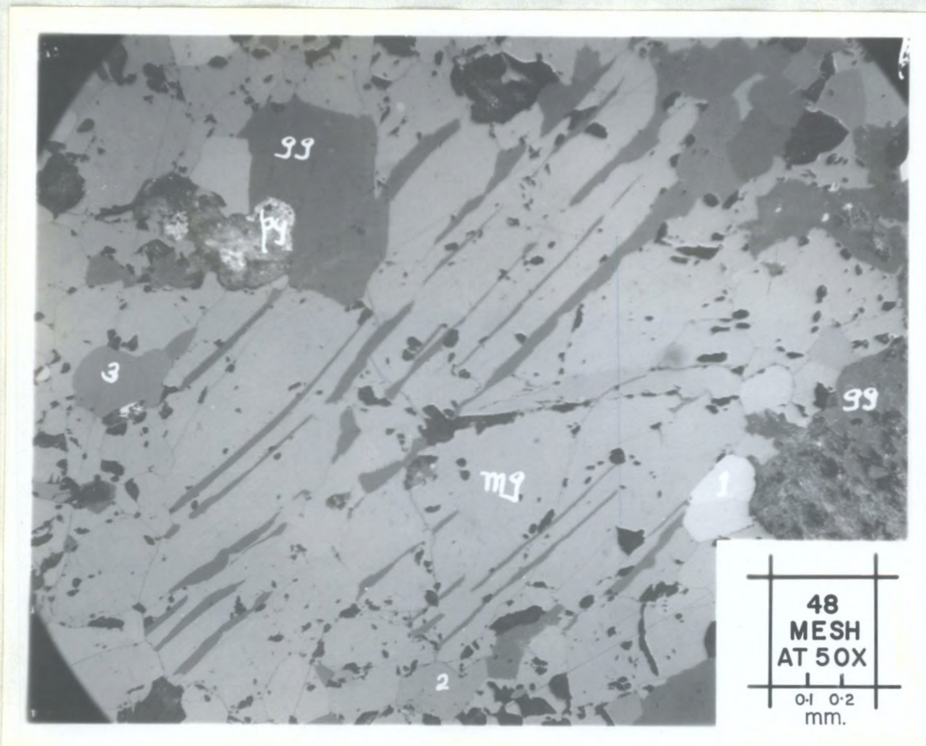

Figure 2. - Narrow parallel lamellae of ilmenite, dark grey, in magnetite (mg), light grey; particles of gangue (gg) are about the same colour as the ilmenite lamellae; other grains of ilmenite are at different orientations and show various shades of grey as at 1, 2, and 3; most of the pyrite (py) has been lost in polishing; pits are black; crossed polars.

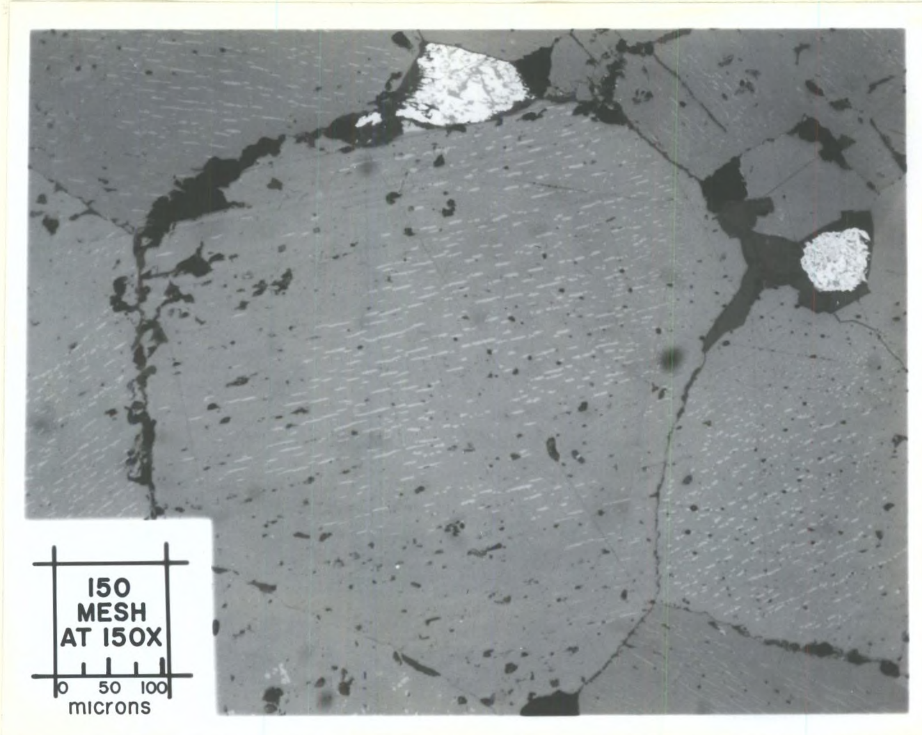

Figure 3. - Photomicrograph of field at higher magnification which shows grains of ilmenite (grey) containing numerous tiny oriented inclusions of hematite (light grey); pyrite particles are white and gangue dark grey; pits, fractures, and grain boundaries are black.

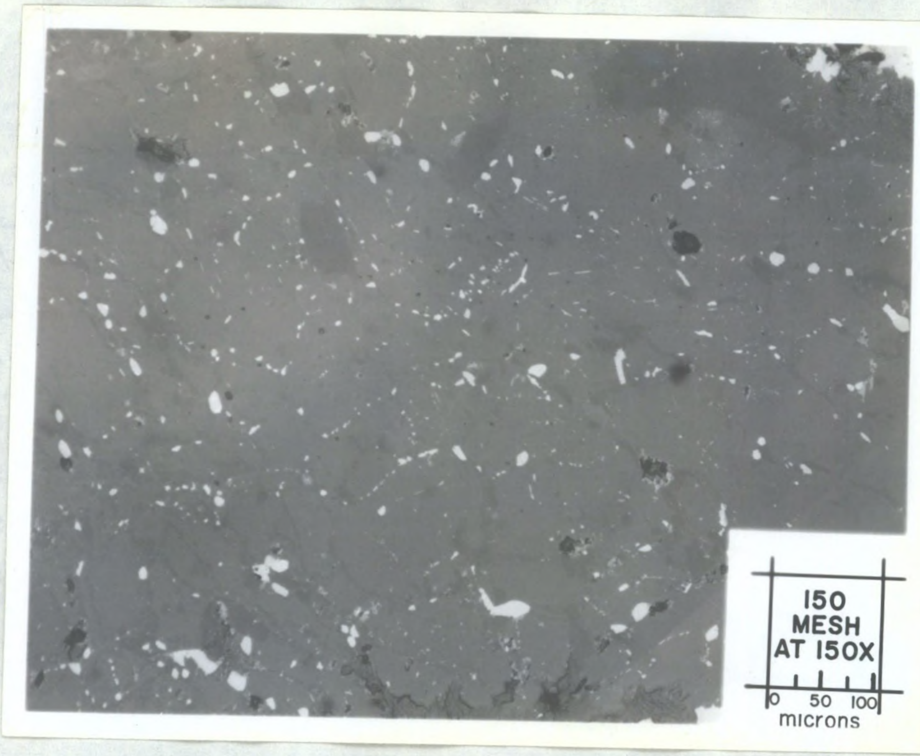

Figure 4. - Field in polished section displaying finely divided magnetite and ilmenite (light grey) scattered through gangue (darker greys); polishing pits are black.

SUMMARY OF TEST PROCEDURE AND RESULTS

Samples of the ore were magnetically concentrated at grinds of -48, -65, -100, -150, and -200 M, to recover magnetite.

The non-magnetic tailings of some tests were concentrated by gravity and also by high intensity magnetic separation to recover ilmenite.

The results of concentrating the five samples at different grinds, by the Davis tube, are as follows:

TABLE 3

Davis Tube Concentrates

Grind	Weight, %	Analysis, % Fe	Distn, % Fe	R/C
-48	54.8	67.6	77.2	1.82:1
-65	52.8	68.8	75.9	1.89:1
-100	52.0	69.6	75.3	1.92:1
-150	52.4	69.3	75.4	1.91:1
-200	52.4	68.4	75.1	1.91:1

R/C = ratio of concentration

The results of concentrating the five samples, at different grinds, by the Jeffrey-Steffensen separator, are as follows:

TABLE 4

Jeffrey-Steffensen Concentrates

Grind	Weight, %	Analysis, %		Distn, %		R/C
		Fe	TiO_2	Fe	TiO_2	
-48	48.2	67.8	0.55	69.9	2.4	2.07:1
-65	47.6	69.1	0.29	69.1	1.2	2.10:1
-100	45.3	69.7	0.28	66.4	1.1	2.21:1
-150	45.1	70.2	0.28	66.8	1.1	2.22:1
-200	40.8	69.9	0.28	60.3	1.0	2.45:1

The results of concentrating ilmenite from tailings by gravity and up-grading the concentrate by high intensity dry separation are as follows:

The table concentrate assayed 35.65% TiO_2 and 2.76% SiO_2. The recovery of TiO_2 in the table concentrate was 62.3% at a ratio of concentration of 5.25:1 in terms of the original feed. The high intensity separator concentrate from the table concentrate, assayed 41.46% TiO_2 and 0.96% SiO_2. The recovery of TiO_2 was 57.2% and the ratio of concentration was 6.7:1 in terms of the original feed.

DETAILS OF TESTS

Test No. 1 - Magnetic Concentration by the Davis Tube Separator

Samples of the ore were ground to -48, -65, -100, -150 and -200 M and concentrated by the Davis tube separator.

TABLE 5

Results of Magnetic Concentration by Davis Tube

Feed -48 M Ore

Product	Weight, %	Analysis, % Fe	Distn, % Fe	R/C
Feed*	100.0	48.0	100.0	
Mag conc	54.8	67.6	77.2	1.82:1
Tailing	45.2	24.2	22.8	

Feed -65 M Ore

Product	Weight, %	Analysis, % Fe	Distn, % Fe	R/C
Feed*	100.0	47.9	100.0	
Mag conc	52.8	68.8	75.9	1.89:1
Tailing	47.2	24.5	24.1	

Feed -100 M Ore

Product	Weight, %	Analysis, % Fe	Distn, % Fe	R/C
Feed*	100.0	48.1	100.0	
Mag conc	52.0	69.6	75.3	1.92:1
Tailing	48.0	24.8	24.7	

Feed - 150 M Ore

Product	Weight, %	Analysis, % Fe	Distn, % Fe	R/C
Feed*	100.0	48.2	100.0	
Mag conc	52.4	69.3	75.4	1.91:1
Tailing	47.6	24.9	24.6	

TABLE 5 (cont'd)

Results of Magnetic Concentration by Davis Tube

Feed -200 M Ore

Product	Weight, %	Analysis, % Fe	Distn, % Fe	R/C
Feed*	100.0	47.7	100.0	
Mag conc	52.4	68.4	75.1	1.91:1
Tailing	47.6	25.0	24.9	

* calculated

R/C = ratio of concentration in terms of the original feed

Test No. 2 - Magnetic Concentration by the Jeffrey-Steffensen Separator

Samples of ore were ground to -48, -65, -100, -150 and -200 M. These were concentrated by a laboratory size Jeffrey-Steffensen 3-drum separator. It produced a concentrate, a middling and a tailing from each of the samples.

The results of these tests indicate that the maximum of titanium dioxide was rejected at the grind of -100 M, the concentrate assaying 0.28% TiO_2. The coarser ore, -48 M and -65 M produced concentrates which assayed 0.55% TiO_2 and 0.29% TiO_2 respectively, both of which are lower than the maximum 1% TiO_2 imposed in some specifications.

TABLE 6

Results of Magnetic Concentration by the Jeffrey-Steffensen Separator

Feed -48 M Ore

Product	Weight, %	Analysis, %		Distn, %	R/C
		Fe	TiO_2	Fe	
Feed*	100.0	46.8		100.0	
Mag conc	48.2	67.8	0.55	69.9	2.07:1
Middling	4.2	50.8		4.6	
Tailing	47.6	25.1	20.24	25.5	

Feed -65 M Ore

Product	Weight, %	Fe	TiO_2	Distn Fe	R/C
Feed*	100.0	47.6		100.0	
Mag conc	47.6	69.1	0.29	69.1	2.10:1
Middling	3.6	56.9		4.3	
Tailing	48.8	25.9	20.6	26.6	

Feed -100 M Ore

Product	Weight, %	Fe	TiO_2	Distn Fe	R/C
Feed*	100.0	47.6		100.0	
Mag conc**	45.3	69.7	0.28	66.4	2.21:1
Middling	4.4	58.1		5.4	
Tailing	50.3	26.8	21.2	28.2	

**conc additional analyses, silica 0.62%, sulphur 0.144%, phosphorus 0 .005%

Feed -150 M Ore

Product	Weight, %	Fe	TiO_2	Distn Fe	R/C
Feed*	100.0	47.4		100.0	
Mag conc	45.1	70.2	0.28	66.8	2.22:1
Middling	5.5	56.7		6.6	
Tailing	49.4	25.6	20.24	26.6	

Feed -200 M Ore

Product	Weight, %	Fe	TiO_2	Distn Fe	R/C
Feed*	100.0	47.3		100.0	
Mag conc	40.8	69.9	0.28	60.3	2.45:1
Middling	5.7	63.5		7.7	
Tailing	53.5	28.3	19.8	32.0	

* calculated Iron only.

Test No. 3 - Concentration of Ilmenite from -65 M Tailing by a High Intensity Wet Separator

This test was made to determine the grade and recovery of ilmenite from Crockett separator tailing.

After separating the magnetite from a sample of -65 M ore, the tailing, consisting of sands and slimes, was concentrated by a Jones high intensity wet magnetic separator to recover ilmenite. The sands and slimes were concentrated separately.

In Table 7 below, the results of concentration by the Crockett separator are shown; and in Table 8 the results of concentration of ilmenite.

The feeds to the Jones separator were first concentrated at 0 amp and the tailing from 0 amp were re-passed at 5 amp. The concentrates were designated as Conc 1 and Conc 2 (ilmenite), respectively. The ilmenite concentrates assayed 10.40% SiO_2, and 16.44% SiO_2, respectively, from sands and slimes. These concentrates are too low in grade to meet commercial specifications.

TABLE 7

Results of Magnetic Concentration by
The Crockett Separator

Feed -65 M Ore

Product	Weight, %	Analysis, %		Distribution, %		R/C
	In test	HCl sol Fe	TiO_2	In test		
				Fe	TiO_2	
Feed*	100.0	40.8	10.76	100.0	100.0	
Conc	55.5	63.36	2.42	86.1	12.5	1.80:1
" o'flow	5.2	22.68	10.75	2.9	5.2	
Sand tail	32.2	11.96	24.58	9.4	73.5	
Slime "	7.1	8.94	13.20	1.6	8.8	

*calculated SiO_2 in conc, 1.95%

TABLE 8

Results of High Intensity Magnetic Concentration of the
Tailing by the Jones Wet Separator

Feed - Sand Tailing

Product	Weight, %		Analysis, %		Distribution, %		R/C
	In test	In orig feed	HCl sol Fe	TiO_2	In test TiO_2	In orig feed, TiO_2	
Feed*	100.0	32.2		25.81	100.0	73.5	
Conc 1	5.6	1.8	9.84	30.12	6.5	4.8	5.5:1
Conc 2 (I1)	85.1	27.4		28.03	93.3	68.6	3.6:1
Tailing	9.3	3.0		0.48	0.2	0.1	
Combined Conc 1 & 2	90.7	29.2		28.41	99.8	73.4	3.4:1

SiO_2 in Conc 2 (I1), 10.40%

Feed - Slime Tailing

Product	In test	In orig feed	HCl sol Fe	TiO_2	In test TiO_2	In orig feed, TiO_2	R/C
Feed*	100.0	7.1		13.57	100.0	8.8	
Conc 1	5.8	0.4	23.5	14.60	6.2	0.5	244:1
Conc 2 (I1)	46.3	3.3		19.85	67.7	6.0	30:1
Tailing	47.9	3.4		7.37	26.1	2.3	

*calculated SiO_2 in Conc 2 (I1), 16.44%

Conc 1 - 0 amp, HCl sol iron indicates magnetite content
Conc 2 - 5 amp, ilmenite and hematite

Test No. 4 - Concentration of Ilmenite from -65 M Tailing by Gravity Concentration, and High Intensity Dry Separation

In this test, the Crockett tailing was concentrated on a concentrating table**, and the ilmenite concentrate was cleaned and upgraded by a Stearns high intensity dry belt separator. The Crockett concentrate was re-passed on the Crockett separator which resulted in a higher grade of concentrate than that of Test No. 3.

TABLE 9

Results of Magnetic Concentration of -65 M Ore by the Crockett Separator

Product	Weight, %	Analysis, %		Distn., %		R/C
		HCl Sol Fe	TiO_2	Fe	TiO_2	
Feed*	100.0	40.3	10.9	100.0	100.0	
Cleaner conc	51.1	66.5	1.53	84.4	7.2	1.96:1
Conc o'flow	3.9	30.64	9.67	3.0	3.5	
Tailing	45.0	11.31	21.65	12.6	89.3	

*calculated

Conc, SiO_2, 1.32%

**Diagonal Deck, Super-duty laboratory size table.

TABLE 10

Results of Gravity Concentration of -65M Crockett Tailing

Product	Weight, %		Analysis, %		Distribution, %		R/C
	In test	In orig feed	SiO_2	TiO_2	In test TiO_2	In orig feed TiO_2	
Feed*	100.0	45.0		21.65	100.0	89.3	
Conc	42.3	19.0	2.76	35.65	69.7	62.3	5.25:1
Midds	5.2	2.3		5.63	1.4	1.2	
Sand Tail	23.8	10.8		10.97	12.1	10.8	
Slime "	28.7	12.9		12.73	16.8	15.0	
Combined Tailing*	52.5	23.7		11.93	28.9	25.8	

*calculated

TABLE 11

Results of High Intensity Magnetic Concentration of the Table Concentrate by the Stearns Separator

Product	Weight, %		Analysis, %				Distribution, %		R/C
	In test	In orig feed	TiO_2	SiO_2	Cu	S	In test TiO_2	In orig feed TiO_2	
Feed*	100.0	19.0	35.4	2.76	-	-	100.0	62.3	
Conc	78.4	14.9	41.46	0.96	-	-	91.8	57.2	6.7:1
Tailing	21.6	4.1	13.47	-	0.011	9.92	8.2	5.1	

*calculated

Screen analyses for titanium dioxide were made on the table sands and slimes tailing.

TABLE 12

Results of Screen Analyses of the Table Tailings

Feed - Sand Tailing

Product	Weight, %		Analysis, %	Distribution, %	
	In test	In orig feed	TiO_2	In test TiO_2	In orig feed TiO_2
Feed*	100.0	10.8	11.05	100.0	10.80
-65+100	3.1	0.3	1.25	0.4	0.04
-100+150	7.4	0.8	2.00	1.3	0.14
-150+200	8.0	0.9	2.24	1.6	0.17
-200	81.5	8.8	13.11	96.7	10.45

Feed - Slime Tailing

Feed*	100.0	12.9	12.94	100.0	15.00
-100+150	0.7	0.1	1.35	0.1	0.01
-150+200	0.8	0.1	1.95	0.1	0.02
-200+325	3.2	0.4	3.77	0.9	0.14
-325	95.3	12.3	13.43	98.9	14.83
-200	98.5	12.7	13.11	99.8	14.97

*calculated

These results indicate no appreciable amount of titanium dioxide remains in the +200 mesh screen fractions. The amount in the -200 mesh portion of the tailing could not be recovered economically.

CONCLUSIONS

The Davis tube recoveries in concentrates are a little higher than those of the Jeffrey-Steffensen separator which rejects a middling product.

Grinding before separation reduces the TiO_2 in the concentrate to 0.29% at a grind of -65 M with no improvement at finer grinds. At -48 M the TiO_2 content is 0.55%.

Approximately 70% of the TiO_2 in the tailing can be recovered by gravity concentration at -65 M if a profitable market can be found for an ilmenite concentrate containing 35.6% TiO_2 and 2.76% SiO_2.

WSJ:EBM