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RECOVERY OF IRON FROM A MILL TAILING SAMPLE FROM CRAIGMONT MINES LIMITED, MERRITT, BRITISH COLUMBIA

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by

P. D. R. MALTBY

MINERAL PROCESSING DIVISION

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Mines Branch Investigation Report IR 62-14

RECOVERY OF IRON FROM A MILL TAILING SAMPLE
FROM CRAIGMONT MINES LIMITED,
MERRITT, BRITISH COLUMBIA

by

P.D.R. Maltby*

SUMMARY OF RESULTS

The tailing sample was found to contain magnetite and hematite in the ratio of about 3:2. As the magnetite was finer and required grinding to produce a marketable concentrate, the magnetite was first removed by magnetic separation. The hematite was then concentrated using either gravity, high intensity magnetic separation, or flotation methods.

In a test, using magnetic separation followed by tabling of the non-magnetic fraction, a combined concentrate containing 65.1% Fe and 4.4% SiO₂ was produced. The combined concentrate contained 19.6% of the weight and 53.1% of the iron in the original feed. Retreatment of the middling fraction would raise the iron recovery to about 60%. The iron lost in tailing from the non-magnetic fraction appeared to be mainly in chlorite form.

A magnetite concentrate was produced containing 14.1% of the weight and 41.5% of the iron in the original feed at a grade of 66.8% Fe and about 4% SiO₂ at a size of 81.1% minus 325 M. A test using a Jones separator on the non-magnetic fraction gave a concentrate of combined 0 and 5 amp fractions assaying 39.0% Fe. The best grade of concentrate obtained by flotation of the non-magnetic fraction was 33.86% Fe. The chief problem appears to be depressing the chlorite gangue to obtain an acceptable hematite concentrate.

*Scientific Officer, Mineral Processing Division, Mines Branch, Dept. of Mines and Technical Surveys, Ottawa.

INTRODUCTION

The purpose of the investigation was to recover the magnetite and hematite present in the mill tailing as a marketable iron concentrate.

Shipment

A sample weighing 300 lb was received at the Mines Branch on October 23, 1961. It was shipped from the mill of Craigmont Mines Limited, at Merritt, B.C. by Mr. H.A. Steane, General Mill Superintendent. The sample was said to be representative of the mill tailings at that time, and was received in the form of undried filter cake in sealed steel 5-gallon cans.

Sample Analysis

A 25 lb head sample was taken by pipe sampling from the shipment cans and a small sample submitted for head analysis, spectrographic analysis and mineralogical examination. Chemical analysis showed the sample to contain 23.36% sol Fe, 0.08% Cu and 0.045% S.

Chemical analyses in connection with this investigation were done by the Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch, Ottawa.

Outline of Investigation

Since the sample consisted of both magnetite and hematite, the investigation was done in two parts.

In the first part a magnetite concentrate was produced by magnetic separation procedure. The non-magnetic tailing was treated either by gravity separation or flotation to produce a hematite concentrate. A high intensity wet magnetic separation test using the Jones separator was also done.

MINERALOGY

About 100 g of the tailing sample was submitted to the Mineral Sciences Division for a mineralogical examination. Dr. W. Petruk in his report* described how the sample was separated into fractions by heavy liquids and a polished section prepared from each fraction. The mineralogy of each fraction was determined by means of microscopical and X-ray diffraction studies and the combined results are listed in Table 1.

TABLE 1

Mineralogy of the Tailing Sample

<u>Mineral</u>	<u>Weight %</u>
Chlorite	42
Quartz	27
Feldspar	10
Mica	5
Calcite	5
Magnetite	8
Hematite	3
Total	100

*Internal Report MS-61-857 by W. Petruk, Mineralogy Section, Mineral Sciences Division, Mines Branch, Ottawa.

Polished section studies showed the magnetite and hematite to be largely liberated from the gangue minerals.

RESULTS OF TEST WORK

Magnetic Separation Tests

A 50 g sample was ground to 150 M and treated by Davis tube with the results shown in Table 2.

TABLE 2

Davis Tube Test on Head Sample

<u>Product</u>	<u>Weight %</u>	<u>Analysis %</u>		<u>Distn % Sol Fe</u>
		<u>Sol Fe</u>	<u>S</u>	
Conc	18.7	64.63	0.007	47.2
Tail	<u>81.3</u>	<u>15.98</u>	0.074	<u>51.8</u>
Feed*	100.0	25.1		100.0

*Calculated

All soluble iron analyses were done using hydrochloric acid alone.

The 25 lb head sample was split in 2 parts, and one half was treated using a Crockett wet belt magnetic separator. No grinding was done and the results of this test are shown in Table 3.

TABLE 3

Results of Crockett Separation on Head Sample

<u>Product</u>	<u>Weight %</u>	<u>Analysis %</u>		<u>Distn % Sol Fe</u>
		<u>Sol Fe</u>	<u>S</u>	
Conc	38.6	40.46	0.018	61.8
Tail	<u>61.4</u>	<u>15.70</u>	-	<u>38.2</u>
Feed*	100.0	25.3		100.0

*Calculated

The Crockett concentrate was ground for 15 minutes to 81.1% minus 325 M and treated by a Jeffrey-Steffensen 3-drum wet magnetic separator followed by a Wade hydroseparator which treated the Jeffrey concentrate. The results of this test are shown in Table 4.

TABLE 4

Results of Jeffrey Test on Crockett Concentrate

<u>Product</u>	<u>Weight % of crude feed</u>	<u>Analysis %</u>		<u>Distn of Crude feed % Sol Fe</u>
		<u>Sol Fe</u>	<u>SiO₂</u>	
Jeffrey tail	22.1	16.30	-	15.9
" midd	2.4	41.20	-	4.4
Hydrosep. Spigot**	13.4)	67.04)	3.95	39.6)
" o'flow	0.7)	61.02)	-	1.9)
	<u>14.1</u>	<u>66.8</u>		<u>41.5</u>
Feed*	38.6	36.3		61.8

*Calculated

**Screen test showed spigot product as 81.1% minus 325 M.

In this test the hydroseparator was not essential to obtain an acceptable grade, so that the recovery by magnetic means was 41.5% of the iron in the original feed.

The Crockett tailing was split into 2 parts. One part was treated by the Jones high intensity wet magnetic separator. The results are shown in Table 5.

TABLE 5
Jones Separator Test on Crockett Tailing

Product	Magnetic Intensity	Weight %	Analysis %		Distn of Crude Feed % Sol Fe
			Sol Fe	S	
No. 1 conc	0 amp	2.9	35.89)	-	4.1
No. 2 conc	5 amp	8.2	40.15)	0.034	13.0
" midd	"	22.8	13.91	-	12.5
" tail	"	27.5	7.89	0.073	8.6
Feed*		61.4	15.75		38.2

*Calculated

The concentrate grade might be improved by using more wash water on the middling cycle.

Flotation Tests

Some flotation tests were done on the other half of the Crockett tailing. No grinding was done before flotation. The tests were done in a 500 g Agitair cell with an impeller speed of 1000 rpm. Conditioning and

flotation times were 2 and 8 minutes respectively for each stage.

In the first test, 500 g of feed was deslimed twice in the cell. A mixture of equal parts of oleic acid and Emulsol X-1 was added in 3 stages, the total used being 1.6 lb/ton of feed. The rougher concentrate was cleaned using 0.5 lb/ton of hydrofluosilicic acid. The pH was 7. The results are shown in Table 6.

TABLE 6

Results of Float No. 1 on Crockett Tailing

<u>Product</u>	<u>Weight %</u>	<u>Analysis %</u>			<u>Distn % Sol Fe</u>
		<u>Sol Fe</u>	<u>SiO₂</u>	<u>S</u>	
Cleaner conc	28.6	33.86	20.04	0.082	56.4
" tail	11.1	16.93			11.0
Rougher tail	38.4	7.07			15.8
Slimes	21.9	13.15			16.8
Feed*	100.0	17.2			100.0

*Calculated

The procedure used in the second flotation test was similar. After desliming, a 5% sodium silicate solution was added for a total of 1 lb/ton. A total of 1 lb/ton of oleic acid and 2 lb/ton of Emulsol X-1 was used. The rougher concentrate was cleaned using no additional reagents. pH was 7. The results are shown in Table 7. In both flotation tests the iron in the rougher

tailing is in the form of chlorite and cannot be recovered economically.

TABLE 7

Results of Float No. 2 on Crockett Tailing

<u>Product</u>	<u>Weight %</u>	<u>Analysis %</u>		<u>Distn % Sol Fe</u>
		<u>Sol Fe</u>	<u>SiO₂</u>	
Cleaner conc	34.9	26.49	27.48	58.4
" tail	15.0	13.14		12.4
Rougher tail	26.7	6.57		11.0
Slimes	<u>23.4</u>	<u>12.35</u>		<u>18.2</u>
Feed*	100.0	15.9		100.0

*Calculated

Examination of the cleaner flotation concentrates showed the hematite to be free of gangue inclusions. The principal gangue was calcite and chlorite. The flotation concentrate was also assayed for total Fe using the bisulphate fusion method; the result was 1% higher than the Sol Fe.

Further Tests

The other half of the original 25 lb head sample was treated on the Ball-Norton dry belt magnetic separator at 1 amp intensity. The results of this test are shown in Table 8.

TABLE 8

Ball-Norton Separation on Head Sample

<u>Product</u>	<u>Weight %</u>	<u>Analysis % Sol Fe</u>	<u>Distn % Sol Fe</u>
B-N conc	38.2	35.2	55.8
" tail	61.8	17.3	44.2
Feed*	100.0	24.0	100.0

*Calculated

The Ball-Norton concentrate was ground for 5 minutes and treated by the Jeffrey-Steffensen separator. A small sample of Jeffrey tailing was taken for assay, and the remainder combined with the Ball-Norton tailing for a tabling test. The results of the Jeffrey-Steffensen test are shown in Table 9.

TABLE 9

Jeffrey Separation on Ball-Norton Ground Concentrate

<u>Product</u>	<u>Weight % of crude feed</u>	<u>Analysis %</u>		<u>Distn of crude feed % Sol Fe</u>
		<u>Sol Fe</u>	<u>SiO₂</u>	
Jeffrey conc	13.2	65.14	5.24	35.8
" midd	2.2	46.89	-	4.3
" tail	22.8	16.59	-	15.7
Feed*	38.2	35.2		55.8

*Calculated

The results of the tabling test on the combined Ball-Norton and Jeffrey tailings are shown in Table 10.

TABLE 10

Results of Tabling Combined Tailing

<u>Product</u>	<u>Weight % of crude feed</u>	<u>Analysis %</u>			<u>Distn of crude feed % Sol Fe</u>
		<u>Sol Fe</u>	<u>SiO₂</u>	<u>S</u>	
Table conc	6.4	65.08	2.62	0.112	17.3
" midd	4.3	25.66	-	-	4.6
" tail	<u>73.9</u>	<u>12.37</u>	-	-	<u>38.0</u>
Feed*	84.6	17.0			59.9

*Calculated

The table middling was collected at the end of the test and contained all recoverable iron, as the separation between the iron minerals and gangue was very well defined. The table tailing contained no free hematite.

If the Jeffrey and table concentrates are combined a product containing 65.1% Fe, and 4.4% SiO₂ is obtained with 19.6% of the weight and a recovery of 53.1% of the iron in the original feed. By retreating the middling fractions the weight recovery would be about 23% increasing the iron recovery to about 60% of the iron in the original feed. The iron not recovered is mainly in the form of chlorite.

Screen tests were done on the Jeffrey and table concentrates with the results shown in Table 11.

TABLE 11

Screen Tests on Jeffrey and Table Concentrates

<u>Mesh</u>	<u>Jeffrey Concentrate</u> <u>Weight %</u>	<u>Table Concentrate</u> <u>Weight %</u>
+ 65	0.5	0.5
+100	1.5	1.8
+150	3.1	7.2
+200	6.5	16.5
+325	19.3	35.3
-325	<u>69.1</u>	<u>38.7</u>
Total	100.0	100.0

CONCLUSIONS

Results of tests on the tailing sample showed that a marketable iron concentrate could be produced. The best method of obtaining this appeared to be by magnetic separation and gravity concentration of the non-magnetic fraction. The magnetite was finer than the hematite and required grinding for good liberation. For this reason the use of the combined separations produced a higher iron recovery than gravity separation alone. The non-magnetic fraction should be recoverable using spirals instead of tables.

Since this investigation was started, it has been learned from the company that the proportion of magnetite and hematite now in the mill tailings has

changed from the sample shipped to the Mines Branch. However, provided the grain size of the iron minerals remained the same, about 90% of the magnetite and over 75% of the hematite could be recovered respectively by magnetic separation and tabling. The iron lost in the non-magnetic tailing was mainly in the form of chlorite and not recoverable economically.

The flotation results obtained in this investigation did not produce a high grade concentrate. The hematite floated readily along with a large amount of gangue minerals. The chief problem was to find an efficient gangue depressant. Further flotation tests should be done if recovery of the non-magnetic fraction is not good using gravity separation.

The results of a test using the Jones separator to treat the non-magnetic fraction were not encouraging. The concentrate from this procedure contained some hematite and some chlorite.