CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA



MINES BRANCH INVESTIGATION REPORT IR 62-64

# BENEFICIATION TESTS ON SAMPLES OF IRON ORE FROM LAKE ST. JOSEPH IRON LIMITED IN NORTHWESTERN ONTARIO

by

W. S. JENKINS

MINERAL PROCESSING DIVISION





JUNE 28, 1962

Mines Branch Investigation Report IR 62-64

# BENEFICIATION TESTS ON SAMPLES OF IRON ORE FROM LAKE ST. JOSEPH IRON LIMITED IN NORTHWESTERN ONTARIO

by

W. S. Jenkins*

- - -

## SUMMARY OF RESULTS

Two samples of iron ore, designated as E1-1 and F1-2, were received in the shipment. The samples assayed as follows:

| Sample | E1-1 | F1-2 |
|---|---|---|
| Soluble iron | 33.25% | 36.5% |
| Sulphur | 0.049% | 0.042% |
| Phosphorus | 0.73% | 0.95% |
| Titanium dioxide | 0.056% | 0.064% |

The samples contained iron as magnetite and hematite. The magnetite was amenable to magnetic concentration, at grinds finer than 200m. The hematite can be recovered by a magnetizing roast followed by magnetic concentration. The hematite could not be successfully recovered by gravity, flotation or high intensity magnetic concentration.

---

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

CONTENTS

TABLES

TABLES (contd)

TABLES (contd)

# INTRODUCTION

## Shipment

A shipment of two samples of drill core rejects was received on January 13, 1961. The samples were designated as E1-1 from Eagle Island, weight 106 lb, and F1-2 from Fish Island, weight 101 lb. They were submitted by Mr. Paul E. Riverin, Vice-President, St. Lawrence Columbium and Metals Corporation, 2500 Marie-Guyard, P.O. Box 233, Montreal 29, Quebec.

## Location of the Property

The property from which the samples originated was stated to be on several islands located in Lake St. Joseph, some 80 miles northeast of Sioux Lookout, Ontario.

## Purpose of the Investigation

The purpose of the investigation was to determine if the ore represented by the shipment was amenable to economic concentration.

## Description of the Property

In a letter dated October 14, 1960, Mr. C. W. Gordon, consultant at Ottawa, for Lake St. Joseph Iron Limited, described the property. The deposits extend across three islands in Lake St. Joseph, and are in sharply defined continuous zones, 50, 100 or 200 feet wide. On one island folding has made a width of about 1200 feet. Several diamond drill holes have been drilled to a depth of about 500 feet.

# SAMPLING AND ANALYSIS OF THE SHIPMENT

TABLE 1

Chemical Analysis of the Head Samples*

| | Eagle Island Ore Sample E1-1 | Fish Island Ore Sample F1-2 |
|---|---|---|
| Total iron | 33.55 % | 36.5 % |
| HCl soluble iron | 33.25 % | 36.5 % |
| Titanium dioxide | 0.056 % | 0.064 % |
| Sulphur | 0.049 % | 0.042 % |
| Phosphorus | 0.73 % | 0.95 % |

* Report of Chemical Laboratories, MS Lab No. 426-427, 1961.

TABLE 2

Semi-Quantitative Spectrographic Analysis** of the Head Samples

| | Eagle Island Ore Sample E1-1 | Fish Island Ore Sample F1-2 |
|---|---|---|
| Major constituents | Fe, Si, Al | Fe, Si |
| Intermediate constituents | Mg | Al, Mg, Ca |
| Minor constituents | Ca, Na, Ti, Mn, Ba, Cu | Na, Ba, Ti, Mn, Cu |
| Trace constituents | Ni, V, Zr, Be, Sn, Cr, B, Pb, Co | Ni, V, B, Be, Sn, Cr, Zr, Pb, Co |

The elements are listed in order of decreasing abundance.

**Analysis by Spectrographic Laboratory, Report No. SL 61-23, MS.

## MINERALOGICAL EXAMINATION*

Four polished sections, two from each sample, were prepared and examined under a reflecting microscope.

### Sample E1-1, Eagle Island

The two polished sections contain eight pieces of ore. Megascopically, several fragments show narrow parallel banding but ore minerals are distributed more or less evenly throughout the others. Gangue material in one piece is stained a rusty brown colour. Both sections are attracted by a magnet.

Under a microscope the ore minerals are seen to be a fine-grained admixture of hematite and magnetite. The proportions of these two minerals vary from piece to piece but, on the whole, hematite is slightly the more abundant and tends to occur in elongated particles. While hematite and

---

* Internal Report MS-61-23 by Wm. E. White, Mineral Sciences Division, March 17, 1961.

magnetite show no minute exsolved intergrowths, they are often mutually associated as fine adjoining grains. An average field is shown in the photomicrograph, Figure 1. Sulphides (pyrite and chalcopyrite) are present as very rare small scattered grains.

In the polished sections, gangue consists essentially of quartz and feldspar with minor amounts of dolomite and apatite as small sporadically scattered particles.

Sample F1-2, Fish Island

The seven pieces of ore in the two polished sections are megascopically similar in appearance to those in the two sections of the Eagle Island sample. While banding can be distinctly seen in several of the polished fragments, it is more irregular than in the previous sample. Again gangue material in one piece of ore bears rusty brown stains and each section is magnetic.

The microscopic examination of the two polished sections corroborates what has been said above about the E1-1 sample. Hematite and magnetite form a granular admixture in a largely hard gangue composed of quartz, feldspar, dolomite and apatite. The average grain size of the ore minerals, however, is somewhat coarser than in the sample from Eagle Island. As in the latter, a small amount of sulphide is present as rare scattered grains. A typical field containing two grains of pyrite is shown in Figure 2.

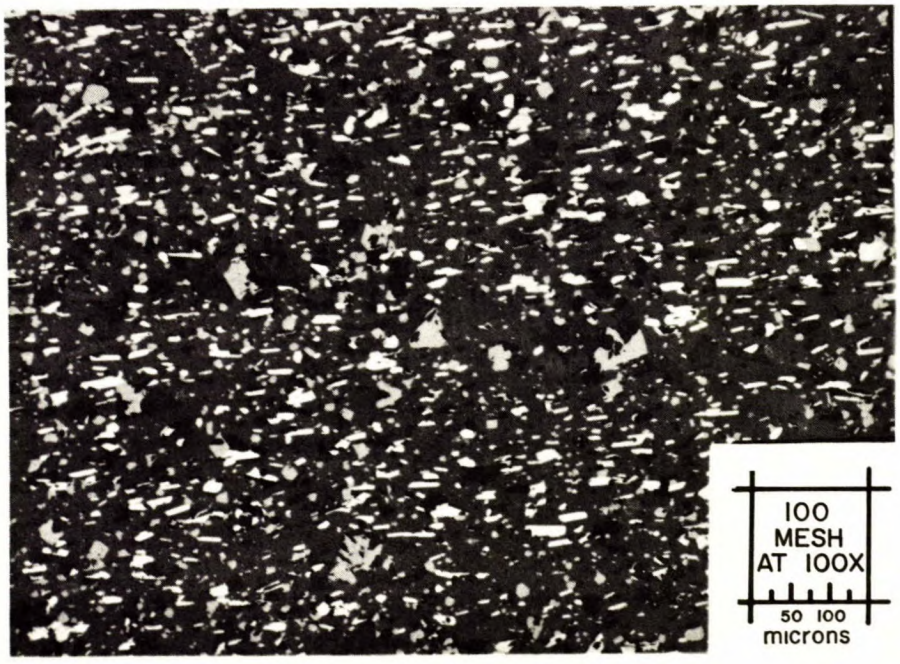


Figure 1. - Average field in polished section, Sample E1-1, showing disseminated grains of hematite (light grey) and magnetite (medium grey) in gangue (dark grey); polishing pits are black.

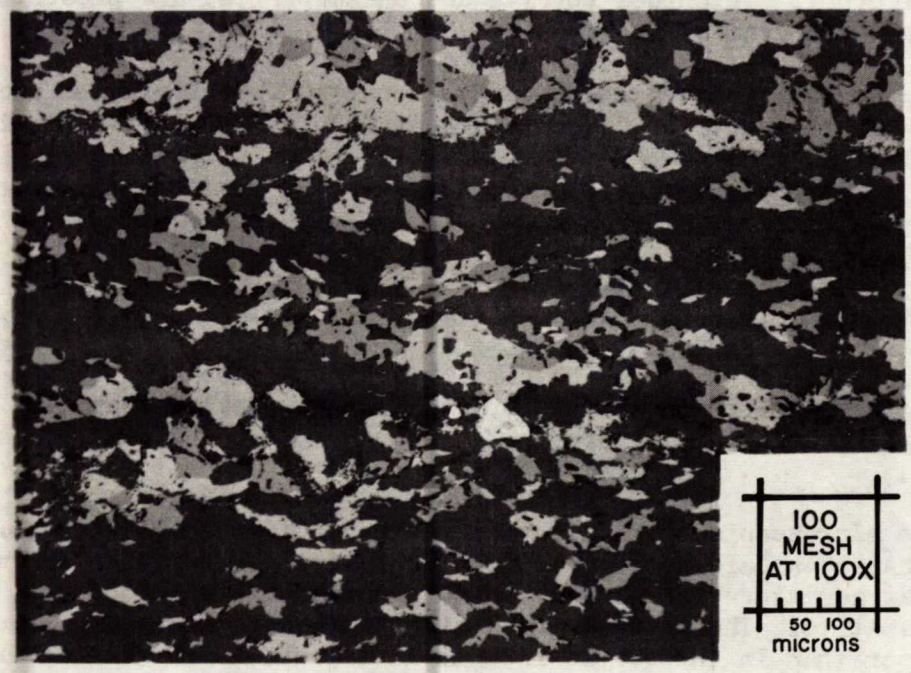


Figure 2. - Photomicrograph of polished section showing typical field in Sample F1-2; hematite is light grey, magnetite is medium grey, and gangue is dark grey; the two white grains slightly below centre are pyrite; pits are black.

## SUMMARY OF TEST PROCEDURE

Instructions were received to test each sample separately. Details of the tests on Sample E1-1 are described in Section 1 of the report and the tests on Sample F1-2 are in Section 2.

The samples were concentrated by magnetic concentration, flotation, gravity concentration and by high intensity magnetic concentration, both separately and in combination. Magnetizing roasts were made on the ore and various products of tests in order to recover hematite as a magnetic concentrate.

## SECTION 1 - TESTS ON SAMPLE E1-1

### SUMMARY OF RESULTS ON SAMPLE E1-1

In this sample iron occurs as both magnetite and hematite. The magnetite was recovered by wet drum (Jeffrey-Steffensen) low intensity magnetic separation. Best results were obtained by stage grinding and two stages of magnetic separation. By this method, magnetite concentrates assaying 66.2% Fe, 7.68% Insol (Test 12) and 70.44% Fe, 2.76% $SiO_2$ (Test 14) were produced. Recoveries of iron in these concentrates were, respectively, 29.1% and 19.3%, the difference being caused by varying the fineness of grind.

The remainder of the iron remained in the non-magnetic tailing products as hematite and iron silicates. The best recovery of this hematite was obtained by a magnetizing roast and magnetic separation (Test 13), by which 72.6% of the iron in the tailing was recovered in a magnetic concentrate assaying 65.62% Fe and 7.12% $SiO_2$.

In Test 14 these two procedures were combined with the two tailings from magnetite concentration and recleaning being roasted and concentrated. The combined concentrates would contain 67.66% Fe and 5.86% $SiO_2$ with a recovery of 72.1% of the iron in 37.8% of the feed weight or a ratio of concentration of 2.65:1. Inclusion of the middling from the final separation would produce a concentrate assaying 66.5% Fe and 6.8% $SiO_2$ with 77.8% recovery in 41.4% of the feed weight or a ratio of concentration of 2.42:1.

The only other successful method of treating the sample was a direct magnetizing roast of the ground ore without preconcentration, followed by regrinding and magnetic separation (Test 15). The product assayed 66.4% Fe and 5.78% $SiO_2$ with a recovery of 78.7% of the iron and a ratio of concentration of 2.34:1. The product was 89.2% -325m which should pelletize easily. The ore was ground to -200m before roasting. Similar tests with ore ground to -48m, -65m, and -100m did not yield as good results but this may have been due to too short a roasting time or insufficient regrinding after roasting.

Direct gravity concentration of the ore produced a 50% Fe concentrate with a recovery of 59.6%. Direct treatment by high intensity (Jones) separation was also unsuccessful. No other method of recovering hematite from the low intensity tailing seems practical. Concentrate grades by flotation, gravity concentration, and high intensity magnetic separation were all well below 50% Fe and recoveries were very low.

## DETAILS OF TESTS ON SAMPLE E1-1

### Magnetic Cobbing, Tests 1 and 2

#### Test 1 - Magnetic Cobbing of -¼ in. Ore by the Ball-Norton Separator

A sample of the ore was crushed to -¼ in. and concentrated by a laboratory size Ball-Norton dry separator.

TABLE 3

Results of Magnetic Cobbing of -¼ in. Ore

| Product | Weight % | Analysis, %** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 32.9 | | 100.0 | |
| Mag conc | 63.7 | 36.9 | 38.94 | 71.4 | 1.57:1 |
| Tailing | 36.3 | 26.0 | | 28.6 | |

* calculated

R/C = Ratio of concentration

** From Report of Analysis, Chemical Laboratories, MS, Feb. 6, 1961.

#### Test 2 - Magnetic Concentration of -20m Ore by the Crockett Separator

A sample of -20m ore was concentrated by the laboratory size Crockett wet separator.

TABLE 4

Results of Magnetic Concentration of -20m Ore

| Product | Weight % | Analysis, %** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 31.8 | | 100.0 | |
| Mag conc | 69.7 | 37.2 | 40.22 | 81.5 | 1.4:1 |
| Tailing | 30.3 | 19.4 | | 18.5 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, Feb. 6, 1961.

Davis Tube Concentration, Tests 3 and 4

Samples of -100m and -200m ore were concentrated by the Davis Tube magnetic separator.

TABLE 5

Results of Magnetic Concentration by Davis Tube

Test 3 -100m Ore

| Product | Weight % | Analysis, %** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 34.33 | | 100.0 | |
| Mag conc | 37.2 | 46.26 | 30.02 | 50.1 | 2.7:1 |
| Tailing | 62.8 | 27.26 | - | 49.9 | |

Test 4 -200m Ore

| | | | | | |
|---|---|---|---|---|---|
| Feed* | 100.0 | 34.47 | | 100.0 | |
| Mag conc | 29.6 | 53.42 | 22.78 | 45.9 | 3.4:1 |
| Tailing | 70.4 | 26.50 | - | 54.1 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 1, 1961.

Wet Drum Magnetic Separation, Tests 5 and 6

Samples of ore ground to -100m and -200m were concentrated by the Jeffrey-Steffensen separator.

TABLE 6

Results of Magnetic Concentration by Jeffrey-Steffensen Separator

Test 5 -100m Ore

| Product | Weight % | Analysis, % ☆☆ | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed☆ | 100.0 | 32.2 | | 100.0 | |
| Mag conc | 14.7 | 55.8 | 18.92 | 25.4 | 6.8:1 |
| Midds | 15.0 | 42.4 | 35.5 | 19.7 | |
| Tailing | 70.3 | 25.1 | -- | 54.9 | |

Test 6 -200m Ore

| | | | | | |
|---|---|---|---|---|---|
| Feed☆ | 100.0 | 33.3 | | 100.0 | |
| Mag conc | 12.8 | 63.5 | 10.0 | 24.5 | 7.8:1 |
| Midds | 11.5 | 45.2 | 31.0 | 15.6 | |
| Tailing | 75.7 | 26.4 | -- | 59.9 | |

☆ calculated

☆☆ From Report of Analysis, Chemical Laboratories, MS, Feb. 6, 1961.

High Intensity Magnetic Concentration of Non-Magnetic Tailings, Test 7

This test was made to recover hematite by high intensity magnetic concentration from the low intensity magnetite concentration tailing.

The tailings of Tests 5 and 6 were concentrated by the Jones separator. The tailings were first concentrated at 0 amp to remove any magnetite present and the tailing from 0 amp was repassed at 5 amp to recover hematite.

The products were two magnetic concentrates and a tailing from each test.

TABLE 7

Results of High Intensity Magnetic Concentration of -100m Tailing of Test 5

| Product | Weight, % | | Analysis, %** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 70.3 | 26.42 | | 100.0 | 54.9 | |
| Conc at 0 a | 19.0 | 13.3 | 34.5 | 42.44 | 24.8 | 13.6 | 7.5:1 |
| Conc at 5 a | 35.1 | 24.7 | 43.0 | 27.1 | 57.1 | 31.4 | 4.1:1 |
| Tailing | 45.9 | 32.3 | 10.4 | -- | 18.1 | 9.9 | |

* calculated

**From Report of Analysis, Chemical Laboratories, MS, Feb. 6, 1961.

The results on -200m tailing from Test 6 were about the same as at -100m. No appreciable concentration of hematite was made at either grind.

## Gravity Concentration, Tests 8 and 9

### Test 8 - Gravity Concentration of the Tailing from Jeffrey-Steffensen Separator

A sample of -100m ore was concentrated by the Jeffrey-Steffensen separator with results similar to Test 5; 50.3% of the iron remained in the tailing. The tailing was concentrated by the Deister table.

TABLE 8

Results of Table Concentration of the -100m Tailing

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In Test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 63.2 | 27.17 | | 100.0 | 50.3 | |
| Table conc | 18.1 | 11.4 | 42.82 | 30.62 | 28.4 | 14.3 | 8.8:1 |
| Midds | 3.0 | 1.9 | 34.30 | - | 3.8 | 1.9 | |
| Tailing | 78.9 | 49.9 | 23.32 | - | 67.8 | 34.1 | |

*calculated

**From Report of Analysis, Chemical Laboratories, MS, March 29, 1961.

### Test 9 - Gravity Concentration of -100m Ore by the Deister Table, Magnetic Concentration of the Tailings.

A sample of -100m ore was concentrated on a Deister table. The products of the test were a concentrate, a middling and a tailing. The tailing sands and slimes were kept separate and portions of each were magnetically concentrated by the Davis tube and the Jeffrey-Steffensen separator.

TABLE 9

Results of Table Concentration of -100m Ore

| Product | Weight % | Analysis, % ** | | | Distn, % | R/C |
|---|---|---|---|---|---|---|
| | | Fe | $TiO_2$ | $SiO_2$ | Fe | |
| Feed* | 100.0 | 34.22 | | | 100.0 | |
| Table conc | 40.7 | 50.12 | 0.12 | 24.08 | 59.6 | 2.46:1 |
| Midds | 2.2 | 14.80 | - | - | 1.0 | |
| Sand tailing | 27.2 | 28.96 | - | - | 23.0 | |
| Slime tailing | 29.9 | 18.80 | - | - | 16.4 | |
| Combined tailing* | 57.1 | 23.64 | - | - | 39.4 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 23, 1961.

Magnetic concentration of the gravity tailings by wet drum separators recovered only 4.3% additional iron from the sand tailing and 1.1% from the slime tailing, so this would not be economic, particularly since the products when combined assayed only 58% Fe.

Flotation, Tests 10, 11 and 12

Test 10 - Magnetic Concentration of -200m Ore by the Jeffrey-Steffensen Separator and Flotation of Hematite from the Tailing.

Several 2000 g samples of -200m ore were concentrated by the Jeffrey-Steffensen separator to provide hematite tailing for flotation tests. The Jeffrey-Steffensen products were sampled and assayed to determine the distribution of iron. Typical magnetic concentration results are shown in Table 10.

The tailing was riffled into several samples for flotation tests with the use of several different reagents.

The flotation feeds were deslimed by diluting with water, adding 0.5 lb/ton of sodium silicate, and mixing. The mixture was allowed to settle for 5 minutes. The slimes remaining in suspension were decanted.

In the test shown in Table 11, the thickened pulp was conditioned in a flotation machine for 10 minutes with sulphuric acid, pH 5.5, oleic acid 0.5 lb/ton, and Petronate 0.02 lb/ton. The pulp was diluted and floated for 5 minutes. The flotation concentrate was cleaned once with 0.5 lb/ton of sodium silicate.

TABLE 10

Results of Magnetic Concentration of -200m Ore

| Product | Weight % | Analysis, %** Fe | Distn % Fe | R/C |
|---|---|---|---|---|
| Feed* | 100.0 | 33.89 | 100.0 | |
| Mag conc | 20.4 | 59.12 | 35.6 | 4.9:1 |
| Midds | 10.3 | 35.46 | 10.7 | |
| Tailing | 69.3 | 26.23 | 53.7 | |

* calculated

** From Internal Report MS-AC-61-686.

TABLE 11

Results of Flotation of Jeffrey-Steffensen Tailing

| Product | Weight % | | Analysis %** | | Distribution % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | Insol | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 69.3 | 25.64 | | 100.0 | 53.7 | |
| Cleaner conc | 34.8 | 24.1 | 45.06 | 28.5 | 61.2 | 32.8 | 4.1:1 |
| " tail | 30.6 | 21.2 | 19.96 | - | 23.9 | 12.8 | |
| Flot tail | 10.2 | 7.1 | 22.95 | - | 9.1 | 4.9 | |
| Slimes | 24.4 | 16.9 | 6.18 | - | 5.8 | 3.2 | |

* calculated

** From Internal Report MS-AC-61-686.

Several other flotation tests were made on Jeffrey-Steffensen tailings with various combinations of reagents without raising the grade of the cleaner concentrate above that in Table 11.

Test 11 - Flotation of the Iron Minerals

The test was made to determine the grade of concentrate that could be recovered directly from the ore by flotation.

A 1000 g sample of -20m ore was ground in a ball mill, deslimed, and conditioned at high density in a flotation machine with sulphuric acid 0.4 lb/ton, pH 4.0, fuel oil 4 lb/ton, and Aero Promoter 801 0.5 lb/ton. The rougher concentrate was cleaned once without reagents. A 25 g sample of the flotation tailing was concentrated by the Davis tube.

TABLE 12

Results of Flotation of the Iron Minerals

| Product | Weight % | Analysis, % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | Insol | Fe | |
| Feed* | 100.0 | 33.63 | | 100.0 | |
| Cleaner conc | 22.9 | 51.22 | 18.54 | 34.9 | 4.4:1 |
| Cleaner tail | 16.2 | 41.50 | 36.36 | 20.0 | |
| Flot tail | 49.1 | 29.09 | - | 42.4 | |
| Slimes | 11.8 | 7.57 | - | 2.7 | |

* calculated

** From Internal Report MS-AC-61-839.

TABLE 13

Results of the Davis Tube Test on the Flotation Tailing

| Product | Weight % | | Analysis % ** | Distribution % | | R/C |
|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 49.1 | 30.11 | 100.0 | 42.4 | |
| Mag conc | 36.4 | 17.8 | 42.69 | 51.6 | 21.9 | 5.6:1 |
| Tailing | 63.6 | 31.3 | 22.91 | 48.4 | 20.5 | |

* calculated

** From Internal Report MS-AC-61-839.

A screen test was made on the flotation tailing.

TABLE 14

Results of Screen Test

| Mesh | Weight % |
|---|---|
| +100 | 0.4 |
| -100+150 | 1.0 |
| -150+200 | 2.6 |
| -200+325 | 10.3 |
| -325 | 85.7 |
| | 100.0 |
| -200 | 96.0 |

The results indicate a possible recovery of 54.9% of the iron by flotation, but the tailing contains 21.9% of the iron and the concentrate grade is low.

Test 12 - Magnetic Cobbing of the Ore, Cobber Concentrate Reground and Magnetically Concentrated, Flotation of Silica from the Cobber Tailing.

The test was made to determine the recovery and grade of concentrate by cobbing the ore and regrinding and reconcentrating the cobber concentrate. The cobber tailing was used as a flotation feed to attempt to up-grade hematite by flotation of silica.

A 2000 g sample of -20m ore was ground in a ball mill to 95% -200m and concentrated by the Crockett separator. The Crockett concentrate was reground in a ball mill to pass 200m and reconcentrated by the Jeffrey-Steffensen separator.

The Jeffrey-Steffensen concentrate assayed - iron 66.2%, insol 7.68%. The recovery of iron was 29.1% at a ratio of concentration of 6.6:1 and at 97.6% -325m.

TABLE 15

Results of Magnetic Cobbing of Ore by the Crockett Separator

| Product | Weight % | Analysis %** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | Insol | Fe | |
| Feed* | 100.0 | 33.72 | | 100.0 | |
| Mag conc | 48.5 | 41.14 | 38.28 | 59.2 | 2.1:1 |
| Tailing | 51.5 | 26.73 | - | 40.8 | |

* calculated

** From Internal Report MS-AC-61-1057.

TABLE 16

Results of Magnetic Concentration of Reground Crockett Concentrate by the Jeffrey-Steffensen Separator

| Product | Weight % | | Analysis %** | | Distribution % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | Insol | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 48.5 | 41.96 | | 100.0 | 59.2 | |
| Mag conc | 31.2 | 15.1 | 66.20 | 7.68 | 49.2 | 29.1 | 6.6:1 |
| Midds | 16.0 | 7.7 | 47.40 | 32.28 | 18.0 | 10.7 | |
| Tailing | 52.8 | 25.7 | 26.00 | - | 32.8 | 19.4 | |

* calculated
Concentrate 97.6% -325m.

** From Internal Report MS-AC-61-1057.

The Crockett tailing was sampled for flotation tests to remove silica. Tests were made with conditioning at a pH of 11.5 and collection of silica with Armac C using T yellow dextrine as an iron depressant. The best silica float, obtained by staging a total of 0.64 lb/ton Armac, assayed 19.22% Fe and 66.32% Insol, and the iron concentrate assayed 43.24% Fe and 12.68% $SiO_2$ with less than 50% iron recovery from the Crockett tailing.

Other schemes for flotation concentration of this ore were investigated on sample F1-2, Tests 7 to 11, but no other scheme was any more successful than this method.

Magnetic Roasting, Tests 13, 14, 15 and 16

Test 13 - Magnetic Roasting of Hematite in a -200m Tailing, Magnetic Concentration of the Roasted Tailing.

A 2000 g sample of ore was ground to -200m and concentrated by the Jeffrey-Steffensen separator. The magnetite concentrate assayed 60.8% iron with a recovery of 30.9% of the iron. A sample of the tailing was roasted in a closed retort with city gas, for 15 minutes, at a temperature of 670°C, to reduce the hematite to a magnetic oxide.

The retort was heated in an electric furnace which was fitted with a thermostatic control. Openings allowed city gas to pass through the retort. The excess gas was burned. During the heating and cooling period, nitrogen gas was passed through the retort. The retort was cooled quickly with a water spray. The roasted material was concentrated by the Jeffrey-Steffensen separator without regrinding.

TABLE 17

Magnetic Concentration of Roasted Tailing

| Product | Weight % | | Analysis % ** | | | Distn % | | R/C in orig feed |
|---|---|---|---|---|---|---|---|---|
| | In Test | In orig feed | Fe | $SiO_2$ | Insol | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 71.9 | 28.47 | | | 100.0 | 54.9 | |
| Mag conc | 31.5 | 22.7 | 65.62 | 7.12 | 7.43 | 72.6 | 39.9 | 4.4:1 |
| Midd | 7.7 | 5.5 | 32.94 | | 48.44 | 8.9 | 4.9 | |
| Tailing | 60.8 | 43.7 | 8.66 | | | 18.5 | 10.1 | |

* calculated

** From Internal Report MS-AC-62-120.

Additional analyses of the Mag conc: S 0.035%, $P_2O_5$ 0.07%, $TiO_2$ 0.26%.

The combined magnetic concentrates from this test assayed 63.57% Fe and 9.55% $SiO_2$ with overall iron recovery of 70.8% and a ratio of concentration of 2.54:1. This does not include middlings from either test which were not treated.

Test 14 - Magnetic Concentration of Ore, Magnetizing Roasting of Tailing and Magnetic Concentration of the Roasted Tailing

A 2000 g sample of E1-1 ore was ground to -100m and concentrated by the Jeffrey-Steffensen separator at 1 amp on each of the three drums. The products were a concentrate and a tailing. The concentrate was ground to 96.5% -200m and reconcentrated by the Jeffrey-Steffensen separator at 1 amp on each of the three drums. The two tailings were combined, mixed and a 1000 g portion was roasted with city gas at 670°C for 15 minutes by the method of previous roasting tests. The roasted material was ground to 97.5% -200m and concentrated by the Jeffrey-Steffensen separator. The first two drums, at 1 amp, made a concentrate and a final tailing. The concentrate was cleaned at 0.5 amp, producing a middling and a finished concentrate. Each product of the test was sampled. Screen tests were made on concentrates (2) and (3).

TABLE 18

Results of Magnetic Concentration of the Ore

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | | 33.97 | - | 100.0 | | |
| Mag conc (1) | 20.0 | | 53.84 | 20.80 | 31.7 | | 5.0:1 |
| Tailing (1) | 80.0 | | 29.00 | - | 68.3 | | |

Results of Magnetic Concentration of Reground Concentrate (1)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Feed* | 100.0 | 20.0 | 55.63 | - | 100.0 | 31.7 | |
| Mag conc (2) | 48.0 | 9.6 | 70.44 | 2.76 | 60.8 | 19.3 | 10.4:1 |
| Tailing (2) | 52.0 | 10.4 | 41.94 | - | 39.2 | 12.4 | |

TABLE 18 (contd)

Results of Magnetic Concentration of the Ore

Results of Magnetic Concentration of Roasted Tailings (1) and (2)

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 90.4 | 31.81 | | 100.0 | 80.7 | |
| Mag conc (3) | 31.2 | 28.2 | 66.72 | 6.92 | 65.4 | 52.8 | 3.54:1 |
| Midds | 4.0 | 3.6 | 55.94 | - | 7.1 | 5.7 | |
| Final tailing | 64.8 | 58.6 | 13.52 | - | 27.5 | 22.2 | |

Combined Magnetic Concentrates (2) and (3)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Conc (2) | - | 9.6 | 70.44 | 2.76 | - | 19.3 | 10.4:1 |
| Conc (3) | - | 28.2 | 66.72 | 6.92 | | 52.8 | 3.54:1 |
| Combined Concs* (2) and (3) | - | 37.8 | 67.66 | 5.86 | - | 72.1 | 2.65:1 |

* calculated

** From Internal Report MS-AC-62-628.

TABLE 19

Screen Tests on Concentrates (2) and (3)

| Mesh | Conc (2) | Conc (3) |
|---|---|---|
| | Wt % | Wt % |
| +100 | 0.5 | - |
| +150 | 1.2 | 0.4 |
| +200 | 1.8 | 2.1 |
| +325 | 1.6 | 8.2 |
| -325 | 94.9 | 89.3 |
| | 100.0 | 100.0 |
| -200 | 96.5 | 97.5 |

Test 15 - Roasting and Magnetic Concentration of -200m Ore

A 500 g sample of ore ground to -200m was roasted by the method of Test 13. The roasted ore was ground for 10 minutes in a ball mill and concentrated by the Jeffrey-Steffensen separator. The magnetite was not concentrated prior to roasting.

TABLE 20

Results of Magnetic Concentration of Roasted Ore

| Product | Weight % | Analysis % ** | | Distn % | R/C | Wt % -325 |
|---|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | | |
| Feed* | 100.0 | 36.0 | | 100.0 | | |
| Mag conc | 42.7 | 66.4 | 5.78 | 78.7 | 2.34:1 | 89.2 |
| Midds | 10.1 | 42.2 | 33.50 | 11.9 | | |
| Tailing | 47.2 | 7.2 | - | 9.4 | | 88.8 |
| Combined* Conc + Midds | 52.8 | 61.76 | 11.09 | 90.6 | 1.9:1 | |

* calculated

** From Internal Report MS-AC-62-212.

Additional analyses of the conc -

S - 0.040 %
$P_2O_5$ - 0.04 %
$TiO_2$ - 0.13 %

Test 16 - Roasting and Magnetic Concentration of -48, -65 and -100m Ore

Samples of raw ore, ground to -48m, -65m and -100m, were roasted in a closed retort with city gas at 670°C for 15 minutes.

The roasted ore was ground in a ball mill for 15 minutes and concentrated by the Jeffrey- Steffensen separator.

TABLE 21

Results of Magnetic Concentration of Ore

(a) Roasted at -48m.

| Product | Weight % | Analysis %** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 34.26 | | 100.0 | |
| Mag conc | 40.1 | 62.40 | 11.80 | 73.0 | 2.5:1 |
| Midds | 12.2 | 40.60 | 38.16 | 14.4 | |
| Tailing | 47.7 | 9.0 | | 12.6 | |

(b) Roasted at -65m.

| | | | | | |
|---|---|---|---|---|---|
| Feed* | 100.0 | 35.81 | | 100.0 | |
| Mag conc | 44.3 | 64.56 | 8.84 | 79.8 | 2.3:1 |
| Midds | 9.9 | 41.32 | 37.0 | 11.5 | |
| Tailing | 45.8 | 6.82 | | 8.7 | |

(c) Roasted at -100m.

| | | | | | |
|---|---|---|---|---|---|
| Feed* | 100.0 | 34.94 | | 100.0 | |
| Mag conc | 42.6 | 63.52 | 9.36 | 77.5 | 2.4:1 |
| Midds | 10.2 | 43.10 | 33.88 | 12.6 | |
| Tailing | 47.2 | 7.38 | | 9.9 | |

* calculated

** From Internal Reports MS-AC-62-255 and 323.

TABLE 22

Screen Tests on Concentrates and Tailings from Roasted Samples

| Mesh | 48m Ore | | 65m Ore | |
|---|---|---|---|---|
| | Conc Wt % | Tailing Wt % | Conc Wt % | Tailing Wt % |
| +100 | 0.2 | 0.4 | 0.3 | 0.3 |
| -100+150 | 3.8 | 0.9 | 3.8 | 0.8 |
| -150+200 | 6.1 | 1.9 | 7.7 | 1.4 |
| -200+325 | 7.7 | 7.0 | 6.2 | 5.0 |
| -325 | 82.2 | 89.8 | 82.0 | 92.5 |
| | 100.0 | 100.0 | 100.0 | 100.0 |
| -200 | 89.9 | 96.8 | 88.2 | 97.5 |

High Intensity Magnetic Concentration, Test 17

A sample of ore, ground to -150m, was concentrated by the Jones high intensity separator. The first pass was made at 0 amp to recover magnetite. The non-magnetic middling and tailing were combined and repassed at 1 amp to recover hematite. This procedure was repeated at 3, 5, 7 and 10 amp. The products of this test were magnetic concentrates at 0, 1, 3, 5, 7 and 10 amps and a middling and a tailing at 10 amp. The slimes from each middling and tailing remaining in suspension were decanted after about 15 minutes and filtered to determine the loss in the slime overflow. Each of the products was analysed for iron and insoluble.

The results are tabulated to show the recoveries of iron in each concentrate separately and also as cumulative values.

It will be observed that suitable elimination of the insoluble from iron was not achieved and the concentrates obtained were too low grade for commercial use.

TABLE 23

Results of High Intensity Magnetic Concentration of -150m Ore

| Product | | Weight % In test | Analysis %** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | | | Fe | Insol | Fe | Insol | |
| Feed* | | 100.00 | 33.74 | 45.33 | 100.0 | 100.0 | |
| | amp. | | | | | | |
| Mag conc | 0 | 29.35 | 52.16 | 25.00 | 45.4 | 16.2 | 3.4:1 |
| Mag conc | 1 | 18.98 | 31.60 | 50.32 | 17.8 | 21.1 | 5.3:1 |
| Mag conc | 3 | 9.45 | 48.18 | 28.28 | 13.5 | 5.9 | 10.6:1 |
| Mag conc | 5 | 7.31 | 50.36 | 23.12 | 10.9 | 3.7 | 13.7:1 |
| Mag conc | 7 | 3.58 | 43.80 | 28.96 | 4.6 | 2.3 | 27.9:1 |
| Mag conc | 10 | 2.44 | 28.02 | 43.36 | 2.0 | 2.3 | 41.0:1 |
| Midds | 10 | 8.64 | 5.42 | 77.72 | 1.4 | 14.8 | |
| Tails | 10 | 10.72 | 4.90 | 81.66 | 1.5 | 19.3 | |
| Slimes | | 9.53 | 10.02 | 68.36 | 2.9 | 14.4 | |
| Combined Mag concs* | | 71.11 | 44.71 | 32.83 | 94.2 | 51.5 | 1.41:1 |

* calculated

** From Internal Report MS-AC-62-294.

TABLE 24

Cumulative Results of Magnetic Concentration
(calculated from Table 23)

| Product | | Weight % | | Analysis % ⁂ | | Distn % | | R/C Cum |
|---|---|---|---|---|---|---|---|---|
| | | In test | Cum % | Cum Fe* | Cum Insol* | Cum Fe | Cum Insol | |
| Feed* | | 100.00 | - | 33.74 | 45.33 | 100.0 | 100.0 | |
| | amp. | | | | | | | |
| Mag conc | 0 | 29.35 | 29.35 | 52.16 | 25.00 | 45.4 | 16.2 | 3.4:1 |
| Mag conc | 1 | 18.98 | 48.33 | 44.09 | 34.95 | 63.2 | 37.3 | 2.1:1 |
| Mag conc | 3 | 9.45 | 57.78 | 44.75 | 33.85 | 76.7 | 43.2 | 1.73:1 |
| Mag conc | 5 | 7.31 | 65.09 | 45.38 | 32.65 | 87.6 | 46.9 | 1.54:1 |
| Mag conc | 7 | 3.58 | 68.67 | 45.30 | 32.46 | 92.2 | 49.2 | 1.46:1 |
| Mag conc | 10 | 2.44 | 71.11 | 44.71 | 32.83 | 94.2 | 51.5 | 1.41:1 |

⁂ From Internal Report MS-AC-62-294.

## SECTION 2 - TESTS ON SAMPLE F1-2

### SUMMARY OF RESULTS ON SAMPLE F1-2

This sample was slightly more amenable to concentration than Sample E1-1, although of the same grade. Only two processes were successful:

(1) direct magnetizing roasting followed by magnetic separation,

and (2) low intensity concentration of the magnetite followed by magnetizing roasting to recover hematite from the non-magnetic tailing.

Flotation, high intensity magnetic separation, and gravity methods were unsuccessful.

Direct magnetizing roasting followed by regrinding and magnetic separation (Test 14) produced a concentrate assaying 67.6% Fe and 5.0% $SiO_2$ with an iron recovery of 81.9%. The final concentrate was 82.4% -325m.

In Test 13, a combined low intensity separation-magnetizing roast treatment produced a concentrate assaying 66.65% Fe and 5.97% $SiO_2$ with 74.8% recovery.

In Test 11, stage grinding of the ore with low intensity separations at each stage produced a concentrate assaying 67.84% Fe and 5.12% $SiO_2$ with 25.6% recovery at a grind of 97.3% -325m. Magnetizing roasting of the middling and tailings from this test should produce a higher recovery and grade, comparable to Test 14, although the flotation treatment in Test 11 was unsuccessful.

### DETAILS OF TESTS ON SAMPLE F1-2

#### Test 1 - Magnetic Cobbing of -1/4 in. Ore

A sample of the ore was crushed to -1/4 in. and concentrated by the Ball-Norton dry magnetic separator.

TABLE 25

Results of Magnetic Cobbing of -1/4 in. Ore

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 32.38 | | 100.0 | |
| Mag conc | 59.0 | 36.06 | 34.0 | 64.7 | 1.7:1 |
| Tailing | 41.0 | 28.31 | | 35.3 | |

* calculated

** From Report of Analysis, Chemical Laboratories MS, Feb. 17, 1961.

Magnetic Concentration of Ore, Tests 2 and 3

Test 2, -100m Ore

Samples of the ore, ground to -100m were concentrated by the Davis tube and the Jeffrey-Steffensen separator.

TABLE 26

Results of Magnetic Concentration of -100m Ore by the Davis Tube

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 38.72 | | 100.0 | |
| Mag conc | 28.4 | 52.02 | 24.92 | 38.2 | 3.5:1 |
| Tailing | 71.6 | 33.44 | - | 61.8 | |

* calculated

** From Report of Analysis, Chemical Laboratories MS, March 1, 1961.

TABLE 27

Results of Magnetic Concentration of -100m Ore by the Jeffrey-Steffensen Separator

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 36.83 | | 100.0 | |
| Mag conc | 15.8 | 59.04 | 17.10 | 25.4 | 6.3:1 |
| Midds | 8.6 | 40.0 | - | 9.4 | |
| Tailing | 75.6 | 31.82 | - | 65.2 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 1, 1961.

Test 3, -200m Ore

Samples of the ore, ground to -200m, were concentrated by the Davis tube and the Jeffrey-Steffensen separator.

TABLE 28

Results of Magnetic Concentration of -200m Ore by the Davis Tube

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 37.05 | | 100.0 | |
| Mag conc | 22.4 | 57.66 | 15.86 | 34.9 | 4.5:1 |
| Tailing | 77.6 | 31.10 | | 65.1 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 1, 1961.

TABLE 29

Results of Magnetic Concentration of -200m Ore by the Jeffrey-Steffensen Separator

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 30.7 | | 100.0 | |
| Mag conc | 13.5 | 65.0 | 8.38 | 28.5 | 7.4:1 |
| Midds | 6.3 | 47.0 | 27.5 | 9.7 | |
| Tailing | 80.2 | 23.7 | - | 61.8 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, Feb. 6, 1961.

Combined Magnetic and Gravity Separation, Tests 4, 5 and 6

Test 4 - Magnetic Concentration of -100m Ore by the Crockett Separator, Gravity Concentration of the Crockett Tailing by the Wilfley Table

The test was made to find the recovery of hematite from non-magnetic tailing by gravity.

A sample of -100m ore, weight 3100 g, was concentrated by the Crockett wet magnetic separator. The tailing consisted of sand and slime fractions and portions of each fraction were concentrated by gravity on a laboratory Wilfley table. The table tailing of each test consisted of sand, slime and slime overflow fractions.

TABLE 30

Results of Magnetic Concentration of -100m Ore by the Crockett Separator

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 33.7 | | 100.0 | |
| Mag conc | 36.4 | 44.42 | 30.40 | 47.9 | 2.75:1 |
| Sand tailing | 38.9 | 32.02 | - | 37.0 | |
| Slime " | 24.7 | 20.58 | - | 15.1 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, Feb. 17, 1961.

TABLE 31

Results of Table Concentration of -100m Sand Tailing

| Product | Weight % | | Analysis % ** | | Distn % | |
|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe |
| Feed* | 100.0 | 38.9 | 39.63 | | 100.0 | 37.0 |
| Table conc | 39.5 | 15.4 | 59.66 | 8.06 | 59.5 | 22.0 |
| Sand tailing | 26.1 | 10.2 | 33.10 | - | 21.8 | 8.1 |
| Slime " | 21.7 | 8.4 | 19.90 | - | 10.9 | 4.0 |
| Slime o'flow tailing | 12.7 | 4.9 | 24.40 | - | 7.8 | 2.9 |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, Feb. 17, 1961.

TABLE 32

Results of Table Concentration of -100m Slime Tailing

| Product | Weight % | | Analysis %** | | Distn % | |
|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe |
| Feed* | 100.0 | 24.7 | 19.85 | | 100.0 | 15.1 |
| Table conc | 3.2 | 0.8 | 48.36 | 23.68 | 7.7 | 1.2 |
| Slime tailing | 27.6 | 6.8 | 20.84 | - | 29.0 | 4.4 |
| Slime o'flow tailing | 69.2 | 17.1 | 18.16 | - | 63.3 | 9.5 |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, Feb. 17, 1961.

The results of this test indicated that 71.1% of the iron might be recovered by magnetic and gravity methods, although the concentrates were below commercial grade.

Test 5 - Magnetic Concentration of -100m Ore by the Jeffrey-Steffensen Separator, Gravity Concentration of the Tailing by the Deister Table.

A sample of -100m ore was concentrated by the Jeffrey-Steffensen separator. The tailing was concentrated by a Deister table.

TABLE 33

Results of Magnetic Concentration of -100m Ore by the Jeffrey-Steffensen Separator

| Product | Weight % | Analysis %** | | | Distn % Fe | R/C |
|---|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | $TiO_2$ | | |
| Feed* | 100.0 | 36.89 | | | 100.0 | |
| Mag conc | 20.3 | 55.62 | 19.28 | 0.01 | 30.6 | 4.9:1 |
| Midds | 10.7 | 34.64 | - | - | 10.1 | |
| Tailing | 69.0 | 31.73 | - | - | 59.3 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 29, 1961.

TABLE 34

Results of Table Concentration of -100m Tailing

| Product | Weight % | | Analysis % ** | | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | $TiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 69.0 | 31.73 | | | 100.0 | 59.3 | |
| Table conc | 33.3 | 23.0 | 55.64 | 12.68 | 0.24 | 58.5 | 34.7 | 4.3:1 |
| Midds | 7.5 | 5.1 | 16.82 | -- | -- | 3.9 | 2.3 | |
| Tailing | 59.2 | 40.9 | 20.15 | -- | -- | 37.6 | 22.3 | |

* calculated

** From Report of Analysis, Chemical Analysis, MS, March 29, 1961.

Overall recovery of iron was 65.3% with a higher grade of concentrate than in the previous test due to better performance of the wet drum (Jeffrey-Steffensen) separator.

Test 6 - Gravity Concentration of -100m Ore by the Deister Table, Magnetic Concentration of the Table Tailings by the Davis Tube and the Jeffrey-Steffensen Separator.

A sample of -100m ore was concentrated on a Deister table. The products of the test were a concentrate, a middling and a tailing consisting of sand and slime fractions. Portions of each tailing fraction were magnetically concentrated by both the Davis tube and the Jeffrey-Steffensen separator.

TABLE 35

Results of Table Concentration of -100m Ore

| Product | Weight % | Analysis % ** | | | Distn % Fe | R/C |
|---|---|---|---|---|---|---|
| | | Fe | $TiO_2$ | $SiO_2$ | | |
| Feed* | 100.0 | 35.9 | | | 100.0 | |
| Table conc | 44.5 | 49.44 | 0.10 | 19.78 | 61.3 | 2.24:1 |
| Midds | 4.0 | 14.16 | - | - | 1.6 | |
| Sand tailing (1) | 34.3 | 27.30 | - | - | 26.1 | |
| Slime tailing (2) | 17.2 | 23.02 | - | - | 11.0 | |
| Combined tailing* | 51.5 | 25.87 | - | - | 37.1 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, Mar. 23, 1961.

TABLE 36

Results of Magnetic Concentration of Table Tailings by the Davis Tube

| Product | Weight % In orig feed | Analysis % ** Fe | Distn % In orig feed Fe | R/C |
|---|---|---|---|---|
| Sand Tailing (1)* | 34.3 | 27.35 | 26.1 | |
| Mag conc (1) | 9.1 | 41.80 | 10.5 | 10.9:1 |
| Tailing (1) | 25.2 | 22.16 | 15.6 | |
| Slime tailing (2)* | 17.2 | 22.92 | 11.0 | |
| Mag conc (2) | 1.7 | 58.06 | 2.8 | 59:1 |
| Tailing (2) | 15.5 | 19.02 | 8.2 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 27, 1961.

TABLE 37

Results of Magnetic Concentration of Table Sand Tailing by the Jeffrey-Steffensen Separator

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 34.3 | 27.34 | | 100.0 | 26.1 | |
| Mag conc | 10.7 | 3.7 | 56.04 | 18.56 | 21.4 | 5.6 | 27.4:1 |
| Midds | 10.6 | 3.6 | 35.80 | 41.18 | 13.7 | 3.6 | |
| Tailing | 78.7 | 27.0 | 22.96 | - | 64.9 | 16.9 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 27, 1961

TABLE 38

Results of Magnetic Concentration of Table Slime Tailing by the Jeffrey-Steffensen Separator

| Product | Weight % | | Analysis %** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 17.2 | 23.88 | | 100.0 | 11.0 | |
| Mag conc | 2.5 | 0.4 | 65.30 | 7.54 | 6.7 | 0.7 | 238:1 |
| Midds | 3.7 | 0.6 | 49.84 | 23.44 | 7.6 | 0.8 | |
| Tailing | 93.8 | 16.2 | 21.79 | - | 85.7 | 9.5 | |

* calculated

** From Report of Analysis, Chemical Laboratories, MS, March 27, 1961.

Overall recovery by tabling and wet drum magnetic separation was 67.6%, but the grade of concentrate would be too low.

Flotation, Tests 7 to 11 incl.

Tests 7 and 8 - Flotation of Silica from Hematite in a Jeffrey-Steffensen Tailing

The method used in this test was the United States Bureau of Mines anionic flotation of calcium activated silica.

Calcium chloride, 1 lb/ton, was used to activate the silica which was then floated using a tall oil collector with a dextrine iron depressant at a pH of 12.

In Test 7 the silica concentrate was not cleaned and, although some silica was floated, the iron concentrate assayed only 38.86% Fe.

In Test 8 the same method was used but dextrine was reduced from 1.0 lb/ton to 0.5 lb/ton in the rougher float. A slightly better result was obtained, but the iron concentrate assayed 45.76% Fe and 24.48% $SiO_2$ so this result was not acceptable. Iron recovery was 73.6% and cleaning of the silica float did not produce acceptable concentrates.

The feed was not deslimed and the slimes appeared to interfere with the silica float.

Tests 9 and 10 - Flotation of Iron Minerals from the Ore

These tests were made to float the iron minerals from the ore into a concentrate of acceptable grade. A sample of -20m ore was ground in a ball mill, to 91.3% -200m, with no reagents.

The pulp was deslimed prior to flotation using 0.4 lb/ton of sodium silicate as a dispersant, and decanting the slimes after 5 min settling time. The pulp was then conditioned at 60% solids and a pH of 6.8 (with $H_2SO_4$) with a collector mixture of 5 parts fuel oil and 1 part Cyanamid Reagent 801 (6 lb/ton). A rougher concentrate was floated and cleaned once using sodium silicate. Results were very poor with less than 35% of the iron floated and very little concentration of iron.

Test 11 - Magnetic Concentration of Ore by the Crockett Separator, Flotation of Silica from the Tailing.

A 2000 g sample of -20m ore was ground to 84% -200m and concentrated by the Crockett wet separator. The Crockett tailing was floated in two tests to remove silica. Armac C was used as a silica collector with dextrine as an iron depressant. The pH was 11.5, regulated by sodium hydroxide (6.0 lb/ton).

Neither flotation test produced acceptable concentrates. The best result was obtained by staging five additions of 0.10 lb/ton Armac C at five-minute intervals, but the iron concentrate still contained 22.88% Insol with only 46.56% Fe. Although 84% of the iron was recovered from the Crockett tailing, this grade of concentrate would not be acceptable. The grind did not appear to be fine enough as coarse silica did not float.

The Crockett concentrate was reground to 99.8% -200m and a magnetite concentrate containing 25.6% of the iron in the ore was obtained by concentration in the Jeffrey-Steffensen separator. This concentrate grade was 67.84% Fe with 5.12% Insol. The results are shown in Table 39.

The magnetite concentrate was 82.4% -325m.

TABLE 39

Results of Magnetic Concentration of Reground Crockett Concentrate by the Jeffrey-Steffensen Separator

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | Insol | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 38.0 | 45.16 | | 100.0 | 47.0 | |
| Mag conc | 36.3 | 13.8 | 67.84 | 5.12 | 54.5 | 25.6 | 7.3:1 |
| Midds | 10.6 | 4.0 | 52.26 | 26.12 | 12.3 | 5.8 | |
| Tailing | 53.1 | 20.2 | 28.24 | - | 33.2 | 15.6 | |

* calculated

** From Internal Report MS-AC-61-1067, 62-88.

## Magnetic Roasting, Tests 12, 13 and 14

### Test 12 - Magnetic Concentration of -200m Ore, Magnetizing Roast of the Tailing and Magnetic Concentration of the Roasted Tailing.

A 2000 g sample of ore finer than 200m was concentrated by the Jeffrey-Steffensen separator. A portion of the tailing was roasted in the closed retort with city gas at 670°C for 15 minutes. The roasted material was concentrated by the Jeffrey-Steffensen separator without regrinding.

TABLE 40

Results of Magnetic Concentration of the Ore and Roasted Tailing, Test 12

| Product | Weight % In orig feed | Analysis % ** | | | Distn % In orig feed Fe | R/C |
|---|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Insol | | |
| Feed* | 100.0 | 37.0 | | | 100.0 | |
| Mag conc (1) | 14.7 | 64.06 | 9.24 | | | 6.8:1 |
| Mag conc (2) | 31.8 | 64.56 | 8.16 | 9.20 | | 3.1:1 |
| Combined conc* | 46.5 | 64.40 | 8.50 | - | 78.6 | 2.15:1 |
| Midds (1) | 7.0 | 43.64 | 35.36 | | | |
| Midds (2) | 5.5 | 35.22 | - | 45.24 | | |
| Combined midd* | 12.5 | 39.93 | - | - | 13.3 | |
| Final tailing | 41.0 | 7.60 | - | - | 8.1 | |

| Additional Analyses** | Mag conc (1) | Mag conc (2) |
|---|---|---|
| S | 0.029 | 0.037 |
| $P_2O_5$ | 0.19 | 0.21 |
| $TiO_2$ | 0.03 | 0.17 |

* calculated

** From Internal Reports MS-AC-62-110, MS-AC-62-120, and MS-AC-62-526.

Test 13 - Magnetic Concentration of Ore, Magnetizing Roasting of Tailing and Magnetic Concentration of the Roasted Tailing

A 2000 g sample of F1-2 ore was ground to -100m and concentrated by the Jeffrey-Steffensen separator at 1 amp on each of the three drums. The products were a concentrate and a tailing. The concentrate was ground to 96.2% -200m and reconcentrated by the Jeffrey-Steffensen separator at 1 amp on each of the three drums. The two tailings were combined, mixed and a 1000 g portion was roasted with city gas at 670°C for 15 minutes by the method of previous roasting tests. The roasted material was ground to 80.8% -200m and concentrated by the Jeffrey-Steffensen separator. The first two drums at 1 amp made a concentrate and a final tailing. The concentrate was cleaned at 0.5 amp, producing a middling and a finished concentrate. Each product of the test was sampled. Screen tests were made on concentrates (2) and (3).

TABLE 41

Results of Magnetic Concentration of the Ore and Roasted Tailing

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | $SiO_2$ | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | | 36.87 | | 100.0 | | |
| Mag conc (1) | 22.3 | | 54.56 | 20.96 | 33.0 | | 4.5:1 |
| Tailing (1) | 77.7 | | 31.80 | - | 67.0 | | |
| Results of Magnetic Concentration of Reground Concentrate (1) | | | | | | | |
| Feed* | 100.0 | 22.3 | 53.86 | | 100.0 | 33.0 | |
| Mag conc (2) | 50.9 | 11.3 | 69.46 | 3.12 | 65.6 | 21.6 | 8.8:1 |
| Tailing (2) | 49.1 | 11.0 | 37.70 | - | 34.4 | 11.4 | |
| Results of Magnetic Concentration of Roasted Tailings (1) and (2) | | | | | | | |
| Feed* | 100.0 | 88.7 | 34.25 | | 100.0 | 78.4 | |
| Mag conc (3) | 35.4 | 31.4 | 65.64 | 7.00 | 67.9 | 53.2 | 3.2:1 |
| Midds | 3.5 | 3.1 | 56.48 | 18.68 | 5.8 | 4.5 | |
| Final Tailing | 61.1 | 54.2 | 14.78 | - | 26.3 | 20.7 | |
| Combined Magnetic Concentrates (2) and (3) | | | | | | | |
| Conc (2) | | 11.3 | 69.46 | 3.12 | - | 21.6 | 8.8:1 |
| Conc (3) | | 31.4 | 65.64 | 7.00 | - | 53.2 | 3.2:1 |
| Combines Concs*(2) & (3) | | 42.7 | 66.65 | 5.97 | - | 74.8 | 2.34:1 |

*calculated

** From Internal Report MS-AC-62-627.

TABLE 42

Screen Tests on Concentrates (2) and (3)

| Mesh | Conc 2 | Conc 3 |
|---|---|---|
| | Wt % | Wt % |
| +100 | 0.5 | - |
| +150 | 1.5 | 9.0 |
| +200 | 1.8 | 10.2 |
| +325 | 7.1 | 6.0 |
| -325 | 89.1 | 74.8 |
| | 100.0 | 100.0 |
| -200 | 96.2 | 80.8 |

Test 14 - Magnetic Concentration of Roasted Ore

A 500 g sample of -200m ore was roasted in the closed retort with city gas at 670°C for 15 minutes. After cooling, the roasted ore was ground in a ball mill to 82.4% -325m and concentrated by the Jeffrey-Steffensen separator. The magnetite was not concentrated prior to roasting.

TABLE 43

Results of Magnetic Concentration of Roasted Ore

| Product | Weight % | Analysis % ** | | Distn % | R/C |
|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | |
| Feed* | 100.0 | 38.7 | | 100.0 | |
| Mag conc | 46.9 | 67.60 | 5.0 | 81.9 | 2.13:1 |
| Midds | 7.7 | 47.20 | 28.50 | 9.4 | |
| Tailing | 45.4 | 7.40 | | 8.7 | |
| Combined Conc & Midd* | 54.6 | 64.71 | 8.33 | 91.3 | 1.83:1 |

* calculated

** From Internal Report MS-AC-62-212, MS-AC-62-526.

Additional analyses** of the conc:

S - 0.028 %
$P_2O_5$ - 0.15 "
$TiO_2$ - 0.11 "

## High Intensity Magnetic Concentration, Tests 15 and 16

### Test 15 - High Intensity Magnetic Concentration of Hematite from -200m Jeffrey-Steffensen Tailing.

The feed used for the test was a portion of tailing from the -200m ore of Test 12. It was concentrated by the Jones high intensity separator at 5 amp. The products of the test were a concentrate, a middling and a tailing.

TABLE 44

Results of High Intensity Magnetic Concentration of -200m Jeffrey-Steffensen Tailing by the Jones Separator

| Product | Weight % | | Analysis % ** | | Distn % | | R/C |
|---|---|---|---|---|---|---|---|
| | In test | In orig feed | Fe | Insol | In test Fe | In orig feed Fe | |
| Feed* | 100.0 | 77.7 | 31.65 | | 100.0 | 67.0 | |
| Mag conc 5a | 41.3 | 32.1 | 51.08 | 23.80 | 66.6 | 44.6 | 3.1:1 |
| Midds | 15.5 | 12.0 | 20.56 | 57.36 | 10.1 | 6.8 | |
| Tailing | 43.2 | 33.6 | 17.06 | - | 23.3 | 15.6 | |

* calculated

** From Internal Report MS-AC-62-139.

### Test 16 - High Intensity Magnetic Concentration of -150m Ore by the Jones Separator

A 2000 g sample of -20m ore was ground in a ball mill for 45 minutes. The pulp was split wet and one-half was wet screened on 150m. The screen over-size was ground to pass 150m.

The -150m ore was concentrated by the Jones separator at 0, 1, 3, 5, 7, and 10 amp. The non-magnetic tailing from each amp setting was re-passed at the next higher amp setting. The products of the test were 6 concentrates, a middling, a tailing and slimes. Each product was analysed for iron and silica. After calculating the recovery of iron in each concentrate, the cumulative values were also calculated.

TABLE 45

Results of High Intensity Magnetic Concentration of -150m Ore by the Jones Separator

| Product | Weight % | | Analysis % ** | | Distn % | |
|---|---|---|---|---|---|---|
| | -- | Cum | Fe | $SiO_2$ | Fe | $SiO_2$ |
| Feed* | 100.00 | | 36.68 | 37.90 | 100.0 | 100.0 |
| Mag conc 0 amp | 23.81 | 23.81 | 56.54 | 18.44 | 36.7 | 11.6 |
| Mag conc 1 " | 12.57 | 36.38 | 37.12 | 40.95 | 12.7 | 13.6 |
| Mag conc 3 " | 11.56 | 47.94 | 51.88 | 20.56 | 16.4 | 6.3 |
| Mag conc 5 " | 11.34 | 59.28 | 55.10 | 16.48 | 17.0 | 4.9 |
| Mag conc 7 " | 4.99 | 64.27 | 45.34 | 27.00 | 6.2 | 3.5 |
| Mag conc 10 " | 3.12 | 67.39 | 30.18 | 39.44 | 2.6 | 3.3 |
| Combined Mag conc | 67.39 | | 49.82 | 24.28 | 91.6 | 43.2 |
| Midds 10 amp | 10.70 | | 7.50 | 69.08 | 2.2 | 19.5 |
| Tailing 10 amp | 12.64 | | 7.06 | 72.84 | 2.4 | 24.3 |
| Slimes | 9.27 | | 15.22 | 53.24 | 3.8 | 13.0 |

*calculated

**From Internal Report MS-AC-62-323.

TABLE 46

Cumulative Results of High Intensity Magnetic Separation

| Product | Weight % | Analysis % | | Distn % | | R/C |
|---|---|---|---|---|---|---|
| | | Fe | $SiO_2$ | Fe | $SiO_2$ | |
| Mag conc 0 amp | 23.81 | 56.54 | 18.44 | 36.70 | 11.59 | 4.2:1 |
| Mag conc 1 " | 36.38 | 49.83 | 26.22 | 49.42 | 25.17 | 2.8:1 |
| Mag conc 3 " | 47.94 | 50.32 | 24.85 | 65.77 | 31.44 | 2.1:1 |
| Mag conc 5 " | 59.28 | 51.24 | 23.25 | 82.80 | 36.37 | 1.7:1 |
| Mag conc 7 " | 64.27 | 50.78 | 23.54 | 88.97 | 39.92 | 1.6:1 |
| Mag conc 10 " | 67.39 | 49.82 | 24.28 | 91.54 | 43.17 | 1.5:1 |

Calculated from Table 45.

Magnetite was recovered at 0 amp and hematite at the remaining amperages. However, as shown in Table 46 above, the concentrates at any amperage were too low in iron.

## CONCLUSIONS

The iron minerals are amenable to magnetic concentration. The magnetite can be recovered in acceptable grades of concentrate when ore or a cobber concentrate is ground finer than 200m. The hematite can be recovered by subjecting the non-magnetic tailing to a magnetizing roast followed by low intensity magnetic concentration. The results indicated that better grades and recoveries of iron can be achieved by roasting the whole ore.

Acceptable grades of hematite concentrate could not be made by gravity, flotation or high intensity magnetic concentration at grinds as fine as -200m.

It would appear that any reasonable recovery of iron from either of the two samples submitted would involve magnetizing roasting to recover hematite. Although the magnetite could be recovered, in a preliminary low intensity separation, iron recovery is higher if the ore is roasted after grinding to 48 or 65 mesh to magnetize the hematite and then reground to a fineness at which magnetic separation will produce an acceptable product. A product assaying about 67% Fe and less than 6% $SiO_2$ is possible by either method.

Although wet grinding was used in the laboratory tests, dry autogenous grinding would be preferable for the preliminary grind since drying costs before roasting would be saved. The regrinding would best be carried out wet since wet drum magnetic separation would be necessary to produce a finished concentrate. Roasted ore usually grinds easily.

It is not known if the treatment of this ore could compete economically with magnetic taconites in the same area at this time, but the low ratios of concentration, 2.1 and 2.4 to 1, are favourable. Since no plants of this type are operating, costs of magnetizing roasting cannot be estimated with accuracy.

## ACKNOWLEDGEMENTS

The semi-quantitative spectrographic analyses of the head samples were made in the Spectrographic Laboratory, Mineral Sciences Division, by Miss E. M. Kranck.

The chemical analyses of the ore and test products were made by the Analytical Chemistry Subdivision of the Mineral Sciences Division by D.J. Charette, F.W. Brethour, R. Craig, Miss E. Mark, and J. Hole.

WSJ:EBM