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O T T A W A  February 24th, 1943.

# R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1360.

## Small-Scale Concentration Tests on a Chromite Ore from the Page Claims, Bird River, Manitoba.

(Copy No.___.)

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Shipment:

A shipment of 1,180 pounds of chromite ore was received on August 31st, 1942, from Mr. Hilding Johnson, Lac du Bonnet, Manitoba. This represented six typical exposures of the chromite band at intervals over a total length of 2,400 feet.

The samples consisted of fresh ore blasted out across the main chromite band over an average width of approximately 7 feet and were taken by Mr. Johnson under the direction of Dr. J. D. Bateman, of the Geological Survey, Mines and Geology Branch, Department of Mines and Resources, Ottawa, Ontario.

Location of the Property:

The Page claims, from which the sample was taken, are situated north of Oiseau River, Lac du Bonnet district, Manitoba. (Sec. 5-6, Tp. 18, R 15E).

Sampling and Analysis:

After crushing and cutting by standard methods, a representative sample of the shipment was obtained which assayed as follows:

| | | Per cent |
|---|---|---|
| Chromium oxide ($Cr_2O_3$) | - | 26.80 |
| Iron (Fe) | - | 12.34 |
| Silica ($SiO_2$) | - | 10.30 |

Characteristics of the Ore:

Six polished sections were prepared and examined under the reflecting microscope for the purpose of determining the character of the ore.

Gangue -

In the polished sections, gangue material consists of soft, fine-textured, dark-grey rock which contains occasional, small, elongated remnants of a harder mineral and probably represents a serpentinized peridotite.

Metallic Minerals -

The polished surfaces exhibit abundant chromite disseminated rather evenly through gangue as more or less rounded grains and crystals. These range from 750 microns down to 10 microns or less in size, the average being about 160 microns (-65+100 Tyler mesh). In general, the chromite contains numerous inclusions and veinlets of gangue which are too small to be economically eliminated by grinding. Chromite grains entirely free of gangue inclusions are very rare and, although some grains are almost free, in most grains such inclusions are numerous and in some cases predominate. Approximately average fields are shown in the photomicrographs.

The gangue inclusions are usually scattered at random

(Characteristics of the Ore, cont'd) -

throughout the chromite but occasionally (1) they show a rough peripheral arrangement in which they form a ring or narrow band around the border of the ore mineral, leaving the centre comparatively free; or (2) they contain a rather large round inclusion at or near the centre of the chromite crystal. In some chromite grains where the latter occurs the borders are comparatively free of smaller gangue inclusions. It is to be noted also that many chromite grains have jagged, corroded edges which appear to have resulted from attack and replacement by gangue. See the photomicrographs, Figures 1, 2, and 3.

The shells or rims of the light-grey material, which are almost universal around the chromite grains in the ore from the Chrome Group of claims (our Min. Lab. Report No. M-869-E, God's Lake Gold Mines Limited, Nov. 1942), are not so abundant in the polished sections of this ore but are common in one. They are much less than ten microns in width and probably average not more than five or six microns (see Figure 1). As explained in the report referred to above, this lighter-coloured material is probably an alteration product. In a previous report (our Min. Lab. Report No. M-664-E, Sept. 1939), made on a sample of another chromite ore, borders of similar-looking material were suggested as being reaction shells of magnetite. This suggestion was made because a light-brown stain was left on the border material after long etching with stannous chloride in 1:1 HCl, while the chromite was unaffected. Similar tests made on the sections from this ore were negative. After an attempt had been made to remove some of the border material with a needle-point, however, one small particle stood on end at the approach of a magnet, but it is not known with certainty whether this particle came from the rim or not. In any case, if magnetite is present it appears to be in very small amount.

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(Pages 4 to 6 are photomicrographs.)
(Text continues on page 7.)

Figure 1.

Photomicrograph of polished section showing chromite crystals with narrow, light-coloured borders around the edges and along gangue-filled fractures.

Borders - almost white.
Chromite - light grey.
Gangue - grey.
Pits - black.

Magnification - 200X.

Figure 2.

Photomicrograph of polished section showing the distribution of small inclusions of gangue in the chromite crystals. Note the comparatively large, round inclusions near the centres of two chromite grains.

Chromite - light grey.
Gangue - grey.
Pits - black.

Magnification - 200X.

Figure 3.

Photomicrograph of polished section showing the corrosion and embayment of chromite by gangue. Also note that the tiny inclusions of gangue are more numerous towards the boundaries of the chromite crystals.

Chromite - light grey.
Gangue - grey.

Magnification - 200X.

Investigative Work:

The character of this ore and the history of chromite concentration point to gravity concentration. This investigation follows that preconception and the report includes the results obtained by table concentration. Flotation also was tried, together with small reconcentration tests, on the gravity concentrates. The possibilities of magnetic separation to increase the chrome-iron ratio were studied.

Table concentration on ore ground minus 48 mesh produced a concentrate assaying 42.4 per cent $Cr_2O_3$ with a chrome-iron ratio of 1.48:1, while, when grinding to minus 10 mesh, the concentrate assayed 33.5 per cent $Cr_2O_3$ with a chrome-iron ratio of 138:1. A recovery of 85.1 per cent was recorded for the coarse grind while the recovery from the finer grind fell off to 66 per cent. A grind of approximately minus 35 mesh is indicated for best results. The highest grade of concentrate obtainable is about 44.28 per cent $Cr_2O_3$ and 20.7 per cent Fe, with a chrome-iron ratio of 1.46:1.

The preliminary investigations consisted of grinding through 14 mesh and table concentration of sized portions of the pulp. Microscopic examination showed that only when 48 mesh was reached were 50 per cent of the chromite grains freed of gangue.

When the grade of concentrate reached 40.7 per cent $Cr_2O_3$, 90 per cent of the grains were free. With a 38 per cent grade, 70 per cent was freed, while a middling product assaying 25.6 per cent contained 80 per cent of attacked chromite-gangue particles. Jigging of minus 100 mesh material in a gold jig produced inferior results.

(Continued on next page)

(Investigative Work, cont'd) -

Flotation of the chrome in the ore was attempted, but was not found to be feasible owing to the tendency of the serpentine talc in the gangue to float along with the chromite mineral.

Better results were secured by first removing the talc by flotation, followed by gravity concentration. By this method the grade of table feed was raised from 26.80 per cent $Cr_2O_3$ (head assay) to 31.4 per cent $Cr_2O_3$ with a removal of 18 per cent of the ore at a loss of only 5.0 per cent of the $Cr_2O_3$. Table concentration of these flotation tailings gave a concentrate assaying 40.6 per cent $Cr_2O_3$ and an overall recovery of 78.9 per cent of the chromium in the ore. By desliming, prior to table concentration, the grade was raised to 29.0 per cent $Cr_2O_3$, with a decantation of 6.5 per cent of the weight of the feed. The ensuing table concentrates assayed 40.3 per cent $Cr_2O_3$ with an overall recovery of 77.6 per cent of the chromium.

Magnetic concentration in the Davis tube of two lots of table concentrates gave results which showed less than 1.0 per cent of the concentrate to be magnetic.

Superpanning tests on different table concentrates raised the grade less than 1.0 per cent $Cr_2O_3$ and did not alter the chrome-iron ratio appreciably.

The results of the test work follow:

Part I. - Wilfley Table Concentration.

Part II. - Flotation Concentration.

Part III. - Flotation and Table Concentration Combined.

## PART I. - WILFLEY TABLE CONCENTRATION.

### Test No. 1 (A to D).

In this test, portions of the ore at minus 14 mesh were ground in water in a ball mill to various degrees of fineness. The pulp density of the grind was 57.0 per cent solids. The pulp was then passed over a Wilfley table, with the following results:

Test No. 1-A (43.5 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.73* | 13.35* | 100.0 | 100.0 | |
| Conc. | 31.27 | 42.42 | 20.68 | 49.6 | 48.4 | 3.2:1. |
| Middling | 23.81 | 33.25 | 15.76 | 29.6 | 28.1 | |
| Tailing | 44.92 | 12.36 | 6.97 | 20.8 | 23.5 | |

Test No. 1-B (65.0 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.55* | 13.61* | 100.0 | 100.0 | |
| Conc. | 25.74 | 43.04* | 21.65 | 41.7 | 41.0 | 3.9:1. |
| Middling | 32.70 | 28.09 | 13.94 | 34.6 | 33.5 | |
| Tailing | 41.56 | 15.14 | 8.36 | 23.7 | 25.5 | |

Test No. 1-C (73.6 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.66* | 13.18* | 100.0 | 100.0 | |
| Conc. | 17.04 | 43.39 | 21.55 | 27.7 | 27.8 | 5.9:1. |
| Middling | 34.60 | 30.87 | 15.22 | 40.1 | 39.9 | |
| Tailing | 48.36 | 17.77 | 8.79 | 32.2 | 32.3 | |

Test No. 1-D (85.9 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.73* | 13.27* | 100.0 | 100.0 | |
| Conc. | 18.15 | 42.94 | 21.12 | 29.2 | 28.9 | 5.5:1. |
| Middling | 22.83 | 32.72 | 15.86 | 27.9 | 27.3 | |
| Tailing | 59.02 | 19.43 | 9.86 | 42.9 | 43.8 | |

* Calculated.

(Continued on next page)

(Test No. 1, cont'd) -

Summary of Test No. 1:

| Test No. | Chrome-iron ratio of concentrate | Assay of concentrate, $Cr_2O_3$, per cent | Overall recovery, per cent $Cr_2O_3$ | Grind, per cent minus 200 mesh |
|---|---|---|---|---|
| 1-A | 1.40:1. | 42.42 | 64.4 | 43.5 |
| 1-B | 1.36:1. | 43.04 | 59.0 | 65.0 |
| 1-C | 1.38:1. | 43.39 | 47.8 | 73.6 |
| 1-D | 1.39:1. | 42.94 | 43.1 | 85.9 |

The overall recovery figures were arrived at by the addition of one-half of the middling product to the concentrate. These recoveries are low due to the unclassified feed to the table.

A portion of the concentrates from these tests were treated on the Haultain superpanning machine. The resultant panner concentrates were weighed and assayed for Cr and Fe.

Results:

| Test No. | Weight of panner concentrate, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Chrome-to-iron ratio |
|---|---|---|---|---|
| 1-A | 64.93 | 42.99 | 21.55 | 1.36:1. |
| 1-B | 73.10 | 43.04 | 22.19 | 1.33:1. |
| 1-C | 81.50 | 43.44 | 22.08 | 1.35:1. |

Test No. 2 (A to I).

In this test, portions of the ore were dry-crushed through a set of rolls to the different sizes as designated. The resultant pulps were then concentrated on Wilfley tables.

(Continued on next page)

(Test No. 2, cont'd) -

Test No. 2-A (Minus 6 mesh and 9.0 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.51* | 13.38* | 100.0 | 100.0 | |
| Table conc. | 60.63 | 32.87 | 16.29 | 74.9 | 73.8 | 1.6:1. |
| " middling | 26.55 | 20.43 | 10.58 | 20.4 | 21.0 | |
| " tailing | 12.82 | 9.81 | 5.40 | 4.7 | 5.2 | |

Test No. 2-B (Minus 8 mesh and 9.6 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.15* | 13.49* | 100.0 | 100.0 | |
| Table conc. | 61.22 | 32.22 | 16.61 | 75.4 | 75.4 | 1.6:1. |
| " middling | 25.56 | 19.84 | 10.16 | 19.4 | 19.3 | |
| " tailing | 13.22 | 10.27 | 5.40 | 5.2 | 5.3 | |

Test No. 2-C (Minus 10 mesh and 12.6 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.54* | 13.35* | 100.0 | 100.0 | |
| Table conc. | 61.84 | 33.50 | 16.66 | 78.0 | 77.2 | 1.6:1. |
| " middling | 23.46 | 18.98 | 9.58 | 16.8 | 16.9 | |
| " tailing | 14.70 | 9.37 | 5.40 | 5.2 | 5.9 | |

Test No. 2-D (Minus 14 mesh and 19.8 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.07* | 13.21* | 100.0 | 100.0 | |
| Table conc. | 56.22 | 33.03 | 16.51 | 71.2 | 70.3 | 1.8:1. |
| " middling | 27.28 | 21.24 | 11.11 | 22.2 | 22.9 | |
| " tailing | 16.50 | 10.36 | 5.45 | 6.6 | 6.8 | |

Test No. 2-E (Minus 20 mesh and 23.0 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.54* | 13.50* | 100.0 | 100.0 | |
| Table conc. | 45.49 | 36.89 | 18.57 | 63.2 | 62.6 | 2.2:1. |
| " middling | 37.51 | 21.59 | 11.00 | 30.5 | 30.6 | |
| " tailing | 17.00 | 9.75 | 5.40 | 6.3 | 6.8 | |

Test No. 2-F (Minus 28 mesh and 24.4 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.80* | 13.41* | 100.0 | 100.0 | |
| Table conc. | 35.70 | 39.19 | 19.67 | 52.2 | 52.3 | 2.8:1. |
| " middling | 46.18 | 23.56 | 11.65 | 40.6 | 40.1 | |
| " tailing | 18.12 | 10.69 | 5.61 | 7.2 | 7.6 | |

Test No. 2-G (Minus 35 mesh and 26.8 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.72* | 13.22* | 100.0 | 100.0 | |
| Table conc. | 34.95 | 40.75 | 19.99 | 53.3 | 52.9 | 2.9:1. |
| " middling | 41.98 | 23.37 | 11.45 | 36.7 | 36.4 | |
| " tailing | 23.07 | 11.58 | 6.17 | 10.0 | 10.7 | |

* Calculated.

(Continued on next page)

(Test No. 2, cont'd) -

Test No. 2-H (Minus 48 mesh and 33.4 per cent minus 200 mesh).

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Ratio of concentration |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.98Φ | 12.22Φ | 100.0 | 100.0 | |
| Table conc. | 29.38 | 42.40 | 19.60 | 46.2 | 46.8 | 3.4:1. |
| " middling | 43.11 | 24.70 | 11.00 | 39.5 | 38.5 | |
| " tailing | 27.51 | 14.10 | 6.60 | 14.3 | 14.7 | |

Test No. 2-I (Minus 65 mesh and 42.8 per cent minus 200 mesh).

| | | | | | | |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 26.51Φ | 11.86Φ | 100.0 | 100.0 | |
| Table conc. | 28.22 | 42.00 | 19.40 | 44.7 | 46.2 | 3.5:1. |
| " middling | 37.49 | 25.10 | 10.80 | 35.5 | 34.2 | |
| " tailing | 34.29 | 15.30 | 6.80 | 19.8 | 19.6 | |

Φ Calculated.

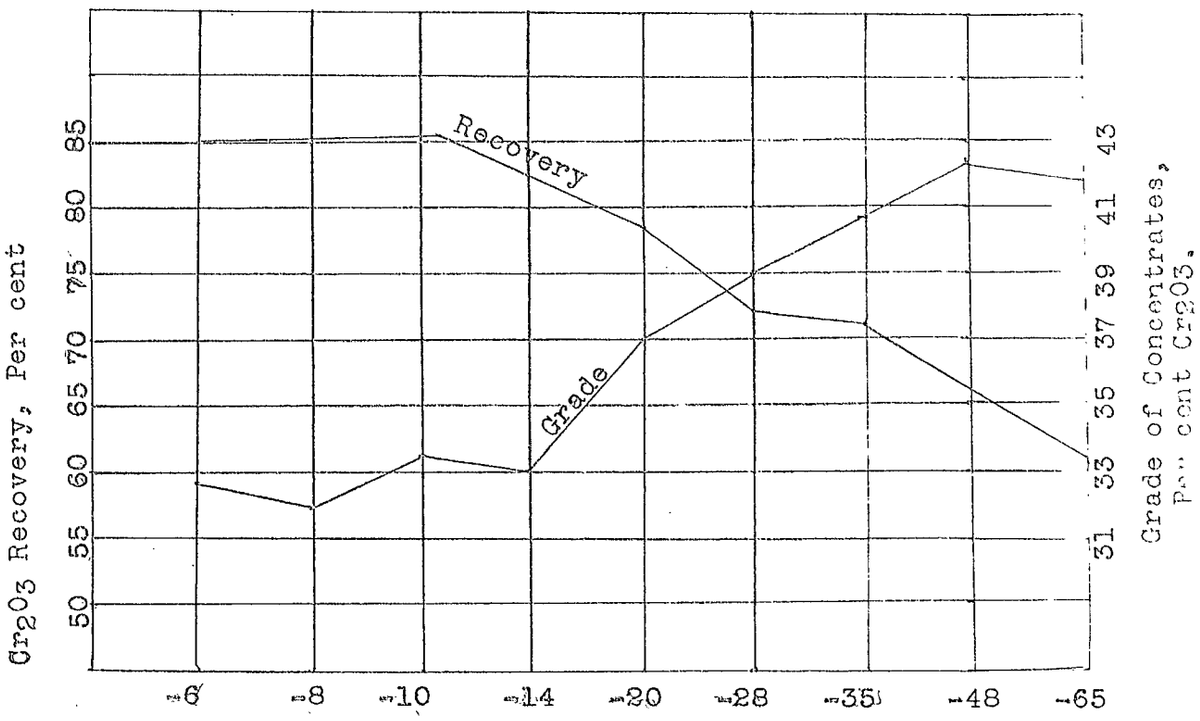
Summary of Results, Test No. 2:

| Test No. | Chrome-iron ratio of concentrate | Assay of concentrate, $Cr_2O_3$, per cent | Overall recovery, per cent $Cr_2O_3$ | Grind |
|---|---|---|---|---|
| 2-A | 1.38:1 | 32.87 | 85.1 | - 6 mesh |
| 2-B | 1.33:1. | 32.22 | 85.1 | - 8 " |
| 2-C | 1.37:1. | 33.50 | 86.4 | -10 " |
| 2-D | 1.37:1. | 33.03 | 82.3 | -14 " |
| 2-E | 1.36:1. | 36.89 | 78.5 | -20 " |
| 2-F | 1.36:1. | 39.19 | 72.5 | -28 " |
| 2-G | 1.39:1. | 40.75 | 71.7 | -35 " |
| 2-H | 1.48:1. | 42.40 | 66.0 | -48 " |
| 2-I | 1.48:1. | 42.00 | 62.5 | -65 " |

(Continued on next page)

(Test No. 2, cont'd) -

In order to illustrate the overall recoveries of the chromite and the assays of the different concentrates, the following graph is presented:




Grind, per cent minus mesh size.

Portions of the concentrates from Tests Nos. 2-F, 2-G, 2-H and 2-I were concentrated on the Haultain superpanner, with the following results:

(Continued on next page)

(Test No. 2, cont'd) -

| Test No. | Weight of panner concentrate | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Chrome - iron ratio |
|---|---|---|---|---|
| 2-F | 51.35 | 41.34 | 20.45 | 1.38:1. |
| 2-G | 66.51 | 41.73 | 20.87 | 1.37:1. |
| 2-H | 74.20 | 42.60 | 21.34 | 1.37:1. |
| 2-I | 86.51 | 42.85 | 21.29 | 1.38:1. |

Magnetic Concentrations.

Portions of table concentrates were ground to minus 100 mesh and passed through the Davis tube magnetic separator, with results as follows:

A Concentrate.

| Product | Weight, per cent | Assays, per cent $Cr_2O_3$ | Assays, per cent Fe | Distribution, per cent $Cr_2O_3$ | Distribution, per cent Fe | Cr:Fe ratio |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 40.94 | 20.18 | 100.00 | 100.00 | 1.39:1. |
| Magnetic conc. | 0.87 | 25.89 | 48.95 | 0.55 | 2.11 | |
| " tailing | 99.13 | 41.07 | 19.93 | 99.45 | 97.89 | 1.41:1. |

B Concentrate.

| | | | | | | |
|---|---|---|---|---|---|---|
| Feed | 100.00 | 39.77 | 21.05 | 100.00 | 100.00 | 1.29:1. |
| Magnetic conc. | 1.00 | 33.19 | 35.67 | 0.83 | 1.70 | |
| " tailing | 99.00 | 39.78 | 20.88 | 99.17 | 98.30 | 1.30:1. |

No beneficial results are apparent from these magnetic concentrations, the Cr:Fe ratio being practically unchanged.

Test No. 2 (A to I) indicates that grinding beyond a critical stage causes excessive sliming of the chromite with a consequent decrease in recovery.

## PART II. - FLOTATION CONCENTRATION.

A number of tests were made in an endeavour to concentrate the chromite mineral by flotation, using oleic acid, sodium oleate, Emulsol XI, and Orso as collectors; sodium hydroxide, sodium carbonate, and lime as modifying agents; lead nitrate, sodium meta phosphate, ferrous sulphate, tannic acid, and ammonium molybdic as activators; sodium silicate and caustic starch as dispersing agents; and pine oil and cresylic acid as frothers. These tests were not successful in producing a chromite concentrate that compared favourably with the results obtained by table concentration, the chief difficulty being in the floatability of the talc mineral (hydrous magnesium silicate) along with the chromite. However, a number of flotation tests are given below, with the reagents used. To obtain comparative conditions, dry crushing through rolls was adopted in the preparation of the samples in all of these tests. These tests were the better of the numerous results obtained.

As the chrome-iron ratio remains fairly constant at about 1.35:1, it was decided that only $Cr_2O_3$ assays would be performed on the different products.

### Test No. 3 (A to F).

In these tests the ore, at minus 14 mesh, was ground in a ball mill to pass 70 per cent minus 200 mesh. Different reagents were added to the grind as noted. The pulp was then transferred to a Denver flotation cell and the chromite concentrate obtained by the addition of different flotation reagents. The products were assayed for $Cr_2O_3$.

(Continued on next page)

(Test No. 3, cont'd) -

The following reagents were added (lb./ton ore):

| Test No. 3: | Sodium hydroxide | Sodium silicate | Sodium metaphosphate | Ferrous sulphate | Lead nitrate | Oleic acid | Sodium oleate | Orso | Emulsol XI |
|---|---|---|---|---|---|---|---|---|---|
| A | 0.5 | 4 | 2.0 | 1.0 | 0.5 | 2.5 | - | - | - |
| B | 0.5 | 3 | 2.0 | 1.0 | 0.5 | 1.5 | 0.4 | - | - |
| C | 0.5 | 3 | " | " | " | 2.0 | " | 0.4 | 0.2 |
| D | 1.0 | 3 | 1.5 | " | " | 2.0 | " | 0.4 | 0.2 |
| E | 1.0 | 3 | 3.0 | " | " | 2.5 | " | 0.4 | 0.2 |
| F | 2.0 | 2 | " | " | " | 1.0 | " | 0.4 | 0.2 |

Results:

Test No. 3-A.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.71© | 100.0 | |
| Flot. conc. | 45.21 | 36.04 | 61.0 | 2.2:1. |
| " tailing | 54.79 | 19.01 | 39.0 | |

Test No. 3-B.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.69© | 100.0 | |
| Flot. conc. | 50.17 | 36.37 | 68.4 | 2:1. |
| " tailing | 49.83 | 16.93 | 31.6 | |

Test No. 3-C.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.54© | 100.0 | |
| Flot. conc. | 66.56 | 32.66 | 81.9 | 1.5:1. |
| " tailing | 33.44 | 14.36 | 18.1 | |

Test No. 3-D.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.65© | 100.0 | |
| Flot. conc. | 75.00 | 31.81 | 89.5 | 1.3:1. |
| " tailing | 25.00 | 11.86 | 10.5 | |

Test No. 3-E.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.67© | 100.0 | |
| Flot. conc. | 74.40 | 32.59 | 90.7 | 1.3:1. |
| " tailing | 25.60 | 9.74 | 9.3 | |

Test No. 3-F.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.64© | 100.0 | |
| Flot. conc. | 68.50 | 33.21 | 85.4 | 1.5:1. |
| " tailing | 31.50 | 12.34 | 14.6 | |

© Calculated.
pH of pulps, 8.7 to 9.3. Time of flotation, 15 to 20 minutes.

(Test No. 3, cont'd) -

A large number of other flotation tests were made using a soda-ash or lime pulp and adding different reagents as previously noted. The results were invariably disappointing, in so far as obtaining a clean chromite concentrate with a good recovery was concerned.

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Test No. 4 (A to F).

In this test, better results were obtained by floating off a talc concentrate and leaving the bulk of the pulp to be subjected to further treatment. Portions of the ore were taken and ground through a set of rolls to pass 100 per cent minus 35 mesh. The pulp was then transferred to a Denver flotation cell and conditioned for 10 minutes with soda ash. Different flotation reagents were then added and a talc flotation concentrate was obtained.

| | Reagents Added, Lb./ton Ore: | | | | | | |
|---|---|---|---|---|---|---|---|
| Test No. | Soda ash | Pine oil | Amine No. 230 | Amine No. 2208 | Amine No. 9039-5 | 2 Amino -2 methyl -3 Hexanol | Ultra-Wet |
| 4-A | 2.0 | 0.15 | 0.14 | " | " | " | - |
| 4-B | 1.4 | 0.20 | " | 0.20 | " | " | " |
| 4-C | 1.6 | 0.20 | " | " | 0.50 | " | " |
| 4-D | 1.8 | 0.20 | " | " | " | 0.60 | - |
| 4-E | 1.8 | 0.15 | " | " | " | " | 0.30 |
| 4-F | 1.8 | 0.15 | " | " | " | " | 0.50 |

The pH of the pulps varied from 9.6 in Test No. 4-A to 8.4 in Test No. 4-B.

Flotation times were from 16 to 29 minutes.

(Continued on next page)

(Test No. 4, cont'd) -

Results:

Test No. 4-A.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 27.57⊛ | 100.0 | |
| Flot. conc. | 11.39 | 6.71 | 2.8 | 8.8:1. |
| " tailing | 88.61 | 30.26 | 97.2 | |

Test No. 4-B.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 27.76⊛ | 100.0 | |
| Flot. conc. | 12.93 | 5.86 | 2.7 | 7.7:1. |
| " tailing | 87.07 | 31.03 | 97.3 | |

Test No. 4-C.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 28.11⊛ | 100.0 | |
| Flot. conc. | 7.71 | 7.28 | 2.0 | 13.0:1. |
| " tailing | 92.29 | 29.85 | 98.0 | |

Test No. 4-D.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 27.96⊛ | 100.0 | |
| Flot. conc. | 12.55 | 5.58 | 2.5 | 8:1. |
| " tailing | 87.45 | 31.17 | 97.5 | |

Test No. 4-E

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 27.43⊛ | 100.0 | |
| Flot. conc. | 14.32 | 8.29 | 4.3 | 7:1. |
| " tailing | 85.48 | 30.70 | 95.7 | |

Test No. 4-F.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 27.29⊛ | 100.0 | |
| Flot. conc. | 17.67 | 8.98 | 5.8 | 5.7:1. |
| " tailing | 82.33 | 31.22 | 94.2 | |

⊛ Calculated.

In Test No. 4-C, the froth was very light and had little body. Time of flotation, 29 minutes.

In Tests Nos. 4-A, 4-B, and 4-D the froth was light. Time of flotation, 25 minutes.

In Tests Nos. 4-E and 4-F, where "Ultra-Wet" was used, the froth had more body and the time of flotation was 16 minutes.

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Test No. 5 (A, B, and C).

In this test, portions of the ore were ground through a set of rolls to different sizes as noted. The pulp was then transferred to a Denver flotation cell and conditioned with 1.8 pounds of soda ash per ton; the talc was floated by the addition of 0.15 pound pine oil and 0.3 pound Ultra-Wet per ton.

Results:

Test No. 5-A. - On Minus 14 Mesh Ore.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.96© | 100.0 | |
| Talc, conc. | 17.18 | 9.81 | 6.3 | 5.8:1. |
| Tailing | 82.82 | 30.52 | 93.7 | |

Test No. 5-B. - On Minus 20 Mesh Ore.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 27.04© | 100.0 | |
| Talc, conc. | 18.31 | 10.00 | 6.8 | 5.5:1. |
| Tailing | 81.69 | 30.86 | 93.2 | |

Test No. 5-C. - On Minus 28 Mesh Ore.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 26.92© | 100.0 | |
| Talc conc. | 19.17 | 12.24 | 8.7 | 5.2:1. |
| Tailing | 80.83 | 30.40 | 91.3 | |

© Calculated.

pH of pulps, 8.9. Time of flotation, 18 minutes.

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Test No. 6 (A, B, and C).

In this test, portions of the ore were crushed through a set of rolls to pass minus 14, minus 20 and minus 28 mesh. The pulps were then transferred to a Denver flotation cell and conditioned with 1.8 pounds soda ash and the talc floated by the further additions of 0.15 pound pine oil and 0.20 pound of Amine No. 2208 per ton.

(Continued on next page)

(Test No. 6, cont'd) -

Test No. 6-A. - On the Minus 14 Mesh Ore.

| Product | Weight: per cent | $Cr_2O_3$ assay, per cent | Distribution: of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 27.07◈ | 100.0 | |
| Talc conc. | 11.00 | 5.73 | 2.3 | 9.0:1. |
| Tailing | 89.00 | 29.71 | 97.7 | |

Test No. 6-B. - On the Minus 20 Mesh Ore.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 27.05◈ | 100.0 | |
| Talc conc. | 14.72 | 6.08 | 3.3 | 6.8:1. |
| Tailing | 85.28 | 30.67 | 96.7 | |

Test No. 6-C. - On the Minus 28 Mesh Ore.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 26.88◈ | 100.0 | |
| Talc conc. | 13.43 | 6.28 | 3.1 | 7.5:1. |
| Tailing | 86.57 | 30.08 | 96.9 | |

◈ Calculated.

pH of pulp, 8.9. Time of flotation, 23 minutes.

From the results obtained using different flotation reagents, it appears that the use of Ultra-Wet in conjunction with pine oil is the most satisfactory, and that a minus 35 mesh size would be the proper crushing.

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## PART III. - FLOTATION AND TABLE CONCENTRATION COMBINED.

### Test No. 7 (A and B).

In this test, portions of the ore were ground through a set of rolls to pass minus 35 mesh in Test No. 7-A and minus 48 mesh in Test No. 7-B. The pulps were then deslimed and the coarse material concentrated on a Wilfley table. The slime product was then combined with the table tailing, filtered, and transferred to a Denver flotation machine. A talc concentrate was then floated.

(Continued on next page)

(Test No. 7, cont'd) -

Test No. 7-A -

After desliming of the minus 35 mesh material, the slime assayed 7.96 per cent $Cr_2O_3$ and was 6.56 per cent of the total weight. The remaining pulp was passed over a Wilfley table, with results as follows:

Table Concentration.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 29.42* | 100.0 | |
| Table conc. | 48.87 | 40.30 | 66.9 | 2.2:1. |
| " middling | 27.23 | 26.23 | 24.3 | |
| " tailing | 23.90 | 10.82 | 8.8 | |

* Calculated.

The overall recovery was 77.6 per cent $Cr_2O_3$.

The table tailing was then combined with the slimes and transferred to a flotation machine. The pulp was conditioned with 1.8 pounds soda ash and a talc concentrate obtained by the further additions of 0.20 pound pine oil and 0.25 pound of a 10 per cent solution of Emulsol XI in coal oil, per ton.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 8.46* | 100.0 | |
| Talc conc. | 31.47 | 6.12 | 22.7 | 3.2:1. |
| Tailing | 68.53 | 9.54 | 77.3 | |

* Calculated.

Test No. 7-B -

This test was performed similarly to Test No. 7-A but the pulp was crushed to minus 48 mesh instead of the minus 35 mesh used in the previous test.

After desliming of the minus 48 mesh material the slime assayed 11.59 per cent $Cr_2O_3$ and was 10.9 per cent of

(Test No. 7-B, cont'd) -

the total weight.

Table Concentration.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 29.11[◎] | 100.0 | |
| Table conc. | 43.30 | 42.19 | 62.6 | 2.3:1. |
| " middling | 31.30 | 25.49 | 27.4 | |
| " tailing | 25.40 | 11.50 | 10.0 | |

◎ Calculated.

The overall recovery of the $Cr_2O_3$, 72.8 per cent.

The table tailing was then combined with the slime product and floated as in the previous test. The pulp was conditioned with 1.8 pounds soda ash per ton and floated with 0.20 pound pine oil and 0.3 pound of 2 Amino -2 methyl -3 Hexanol per ton.

Results of Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 11.32[◎] | 100.0 | |
| Talc conc. | 46.65 | 8.04 | 33.1 | 2.2:1. |
| Tailing | 53.35 | 14.19 | 66.9 | |

◎ Calculated.

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Test No. 8 (A and B).

In this test, and the ones following, the different flotation reagents were used on various sizes of particles. The ore was first passed through a set of rolls to the required size and the pulp transferred to a Denver flotation cell. The pulp was then conditioned with soda ash, the flotation reagents added, and a talc concentrate obtained. The flotation tailing was then concentrated on a Wilfley table.

(Continued on next page)

(Test No. 8, cont'd) -

Test No. 8-A -

A portion of the ore was crushed to minus 35 mesh, conditioned with 1.8 pounds soda ash, and floated with 0.20 pound pine oil and 0.18 pound Ultra-Wet per ton.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.69◊ | 100.0 | |
| Talc conc. | 9.38 | 9.02 | 3.2 | 10.6:1. |
| Tailing | 90.62 | 28.56 | 96.8 | |

◊ Calculated.

The pH of the pulp was 8.9.

Table Concentration of Flotation Tailing.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 28.56◊ | 100.0 | |
| Table conc. | 53.16 | 40.63 | 75.6 | 1.9:1. |
| " middling | 20.97 | 22.37 | 16.4 | |
| " tailing | 25.87 | 8.80 | 8.0 | |

◊ Calculated.

The overall recovery of the $Cr_2O_3$ was 81.1 per cent.

Test No. 8-B -

A portion of the ore was crushed to minus 48 mesh, conditioned with 1.8 pounds soda ash and floated with 0.20 pound pine oil and 0.18 pound Ultra-Wet per ton.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of |
|---|---|---|---|---|
| Feed | 100.00 | 26.45◊ | 100.0 | |
| Talc conc. | 10.17 | 11.16 | 4.3 | 9.8:1. |
| Tailing | 89.83 | 28.19 | 95.7 | |

◊ Calculated.

(Continued on next page)

(Test No. 8-B, cont'd) -

Table Concentration of Flotation Tailing.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 28.28[◊] | 100.0 | |
| Table conc. | 42.10 | 42.38 | 63.1 | 2.4:1. |
| " middling | 23.25 | 27.43 | 22.6 | |
| " tailing | 34.65 | 11.73 | 14.4 | |

◊ Calculated.

Overall recovery of $Cr_2O_3$, 71.2 per cent.

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Test No. 9 (A to D).

Portions of the ore were crushed through a set of rolls to pass minus 35 mesh. The pulp was then transferred to a Denver cell and a talc concentrate removed. The flotation tailing was then concentrated on a Wilfley table.

Test No. 9-A.-

In this test, 1.8 pounds soda ash, 0.15 pound pine oil, and 0.4 pound of 2 Amino-2 methyl-3 Hexanol per ton of ore were used.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.55[◊] | 100.0 | |
| Talc conc. | 14.41 | 7.61 | 4.1 | 6.9:1. |
| Tailing | 85.59 | 29.74 | 95.9 | |

Table Concentration of Flotation Tailing.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 29.74[◊] | 100.0 | |
| Table conc. | 46.16 | 40.63 | 63.0 | 2.2:1. |
| " middling | 31.38 | 26.23 | 27.7 | |
| " tailing | 22.46 | 12.29 | 9.3 | |

◊ Calculated.

The overall recovery of the $Cr_2O_3$ was 73.6 per cent.

(Test No. 9, cont'd) -

Test No. 9-B -

Similar to Test No. 9-A, using 1.8 pounds soda ash, 0.20 pound pine oil and 0.25 pound Amine No. 230 per ton with minus 35 mesh feed.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 26.97© | 100.0 | |
| Table conc. | 18.39 | 7.29 | 5.0 | 5.4:1. |
| Tailing | 81.61 | 31.41 | 95.0 | |

Table Concentration of Flotation Tailing.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 31.41© | 100.0 | |
| Table conc. | 55.56 | 40.59 | 71.4 | 1.8:1. |
| " middling | 30.71 | 23.98 | 23.4 | |
| " tailing | 14.03 | 11.55 | 5.2 | |

© Calculated.

The overall recovery of $Cr_2O_3$ was 78.9 per cent.

Test No. 9-C -

Similar to previous tests, using 1.8 pounds soda ash, 0.20 pound pine oil and 0.25 pound of Amine No. 2208 per ton.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 27.25© | 100.0 | |
| Talc conc. | 15.87 | 5.23 | 3.1 | 6.3:1. |
| Tailing | 84.13 | 31.41 | 96.9 | |

Table Concentration of Flotation Tailing.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 31.31© | 100.0 | |
| Table conc. | 48.57 | 41.32 | 63.9 | 2.1:1. |
| " middling | 36.66 | 25.63 | 29.9 | |
| " tailing | 14.77 | 13.11 | 6.2 | |

© Calculated.

Overall recovery of $Cr_2O_3$, 76.3 per cent.

(Test No. 9, cont'd) -

Test No. 9-D -

Similar to previous tests using 1.8 pounds soda ash, 0.15 pound pine oil and 0.40 pound Ultra-Wet per ton.

Flotation.

| Product | Weight, per cent | $Cr_2O_3$ assay, per cent | Distribution of $Cr_2O_3$, per cent | Ratio of concentration |
|---|---|---|---|---|
| Feed | 100.00 | 27.26* | 100.0 | |
| Talc conc. | 18.73 | 9.90 | 6.8 | 5.3:1. |
| Tailing | 81.27 | 31.27 | 93.2 | |

Table Concentration of Flotation Tailing.

| | | | | |
|---|---|---|---|---|
| Feed | 100.00 | 31.27* | 100.0 | |
| Table conc. | 56.32 | 40.40 | 72.7 | 1.8:1. |
| " middling | 29.96 | 24.20 | 23.2 | |
| " tailing | 13.72 | 9.26 | 4.1 | |

* Calculated.

Overall recovery of $Cr_2O_3$, 78.6 per cent.

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SUMMARY:

The table concentration tests indicate that grinding beyond a critical size causes excessive sliming of the chromite, with a consequent decrease in recovery. This is borne out in Test No. 4, made by grinding in the laboratory ball mill, and also in Test No. 5, where the ore was stage-ground through the laboratory rolls. From these tests, grinding to minus 35 mesh appears to be the most suitable size.

Flotation of the pulp produced a chromium concentrate assaying 36.3 per cent $Cr_2O_3$, the recovery being 68.4 per cent. With a recovery of 90.7 per cent $Cr_2O_3$, the concentrate assayed 32.6 per cent $Cr_2O_3$.

Flotation of a talc concentrate prior to further treatment of the flotation tailing raises the grade to 31 per cent $Cr_2O_3$ with a loss of 5 per cent of the chromium and

(Summary, cont'd) -

17 per cent of the weight of the feed.

By desliming the pulp prior to table concentration the grade was raised to 29.0 per cent $Cr_2O_3$ with a loss of 6.5 per cent of the weight of the feed.

Flotation of the talc, followed by table concentration of the flotation tailing, gave a recovery of 81.0 per cent of the chromium with a grade of 40.6 per cent $Cr_2O_3$ in the table concentrate.

The chrome to iron ratio of the table concentrates remained fairly constant at 1.35:1. Superpanning of the table concentrates raised the grade very slightly.

A magnetic concentration of the table concentrates in the Davis tube gave results indicating about 1.0 per cent of magnetic material.

The microscopic examination of the polished sections showed that the average size of the chromite grains was 160 microns (-65+100 mesh) and that these grains contain numerous small inclusions of gangue material.

The foregoing summary of the small-scale test work showed that desliming prior to tabling should be incorporated in the flow-sheet. While the removal of the slime by flotation gave the best results on this ore, the tests made by desliming in the usual manner showed comparable results within the limits of experimental error. The excessive flotation time required in order to remove the talcy constituents of the gangue makes this method less practical than desliming by hydroseparator or classifier.

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