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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-123

MINERALOGICAL INVESTIGATION OF FRACTIONS FROM TESTS ON THE BIRD RIVER CHROMITE ORE FOR STRATMAT CO. LIMITED

by

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MINERAL SCIENCES DIVISION

COPY NO. 5

OCTOBER 16, 1961

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SUMMARY OF RESULTS

The mineralogy of a suite of samples from the Jones magnetic separator was investigated by microscopical and X-ray diffraction studies. It was found that the magnetic fractions contain free chromite, chromite grains bordered by magnetite and serpentine grains containing magnetite inclusions. The chromite grains are liberated from the non-metallic minerals in -200 mesh and finer fractions but are not freed from the magnetite in any fraction. The amount of serpentine containing magnetite inclusions is generally the same in each fraction but the amount of gangue increases in the finer fractions.

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INTRODUCTION

This report deals with the mineralogical study of a suite of samples resulting from tests on a chrome ore from the Bird River area in Manitoba. The samples were submitted to the Mines Branch by W.B. Magyar of Stratmat Co. Limited, who stated that the tests were performed on the new Jones magnetic separator by W.J.D. Stone, consulting engineer, Ottawa, Ontario. Mr. Magyar and Mr. Stone indicated that the grade of the concentrates from the magnetic separator was unsatisfactory and it was hoped that a mineralogical investigation would ascertain whether or not better results are possible.

SAMPLES

The shipment received from Mr. Magyar in May, 1961, consisted of seven unsized samples and twenty-five sized samples. A list of the samples and the weight percentage of each is given in Table 1.

TABLE 1

Samples Received from Stratmat Co. Limited

Coarse Grind at -28 Mesh (Test 66)

Magnetic Concentrate = 43.5% Tailings (non-magnetic) = 56.5%

Sized Samples of Magnetic Concentrates		Sized Samples of Tailings	
Mesh Size	Weight per cent	Mesh Size	Weight per cent
+100	64.4	+100	27.5
+200	18.5	+200	16.3
+325	5.9	+325	21.6
-325	11.2	-325	34.6
Total	100.0		100.0

Medium Grind at -65 Mesh (Test 74)

Magnetic Concentrate = 34.2% Tailings (non-magnetic) = 65.8%

Sized Samples of Magnetic Concentrates		Sized Samples of Tailings	
Mesh Size	Weight per cent	Mesh Size	Weight per cent
+100	13.1	+100	2.1
+200	34.7	+200	19.9
+325	15.7	+325	45.6
-325	36.5	-325	32.4
Total	100.0		100.0

Fine Grind at -200 Mesh (Test 14)

Magnetic Concentrate = 30.7%; Middlings = 26.5%; Tailings = 42.8%

Sized Samples of Magnetic Concentrates		Sized Samples of Middlings		Sized Samples of Tailings	
Mesh Size	Weight per cent	Mesh Size	Weight per cent	Mesh Size	Weight per cent
+200	0.8	+200	0.4	+200	0.2
+325	20.0	+325	49.0	+325	71.4
-325	79.2	-325	50.6	-325	28.4
Total	100.0		100.0		100.0

METHODS OF INVESTIGATION

The first step was to study polished sections from about half of the samples in order to discover the minerals typically present in each. Next, the +100, +200 and +325 mesh sized samples from all tests, as well as the unscreened magnetic concentrate from Test 74, were split into fractions by means of a series of separations with a hand magnet, Frantz isodynamic separator and heavy liquids. Identification of the minerals in the fractions resulting from the separations was effected by means of the binocular, petrographic and ore microscopes. The distribution of the minerals was calculated from the weights of the various products.

RESULTS OF INVESTIGATION

General Mineralogy

The metallic minerals present are chromite, magnetite, hematite, pyrite, pyrrhotite and chalcopyrite. The non-metallic minerals are serpentine, chlorite, dolomite, calcite, forsterite, amphibole, spinel, mica and quartz.

Chromite is the principal metallic mineral and serpentine the principal non-metallic mineral. The chromite occurs as euhedral to anhedral crystals that are larger than about 0.07 mm in diameter. Some of these chromite crystals are bordered by narrow magnetite rims (see Figure 1).

Serpentine occurs as irregular grains and some of them contain inclusions of chromite and magnetite (see Figure 2).

The remaining minerals are generally non-magnetic and do not appear to affect the magnetic concentrates.

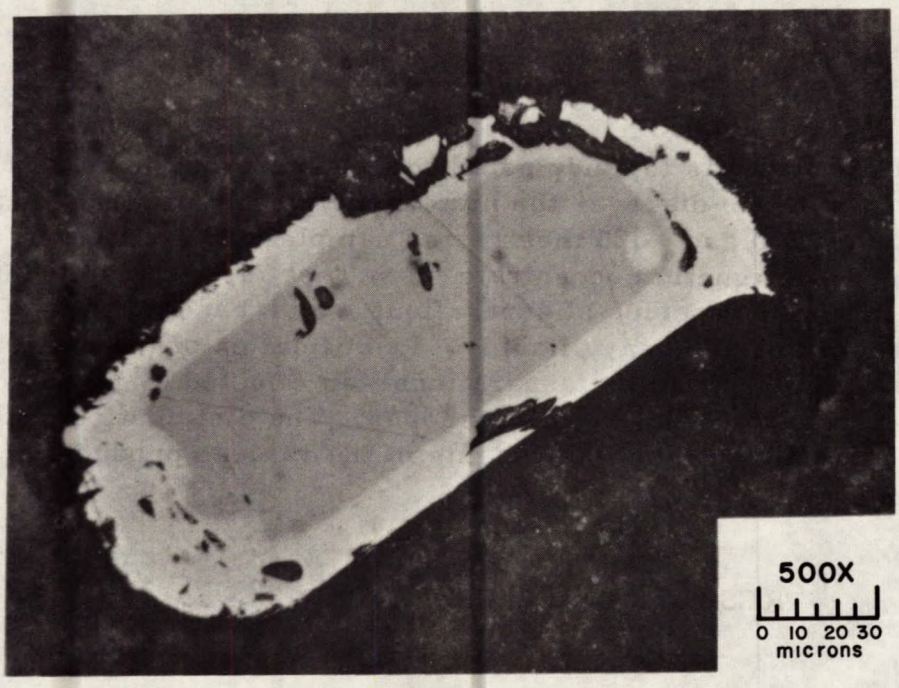

Figure 1. Photomicrograph in oil immersion of a polished section showing a chromite grain bordered by magnetite.

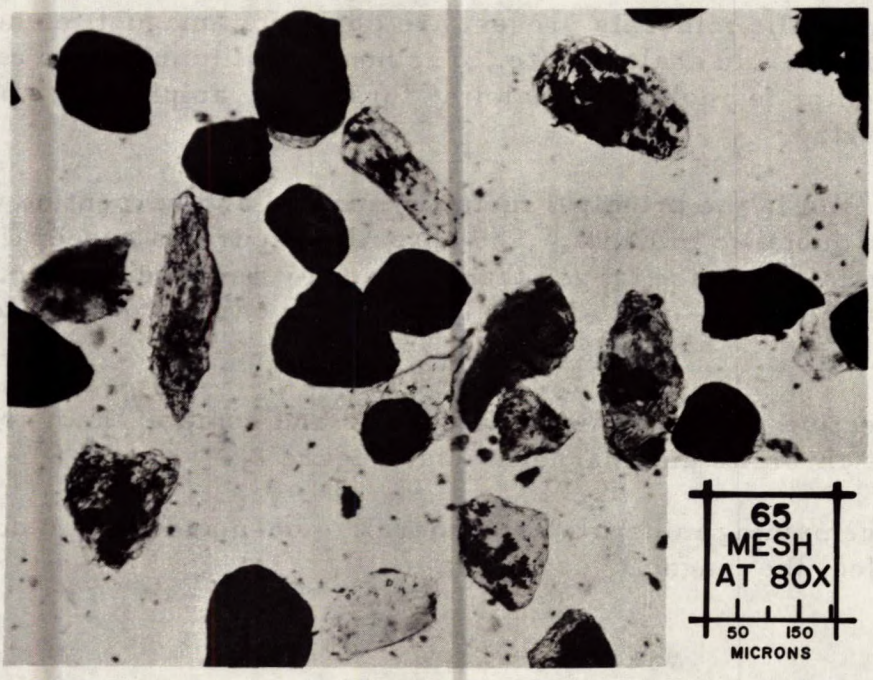

Figure 2. Photomicrograph showing the grains present in a sized sample in transmitted light. The opaque grains are chromite and the transparent grains containing black inclusions are serpentine. The well rounded inclusions are chromite, and the irregular dusty to fine-grained inclusions are magnetite.

Relative Magnetic Susceptibilities of Chromite, Chromite Bordered by Magnetite and Serpentine Containing Magnetite Inclusions

In order to determine whether it is possible to improve the grade of the magnetic concentrate with a magnetic separator, the relative magnetic susceptibilities of the chromite, chromite grains bordered by magnetite and serpentine grains containing magnetite inclusions were investigated. A sized sample of a magnetic concentrate was passed over a hand magnet after which it was passed twice through a Frantz isodynamic separator at 0.2 amperes and at 0.4 amperes. The fraction attracted to the hand magnet consists of chromite grains bordered by magnetite (see Figure 3) and of serpentine grains containing magnetite inclusions (see Figure 4). The 0.2 ampere magnetic fraction consists of spinel, chromite grains partially bordered by narrow magnetite rims (see Figure 5) and of serpentine grains containing magnetite inclusions (see Figure 6). The 0.4 ampere magnetic fraction consists of chromite, spinel and serpentine containing minute amounts of magnetite. The 0.4 ampere non-magnetic fraction consists of non-metallic minerals and a few grains of non-magnetic metallic minerals.

This test shows that the chromite has a moderate magnetic susceptibility, and the chromite grains bordered by magnetite as well as the serpentine grains containing magnetite inclusions have comparatively high magnetic susceptibilities.

Mineral Content of +100 Mesh, +200 Mesh and +325 Mesh Sized Samples from all Tests and of the Concentrate from Test 74

In order to obtain chromite concentrates from the samples supplied and to determine the mineral content of each sample, the +100 mesh, +200 mesh and +325 mesh sized samples, as well as the magnetic concentrate from Test 74, were separated into fractions with a hand magnet and a Frantz isodynamic separator. The resulting fractions were weighed and examined under a binocular microscope. Those containing metallic minerals were further separated into sink and float fractions with clerici solution (specific gravity = 3.7). The results of these separations are given in Table 2.

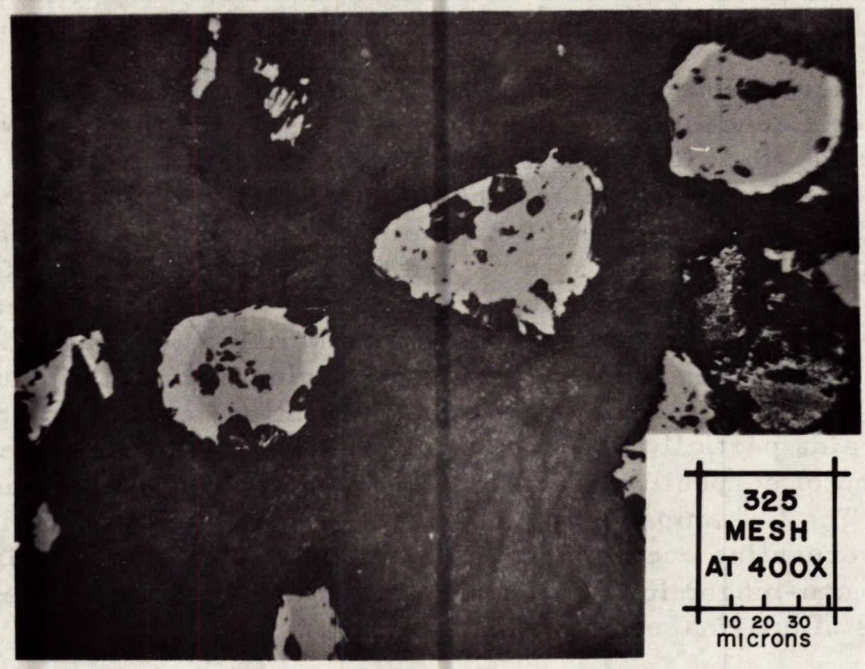

Figure 3. Photomicrograph in oil immersion of a polished section of a hand magnet fraction showing chromite grains (grey) bordered by magnetite (white).

Figure 4. Photomicrograph showing the grains present in the hand magnet fraction of Test 74 in transmitted light. The opaque grains are chromite bordered by magnetite and the transparent grains are serpentine containing magnetite inclusions.

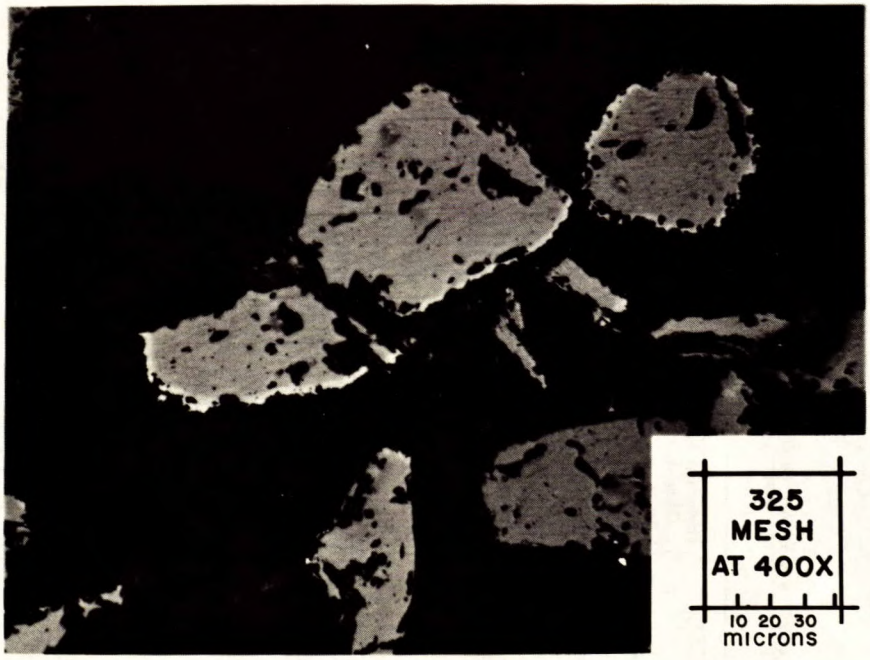

Figure 5. Photomicrograph in oil immersion of a polished section of a 0.2 ampere magnetic fraction showing chromite grains (grey) partially bordered by narrow magnetite rims (white).

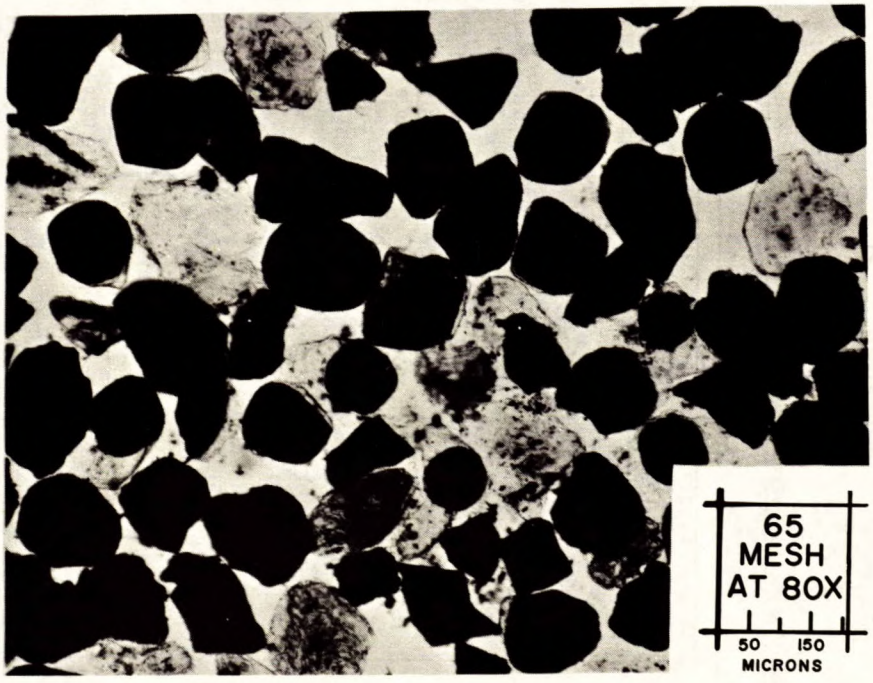

Figure 6. Photomicrograph showing the grains present in the 0.2 ampere magnetic fraction of Test 74 in transmitted light. The opaque grains are chromite partially bordered by magnetite and the transparent grains are serpentine containing magnetite inclusions.

TABLE 2

Results of Separations of Sized Samples with a Hand Magnet, Frantz Isodynamic Separator and Heavy Liquid (Specific Gravity = 3.7)

Fraction	TEST 66				TEST 74				TEST 14		
	+100 Mesh Wt per cent	+200 Mesh Wt per cent	+325 Mesh Wt per cent	-325 Mesh Wt per cent	+100 Mesh Wt per cent	+200 Mesh Wt per cent	+325 Mesh Wt per cent	Unscreened Magnetic Concentrate Wt per cent	+200 Mesh Wt per cent	+325 Mesh Wt per cent	-325 Mesh Wt per cent
CONCENTRATE FRACTION											
Hand magnet sink	7.4	19.3	12.0	--	22.8	22.9	13.5	17.3	22.3	15.6	--
" float	17.2	9.8	13.0	--	10.8	7.4	5.2	9.9	16.7	11.9	--
0.2 amp magnetic sink	8.7	4.2	1.8	--	8.0	5.6	20.6	5.5	7.5	1.4	--
" float	12.7	3.2	1.8	--	3.0	3.9	13.1	22.9	5.5	4.8	--
0.4 amp magnetic sink	35.6	41.5	33.7	--	45.6	48.5	34.6	36.2	39.0	54.8	--
" float	6.2	15.9	28.7	--	5.4	5.6	7.6	6.3	5.5	11.4	--
0.4 amp non-magnetic	12.2	6.1	9.0	--	4.4	6.1	5.4	1.9	3.5	0.1	--
TOTAL	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0	100.0	
MIDDLING FRACTIONS											
0.2 amp magnetic	--	--	--	--	--	--	--	--	3.2	12.1	--
0.4 amp magnetic	--	--	--	--	--	--	--	--	24.5	15.6	--
0.4 amp non-magnetic	--	--	--	--	--	--	--	--	72.3	72.3	--
TOTAL									100.0	100.0	
TAILING FRACTIONS											
0.2 amp magnetic	0.5	tr	0.1	--	0.9	0.5	1.0	--	1.0	5.2	--
0.4 amp magnetic	5.5	tr	0.2	--	5.9	4.5	2.2	--	11.0	17.0	--
0.4 amp non-magnetic	94.0	100.0	99.7	--	93.2	95.0	96.8	--	88.0	77.8	--
TOTAL	100.0	100.0	100.0		100.0	100.0	100.0		100.0	100.0	

The mineralogy of each sink and float fractions listed in Table 2 is as follows: The hand magnet sink fractions consist of chromite grains bordered by magnetite rims (see Figure 3); the hand magnet float fractions consist of serpentine grains containing magnetite; the 0.2 ampere magnetic sink fractions consist of chromite grains partially bordered by very narrow magnetite rims (see Figure 5); the 0.2 ampere magnetic float fractions consist of spinel, and serpentine containing magnetite inclusions; the 0.4 ampere magnetic sink fractions consist of chromite and small amounts of serpentine, and the 0.4 ampere magnetic float fractions consist of serpentine and spinel.

Although most of the sink and float fractions contain only the minerals listed above, a few contain contaminating minerals. The amount of contaminant was estimated by preparing oil immersion mounts and examining them under binocular and petrographic microscopes. The mineral contents of the sized samples as received were then calculated by combining these estimates with the data in Table 2. The results are given in Table 3.

Effect of Grain Size on Distribution of Minerals in the Sized Samples

An examination of Column 5 in Table 3 shows that the +200 mesh and coarser samples contain serpentine with chromite inclusions. This indicates that in order to liberate the chromite grains from the gangue minerals the ore must be ground to -200 mesh.

Columns 3 and 4 of Table 3 show that the magnetic concentrates contain significant amounts of chromite grains bordered by magnetite but no trend with respect grain size is indicated.

Column 6 of Table 3 shows that the magnetic concentrates from Test 66 and Test 74 contain approximately equal amounts of serpentine that contains magnetite inclusions.

Column 7 of Table 3 shows that the amount of non-magnetic gangue increases with diminishing grain size in Tests 66 and 74.

The sum of Columns 6 and 7, given in Column 8, shows that for all tests the total amount of gangue increases with diminishing grain size.

TABLE 3

Mineralogical Composition of +100 Mesh, +200 Mesh and +325 Mesh Sized Samples
(Weight %)

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
Samples Mesh Size	Free Chromite	Chromite Partially Bordered by Magnetite	Chromite Surrounded with Magnetite	Serpentine with Chromite Inclusions	Spinel and Serpentine with Magnetite Inclusions	Total Non-magnetic Fractions*	Sum of Columns 6 and 7	Cr, Wt % (Calculated)
Test 66 (Magnetic)								
+100	33.9	7.0	7.2	26.4	18.9	6.6	25.5	12.9
+200	42.0	4.2	18.3	8.3	17.3	9.9	27.2	17.1
+325	39.8	1.4	13.3		16.8	28.7	45.5	14.6
Test 74 (Magnetic)								
+100	45.6	8.0	22.8	3.5	15.7	4.4	20.1	20.1
+200	48.5	5.6	22.9	0.8	16.1	6.1	22.2	20.3
+325	41.6	16.3	12.1	--	20.7	9.3	30.0	18.6
Test 14 (Magnetic)								
+200	42.2	7.5	26.3	--	19.6	4.4	24.0	19.9
+325	54.8	1.4	16.6	--	27.1	0.1	27.2	19.5
Test 14 (Middling)								
+200	16.0	3.2	--	--	2.5	78.3	80.8	4.5
+325	0.3	--	--	--	38.1	61.6	99.7	tr
Test 66 (Non-magnetic)								
+100	--	--	--	16.0	2.8	81.2	84.0	(?)
+200	--	--	--	--	--	100.0	100.0	0.0
+325	--	--	--	--	4.1	95.9	100.0	0.0
Test 74 (Non-magnetic)								
+100	12.4	0.3	0.1	--	11.2	76.0	87.2	3.6
+200	2.4	0.1	0.1	--	7.1	90.3	97.4	0.7
+325	2.4	0.1	--	--	1.5	96.0	97.5	0.7
Test 14 (Non-magnetic)								
+200	6.6	0.1	--	--	0.9	92.4	93.3	1.8
+325	0.2	--	--	--	27.7	72.1	99.8	tr

*Consists of clean serpentine, dolomite, spinel, forsterite, amphibole, chlorite, quartz, mica, pyrite and chalcopyrite.

Calculated Cr Content of Sized Samples

The Cr contents of the free chromite grains (Column 2, Table 3) and of the chromite grains bordered by magnetite (Column 4, Table 3) were determined by chemical analyses. The results are given in Table 4.

TABLE 4

Cr and Fe Contents of Free Chromite and of Chromite Grains Bordered by Magnetite

Mineral	Weight per cent Cr	Weight per cent Fe
Free chromite	28.14	21.53
Chromite grains bordered by magnetite	23.42	27.53

No analytical data are available for the chromite grains partially bordered by narrow magnetite rims (Column 3, Table 3), but it can be assumed, with a fair degree of confidence, that they contain about 25% Cr.

By using the above values for the Cr content of the specific minerals, the approximate Cr contents of the +100 mesh, +200 mesh and +325 mesh sized samples were calculated. The results are given in Column 9 of Table 3.

It is noted that the calculated Cr contents of the magnetic concentrates from Test 66 are considerably lower that those from the other tests. This is because a large amount of the chromite was not liberated from the gangue and was not included in the calculations.

Calculated Cr Content of Hand Magnet, 0.2 Ampere Magnetic and 0.4 Ampere Magnetic Fractions

The Cr content of the hand magnet, 0.2 ampere magnetic and the 0.4 ampere magnetic fractions were calculated from the data in Table 2 and the values for the analysed Cr content of the chromite, chromite grains rimmed by magnetite and chromite grains partially rimmed by magnetite. The results are given in Table 5.

TABLE 5

Approximate Cr Content of Hand Magnet, 0.2 amp Magnetic and 0.4 amp Magnetic Fractions

(as calculated from the Cr content of chromite and chromite bordered by magnetite)

Fraction	TEST 66			TEST 74				TEST 14	
	+100 Mesh Wt per cent	+200 Mesh Wt per cent	+325 Mesh Wt per cent	+100 Mesh Wt per cent	+200 Mesh Wt per cent	+325 Mesh Wt per cent	Unscreened Concentrate Wt per cent	+200 Mesh Wt per cent	+325 Mesh Wt per cent
Hand magnet	6.8	14.7	12.5	15.9	17.8	15.1	14.9	15.8	14.1
0.2 amp magnetic	8.2	15.0	9.7	18.2	14.7	16.2	4.8	14.4	5.6
0.4 amp magnetic	22.7	20.4	17.7	25.0	25.2	24.4	23.9	26.4	23.3

Table 5 shows that the 0.4 ampere magnetic fractions of the sized samples from Tests 74 and 14 are high-grade chromite concentrates. This suggests that a high-grade chromite concentrate can be obtained from the ore by passing the magnetic concentrate through a separator having a weak magnetic field. Such an operation would produce two fractions. One would consist of serpentine grains containing magnetite inclusions as well as chromite grains bordered with magnetite. The other would consist of chromite and non-magnetic gangue. The chromite could then be concentrated further by passing the latter fraction through a magnetic separator having a stronger magnetic field.

The possible recovery in obtaining such a concentrate cannot be predicted, but Columns 2, 3 and 4 of Table 3 indicate that about 30 to 40% of the chromite is bordered by magnetite and this would be lost.

Amenability of the Magnetic Concentrate to Gravity Separations

In order to determine whether a chromite concentrate can be produced by gravity separations the unscreened magnetic concentrate from Test 74 was separated into sink and float fractions with liquids having specific gravities of 2.96 and 3.7. Most of the gangue was removed from the concentrate with a liquid having a specific gravity of 3.7, but not with one having a specific gravity of 2.96 (see Table 6).

TABLE 6

Heavy Liquid Separations on Magnetic Concentrate from Test 74

Liquid Used	Sink Wt %	Float Wt %
Specific gravity = 3.7	59.4	40.6
Specific gravity = 2.96	94.6	5.4

CONCLUSIONS

This study of a suite of magnetic and non-magnetic samples of chromite ore from the Bird River area in Manitoba indicates that the chromite grains are largely liberated from the non-metallic minerals at a grind of -65 mesh and completely liberated at -200 mesh. The results also show that a large percentage of the grains in the magnetic concentrates have a high magnetic susceptibility. These grains are serpentine containing magnetite inclusions, chromite bordered by magnetite and free chromite. The magnetic susceptibility of free chromite is lower than that of the combined chromite-magnetite and serpentine-magnetite grains. This suggests that it may be possible to separate chromite from the combined grains by passing the magnetic concentrate through a separator having a very weak magnetic field, and that a chromite concentrate containing from 18% to 26% chromium might be produced by such an operation. The chromite recovery by such an operation cannot be predicted but chromite in the form of combined chromite-magnetite grains would certainly be lost.

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