

MAR 19570004: BURMIS

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19570004

ECONOMIC MINERALS

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DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

A. 24

Ottawa, April 8, 1957.

REPORT

of the

MINERAL DRESSING AND PROCESS METALLURGY DIVISION

Investigation No. MD3197.

Concentration and Magnetic Roasting Tests on
Three Samples of Iron Ore from West Canadian Collieries Limited,
Blainmore, Alberta.

Note:

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CANADA

Mines Branch

DEPARTMENT
OF
MINES AND TECHNICAL SURVEYS

OTTAWA, April 8, 1957.

R E P O R T

of the

MINERAL DRESSING AND PROCESS METALLURGY DIVISION.

Investigation No. MD3187.

Concentration and Magnetic Roasting Tests on
Three Samples of Iron Ore from West Canadian Collieries Limited,
Blairmore, Alberta.

Shipment:

A shipment of three bags of ore, net weight 179 pounds, was received at the Mines Branch on August 3, 1956. The shipment consisted of three samples, each weighing approximately 60 pounds, which were identified as follows:

- Sample No. 1 - Sample of ore from Burnis North.
- Sample No. 2 - Sample of ore from Burnis South.
- Sample No. 3 - Sample of ore from Iron Flats.

The samples were submitted by Mr. W. Bird, General Manager, West Canadian Collieries Limited, Blairmore, Alberta.

Location of the Property:

The samples were taken from areas north and south of Burmis, Alberta. The detailed location of each sample was as follows:

Sample No. 1 - Sections 10 and 27, Township 8, Range 3, west of the Fifth meridian.

Sample No. 2 - Section 24, Township 7, Range 3, west of the Fifth meridian.

Sample No. 3 - Sections 12, 13 and 14, Township 3, Range 30, west of the Fourth meridian.

Purpose of the Investigation:

In correspondence from Mr. Bird, it was stated that exploration work by means of aerial and ground magnetometer and by diamond drilling in this area of southwestern Alberta by his company had indicated a potential of approximately 15 million tons of iron ore. Previous magnetic concentration tests* on samples of ore from this area had shown a large loss of iron in the tailings. The company believed this was due to the presence of siderite.

It was requested that the three samples be tested separately for the recovery of the iron by magnetic concentration and that the tailings be subjected to magnetic roasting or a process that might ultimately recover the iron lost in the tailing.

In later correspondence from Mr. Bird it was stated that the company proposed to treat the ore concentrates in electric furnaces

* Investigation Report No. MD3031, May 10, 1954.

rather than blast furnaces.

Sampling and Analyses:

The three samples as received consisted of broken ore ranging in size up to about 2 inches. After selecting specimens for microscopic examination, the samples were crushed to minus 3/4 inches and a 20 pound sample was riffled out of each sample. The remaining portions were crushed to minus 10 mesh and a head sample was cut out of each sample by conventional methods.

The chemical analyses of the head samples gave the following results:

	<u>Head Sample No.1</u>	<u>Head Sample No.2</u>	<u>Head Sample No.3</u>
	- Per Cent -		
Total Iron (Fe) -	39.25	47.10	33.75
Titanium dioxide (TiO ₂) -	5.78	6.20	6.19
Manganese (Mn) -	0.28	0.32	0.21
Silica (SiO ₂) -	17.33	10.17	25.46
Line (CaO) -	4.39	2.29	4.70
Magnesia (MgO) -	1.66	1.36	2.82
Phosphorus (P) -	0.18	0.22	0.17
Sulphur (S) -	0.053	0.030	0.049
Alumina (Al ₂ O ₃) -	6.70	3.84	5.18
Zirconia (ZrO ₂) -	0.10	0.24	0.12
Vanadium pentoxide (V ₂ O ₅) -	0.29	0.38	0.28
Insoluble -	19.0	12.1	29.2
Loss on Ignition -	7.20	7.06	5.09

Investigation Procedure:

Polished sections were prepared from pieces of ore from each sample and studied microscopically to determine the characteristics and metallic mineral content of the ore. As the investigation went on, further microscopic investigations were conducted to determine the mode of occurrence of the iron-bearing gangue minerals in the ore and of the artificial magnetite resulting from tests on magnetic roasting.

Sized fractions from each sample were tested by magnetic cobbing to see if gangue rock could be rejected from the ore before grinding.

A series of Davis Tube magnetic concentration tests was carried out on each sample to determine the fineness of grind required for mechanical liberation of the magnetite from the gangue minerals.

Composite samples, prepared by mixing equal parts by weight of samples Nos. 1, 2 and 3, were ground to minus 150 mesh and fed to a Crockett type wet magnetic separator and a Jeffrey-Steffensen wet magnetic separator, respectively. The tailings from magnetic concentration were tested for the recovery of the contained iron by gravity concentration and magnetic roasting. Finally, dry magnetic concentration at a coarse size was carried out on each sample, followed by wet magnetic separation of the reground concentrates.

Character of the Ore:

Microscopic examination of polished sections and mill products indicated that the metallic mineralization was predominately finely disseminated magnetite occurring in a carbonate cement. In general, the grain size of the magnetite ranged from 65 mesh to 150 mesh with the

largest portion occurring in the fine grain sizes. The only other iron-bearing mineral identified in appreciable amounts was limonite, with minor amounts of ilmenite, anatase, hematite and goethite also being present.

The gangue minerals were composed of quartz, calcite, dolomite and chlorite. No siderite was present in the sample and the calcite and dolomite proved to be almost completely iron-free. Since the amount of chlorite, a hydrous iron magnesium silicate, was very small, the only mineral which could account for high tailing losses from magnetic concentration was limonite.

Summary and Conclusions:

The three samples of ore were very similar, differing only in the relative amounts of magnetite and gangue minerals contained in the samples. The following conclusions, therefore, apply to all three samples and, in most cases, are based on the results of testing composite samples prepared by combining equal parts by weight of each sample. Magnetite is the only abundant ore mineral in the samples. It is disseminated through the gangue in fine grains requiring grinding to a fineness of 150 to 200 mesh for mechanical liberation.

Wet magnetic concentration of the ore, ground to minus 150 mesh, on a Jeffrey-Staffensen magnetic separator recovered 70.4 per cent of the iron in a concentrate assaying 61.1 per cent iron (test No. 4). A recovery of 79.1 per cent of the iron was obtained, using a Crockett magnetic separator; however, the grade of this concentrate was only 54.5 per cent iron (test No. 3).

Since very fine grinding of the ore is required to produce

a high grade iron concentrate, as much of the gangue as economically possible should be discarded during the crushing and coarse grinding stages. The results from magnetic cobbing (test No. 1) were not conclusive, since some of the high iron assays of the coarser non-magnetic fraction may have been due to limonitic iron rather than fine grained magnetite. However, dry belt magnetic separation of the ore ground to minus 10 mesh was successful in eliminating 20 per cent of the feed containing very little magnetite.

Test No. 9 conducted along these lines resulted in 20.2 per cent of the feed being discarded as a tailing containing only 7 per cent of the iron in the ore. Regrinding the magnetic concentrate to minus 200 mesh and feeding it to a Jeffrey Steffensen wet magnetic separator produced a final concentrate assaying 61.5 per cent Fe, 5.17 per cent TiO_2 , 5.2 per cent SiO_2 , 0.11 per cent P, and less than 0.02 per cent sulphur (test No. 10). The overall recovery of the iron from the two operations was 75.7 per cent.

The titanium content of the iron concentrates from the ore is high and may make them unacceptable as blast furnace feed, since steel companies normally place a limit on the TiO_2 content of approximately 2 per cent. However, if the concentrates are smelted in an electric furnace, the titanium content will not be a limiting factor.

As already mentioned, the high tailing losses may be accounted for by the limonite contained in the ore. The investigation has indicated that approximately 20 per cent of the iron is present as this extremely friable iron oxide, which slimes on grinding and cannot be recovered by any standard ore dressing procedure. Attempts to recover the limonitic iron by magnetic roasting were unsuccessful due

to the iron oxide being reduced to a slime coating of magnetite which appeared to be baked onto the surface of the gangue minerals, making separation very difficult.

Microscopic examination of the ore indicated that the non-magnetic iron oxide was the result of an alteration product of magnetite, probably caused by surface oxidation. It is possible that underground ore will not be so altered, in which case high tailing losses may not persist during the commercial milling of the ore.

This report follows progress reports written on October 12, 1956 and January 10, 1957.

DETAILS OF THE INVESTIGATION:

I. MINERALOGY OF THE ORE.

1. Microscopic Examination of Polished Ore Sections*

Six polished sections, two from each sample, were prepared from selected pieces of the ore and studied microscopically for the purpose of determining the characteristics of the ore. Since the examination showed the samples to be similar in character, except for differences in the abundance of ore minerals in each, they need not be described separately.

Gangue

In the polished sections, gangue material is composed essentially of medium coarse to fine grains of quartz embedded in a carbonate groundmass (Figures 1 and 2). A majority of the quartz grains are quite angular in shape with corroded edges, but some are quite round and smooth and must have undergone considerable attrition before consolidation. X-ray photographs identify the carbonate as a

* Mineragraphic Report No. M-1461-E, by W. E. White, September 20, 1956.

mixture of dolomite and calcite. Occasional small particles of a soft shredded mineral, identified as asbestos by means of an x-ray powder sample, are scattered here and there throughout the quartz-carbonate admixture.

Metallic Minerals

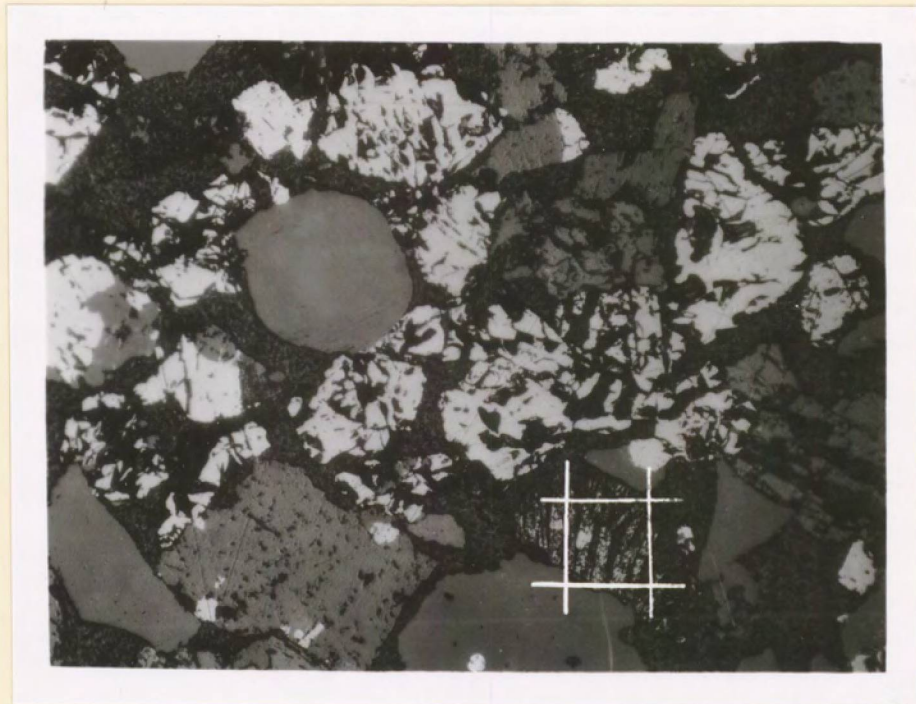
As far as can be seen with the unaided eye and with the aid of a small horseshoe magnet, metallic mineralization consists largely of finely disseminated magnetite. It can also be seen megascopically that the two sections prepared from sample No. 1 are the most heavily mineralized and those from sample No. 3 are sparsely mineralized.

Under a microscope metallic mineralization is seen to occur predominantly in the carbonate cement. In general, the quartz grains are free of inclusions but some do contain tiny particles of iron oxide much too fine to recover economically by grinding (Figure 2). As represented in the six polished sections, however, the total amount of iron in such fine grain sizes is comparatively small.

Magnetite, the only really abundant ore mineral in the polished sections, occurs as irregular grains which range from about 250 microns (-48+65 mesh) down to minute particles only a few microns across, with the average size probably about 120-140 microns (-100+150 mesh). Some grains contain a few small inclusions of gangue and some are, apparently, altering to hematite. All stages of alteration are visible, from narrow rims of hematite to grains of completely altered material. The total quantity of hematite present in the ore, however, is relatively very small. Goethite is almost as abundant as hematite and, like this mineral, it appears to be an alteration product of magnetite.

Under crossed polars a few grains of ilmenite were seen. They are not finely intergrown with magnetite but simply substitute for grains of the latter mineral in gangue. In the writer's opinion, however, the number of grains of this mineral seen in the sections is not sufficient to account for all the titanium reported in the analysis. But due to the similarity in appearance of magnetite and ilmenite on polished surfaces, the latter mineral may be more prevalent than realized. Also, since the deposit is evidently of sedimentary origin, grains of rutile and/or titanite may be present and add to its titanium content. Pyrite is present in almost negligible amount as rare tiny particles in gangue and in magnetite.

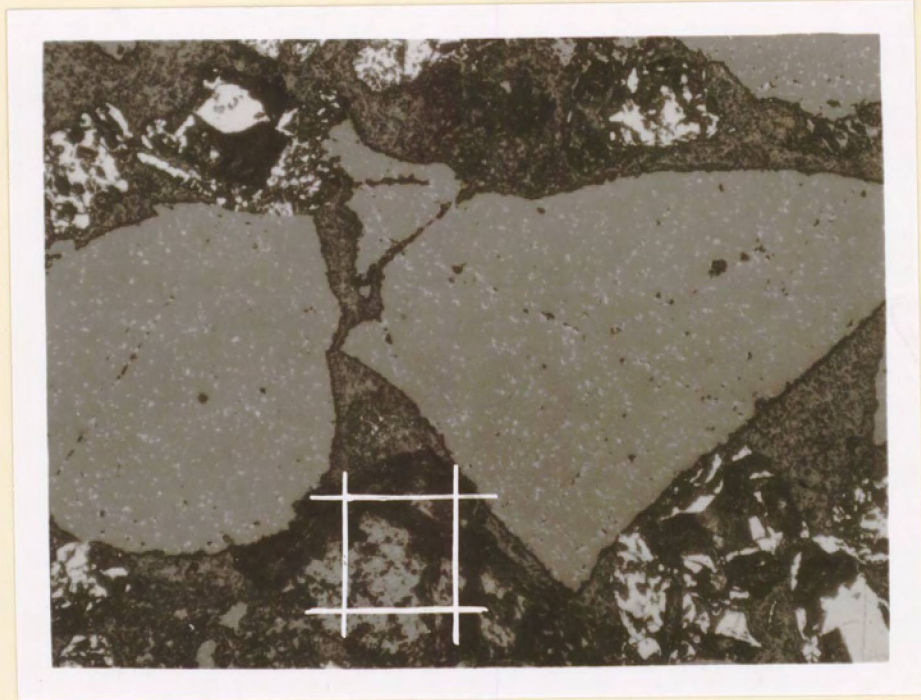
Fig. 1



150X

Average field in polished sections, sample No. 1, showing abundance, grain sizes and modes of occurrence of magnetite, white; quartz grains are light grey with relief and carbonate is dark grey with rough surface; white square represents a 200 mesh Tyler screen opening.

Fig. 2



200X

Photomicrograph of polished section, sample No. 2, showing numerous tiny particles of iron oxide (white) in grains of quartz (grey); white square is a 200 mesh Tyler screen opening.

2. Microscopic Investigation of Gangue Minerals in the Ore*

Three samples of the ore, one from each of the three head samples cut from the ore shipment, were crushed to minus 65 mesh and submitted for mineralogical examination to determine the presence of iron-bearing minerals which might explain high tailing losses from magnetic concentration. Analysis of Davis Tube wet magnetic separation tailings indicated iron contents of 17.0 per cent, 21.0 per cent and 13.4 per cent from samples 1, 2 and 3, respectively.

Results of Investigation:

The above samples were screened and the +325 mesh fractions were weighed. The -325 mesh fraction was not dealt with, because of the difficulties attending its mineralogical study. Specific gravity determinations were made on several of the sizes to see if there were any significant differences. The results are shown in Table I.

TABLE I. - Weight Percentages and Specific Gravity of +325 Mesh Screened Fractions of Ore.

<u>Mesh Size</u>	<u>Weight % (1)</u>	<u>S.G.</u>	<u>Weight % (2)</u>	<u>S.G.</u>	<u>Weight % (3)</u>	<u>S.G.</u>
- 65+100	24.9	3.33	24.5	3.30	26.3	3.14
-100+150	57.6	3.63	54.2	3.74	53.7	3.42
-150+200	8.5		10.6		9.8	
-200+325	9.0	3.85	10.7	3.87	10.2	3.70
	<u>100.0</u>		<u>100.0</u>		<u>100.0</u>	

As may be seen from Table I, the majority of the +325 mesh ore is in the -100+150 mesh fraction and therefore the subsequent

* Mineragraphic Report No. M-1471-E by E. H. Mickal, October 25, 1956.

mineralogical investigation was carried out on it. It is of interest to note that the specific gravity of the sized fractions increases markedly with comminution. It is to be expected, therefore, that the -325 mesh fraction should have a still greater density and suggests that its iron content is probably appreciably greater than that of the +325 mesh fractions.

A hand magnetic separation followed by a series of heavy liquid separations was carried out on the -100+150 mesh fractions, and each of the products was weighed and examined microscopically for its mineral content. The results are shown in Table II.

TABLE II. - Hand Magnetic and Heavy Liquid Separation of -100+150 Mesh Ore

<u>Density Range and Mineral Composition</u>	<u>Weight % (1)</u>	<u>Weight % (2)</u>	<u>Weight % (3)</u>
Magnetite	73.6	80.9	63.9
S. G. less than 2.69 (Quartz)	6.8	3.3	10.6
S. G. 2.69-2.78 (Quartz, calcite)	4.9	2.9	7.8
S. G. 2.78-2.96 (Dolomite, chlorite, limonite)	8.2	5.1	11.6
S. G. 2.96-3.32 (Chlorite, limonite)	2.4	2.0	1.5
S. G. greater than 3.32 (Ilmenite, limonite)	4.1	5.8	4.6
	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

The same gangue minerals were found in all three samples, the chief difference between the samples being the relative proportions of

the minerals.

Since limonite was found in the three heaviest density fractions, a grain count was made of each of them to determine the amount of this mineral present. The results are shown in Table III.

TABLE III. - The Amount of Limonite in the -100+150 Mesh Portions, Based on a Grain Count of the Three Limonite-Containing Density Fractions.

<u>Density Range</u>	<u>% Limonite (1)</u>	<u>% Limonite (2)</u>	<u>% Limonite (3)</u>
2.78-2.96	0.4	0.4	0.1
2.96-3.32	0.3	0.6	0.03
Greater than 3.32	0.4	0.9	0.1
Total limonite	1.1	1.9	0.23

As can be seen from Table III, there is not nearly enough limonite in the -100+150 mesh fraction to account for the high tailing losses. It should be noted, however, that the variations in limonite content in Samples 1, 2 and 3 roughly parallel the tailing losses in the three samples. Thus, sample 3 has the lowest limonite content and exhibits the lowest tailing loss (13.4% Fe) and sample 2 with the highest limonite content has the highest tailing loss (21.0% Fe).

The other gangue minerals present in the -100+150 mesh fraction cannot fully account for the high tailing losses. The calcite and dolomite proved to be almost completely free of iron, as determined by refractive index measurements. The chlorite, which is a hydrous iron-magnesium silicate, may contribute some iron to the analysis, but the amount of this mineral present is too small to account for more than several per cent iron.

Conclusions:

A study of the -100+150 mesh fraction has shown that the gangue minerals in that fraction cannot account for the high tailing losses reported. It is possible that the chief tailing losses may occur in the -325 mesh fraction due to the presence of limonite. The reasons for this conclusion are:

1. Limonite is an extremely friable mineral and therefore has a tendency to slime.
2. The specific gravity of the ore increases with comminution, suggesting enrichment of iron minerals in the finest fractions.
3. The highest tailing losses occur in the sample with the greatest amount of limonite in the -100+150 mesh fraction. This sample probably contains more total limonite than the others and would therefore have a tendency to incur the greatest tailing losses.

3. Microscopic Examination of Products from Magnetic Roasting Tests *

The roasted products from tests Nos. 5, 6 and 8 were submitted for microscopic examination to determine the chief ore components present.

The tests were described as follows:

Test No. 5: Jeffrey magnetic tailing, roasted in a reducing atmosphere at 900°C for 1 hour.

Test No. 6: Jeffrey magnetic tailing, roasted in a reducing atmosphere at 600°C for 1 hour.

Test No. 8: Jeffrey magnetic tailing, roasted in a reducing atmosphere at 600°C for 1/2 hour.

Results of Investigation -

Almost all the mineral particles present in the three samples were found to be magnetic to some degree. Examination of the samples

* From Mineragraphic Report No. M-11,84-E, Dec. 11, 1956, by E. H. Nickel.

under a binocular microscope revealed that many of the slightly magnetic grains consist of gangue minerals partially surrounded by a thin dusting of magnetite, which persists even after washing and drying. The magnetite coating has probably formed from the reduction of the limonitic slimes in the ore.

Microscopic examination of a polished section prepared from the product of test No. 5 reveals that the principal ore components identifiable are magnetite, metallic iron, anatase, and ilmenite. The anatase and ilmenite generally occur in separate grains, while the magnetite and metallic iron are closely intergrown. The presence of the iron indicates strongly reducing conditions during its formation, hence over-roasting. It is possible that wüstite (FeO) formed during the roasting process and, since it is unstable at room temperatures, broke down into its decomposition products magnetite and iron. This decomposition would be accelerated by the heat produced during polishing.

Polished sections prepared from the other two tests, namely 6 and 8, also contain magnetite, ilmenite and anatase but no appreciable metallic iron. Some of the larger magnetite grains contain cores of incompletely reacted hematite. The lower temperatures used in these roasts would probably inhibit the formation of wüstite, since it does not form at temperatures below 570°C.

II. INVESTIGATIVE TEST WORK.

Test No. 1. - Magnetic Cobbing.

Three 20-pound samples, crushed to minus 3/4 inch size, were cut out of each of the three samples of ore. The samples were each

screened on 1/2 inch, 1/4 inch, 6 mesh and 10 mesh screens to produce the following fractions:

Sized Fractions	- Per Cent Weight -		
	Sample No.1	Sample No.2	Sample No.3
-3/4 + 1/2 inch	13.9	13.9	12.3
-1/2 + 1/4 inch	50.8	50.5	50.3
-1/4 inch + 6 mesh	13.0	13.0	12.4
-6 + 10 mesh	6.6	6.9	7.3
-10 mesh	15.7	15.7	17.7
Total	100.0	100.0	100.0

Each of the above fractions was separately fed to a dry magnetic separator.

Results of Test No. 1:

Product	Weight, per cent		Assay, Fe, per cent		Distribution of Fe, per cent	
	Conc.	Tail.	Conc.	Tail.	Conc.	Tail.
<u>Sample No. 1</u>						
-3/4 + 1/2 inch	11.9	1.9	40.9	22.0	12.4	1.1
-1/2 + 1/4 inch	46.7	4.6	41.2	17.8	49.0	2.1
-1/4 inch + 6 mesh	12.1	0.8	42.0	15.2	13.0	0.3
- 6 + 10 mesh	6.1	0.4	42.6	12.9	6.6	0.1
-10 mesh	11.8	3.7	46.8	13.8	14.1	1.3
Totals (calc'd)	88.6	11.4	42.1	16.9	95.1	4.9
Feed (calc'd)	100.0		39.2		100.0	

Results of Test No. 1: (continued)

Product	Weight, per cent		Assay, Fe, per cent		Distribution of Fe, per cent	
	Conc.	Tail.	Conc.	Tail.	Conc.	Tail.
<u>Sample No. 2</u>						
-3/4 + 1/2 inch	12.9	0.6	46.3	35.5	12.9	0.5
-1/2 + 1/4 inch	51.5	0.7	46.3	18.2	51.6	0.3
-1/4 inch + 6 mesh	12.1	0.4	47.4	35.7	12.4	0.3
-6 + 10 mesh	6.6	0.1	47.3	11.7	6.7	0.0(3)
-10 mesh	13.5	1.6	50.3	17.0	14.7	0.6
Totals (calc'd)	96.6	3.4	47.1	22.6	98.3	1.7
Feed (calc'd)	100.0		46.2		100.0	
<u>Sample No. 3</u>						
-3/4 + 1/2 inch	8.9	3.3	37.2	16.2	9.7	1.6
-1/2 + 1/4 inch	40.6	10.0	38.7	15.7	46.0	4.6
-1/4 inch + 6 mesh	10.6	1.9	39.2	14.8	12.2	0.8
-6 + 10 mesh	6.2	1.0	39.1	13.0	7.1	0.4
-10 mesh	12.5	5.0	43.2	12.2	15.8	1.8
Totals (calc'd)	78.8	21.2	39.3	14.8	90.8	9.2
Feed (calc'd)	100.0		34.1		100.0	

Calculated Results of Combining the Products of the Three Samples from Test No. 1:

Product	Weight, per cent	Assay, Fe, per cent	Distribution of Fe, per cent
Magnetic conc.	88.0	43.1	94.7
Magnetic tailing	12.0	16.4	5.3
Feed	100.0	39.9	100.0

Test No. 2 - Davis Tube Magnetic Concentration.

25-gram samples from samples Nos. 1, 2 and 3 were

ground to minus 65, minus 100, minus 150, and minus 200 mesh, and each sample was then fed to a Davis Tube wet magnetic separator.

Results of Test No. 2:

Product	Weight, per cent	Assay, Fe, per cent	Distribution of Fe, per cent
<u>Sample No. 1</u>			
-65M D.T. conc.	62.5	56.3	85.4
-65M D.T. tailing	37.5	16.1	14.6
Feed (calc'd)	100.0	41.2	100.0
<u>-100M D.T. conc.</u>			
-100M D.T. tailing	43.9	16.8	18.4
Feed (calc'd)	100.0	40.0	100.0
<u>-150M D.T. conc.</u>			
-150M D.T. tailing	48.1	17.4	21.0
Feed (calc'd)	100.0	39.8	100.0
<u>-200M D.T. conc.</u>			
-200M D.T. tailing	50.4	17.3	22.2
Feed (calc'd)	100.0	39.7	100.0
<u>Sample No. 2</u>			
-65M D.T. conc.	72.2	58.0	88.6
-65M D.T. tailing	27.8	19.3	11.4
Feed (calc'd)	100.0	47.2	100.0
<u>-100M D.T. conc.</u>			
-100M D.T. tailing	33.0	22.2	15.4
Feed (calc'd)	100.0	47.7	100.0
<u>-150M D.T. conc.</u>			
-150M D.T. tailing	35.2	20.9	15.4
Feed (calc'd)	100.0	47.8	100.0
<u>-200M D.T. conc.</u>			
-200M D.T. tailing	39.6	22.2	18.7
Feed (calc'd)	100.0	47.1	100.0

32.65
7.38

Results of Test No. 2:(continued)

Product	Weight, per cent	Assay, Fe, per cent	Distribution of Fe, per cent
<u>Sample No. 3</u>			
-65M D.T. conc.	52.9	54.2	82.5
-65M D.T. tailing	47.1	12.9	17.5
Feed (calc'd)	100.0	33.7	100.0
<hr/>			
-100M D.T. conc.	47.4	56.8	79.8
-100M D.T. tailing	52.6	13.0	20.2
Feed (calc'd)	100.0	33.8	100.0
<hr/>			
-150M D.T. conc.	46.2	59.0	79.3
-150M D.T. tailing	53.8	13.2	20.7
Feed (calc'd)	100.0	34.4	100.0
<hr/>			
-200M D.T. conc.	44.0	60.8	77.2
-200M D.T. tailing	56.0	14.1	22.8
Feed (calc'd)	100.0	34.6	100.0

Test No. 3. - Magnetic Concentration Followed by Tabling.

A 12-pound composite sample, crushed to minus 150 mesh, was prepared by mixing equal parts by weight of samples Nos. 1, 2 and 3. The sample was fed to a Crockett type wet belt magnetic separator. The underflow (non-magnetic sands) from the Crockett was passed over a Wilfley table.

Results from Test No. 3:

Product	Weight, per cent	Assays, per cent		Distribution, per cent	
		Fe	Insol.	Fe	Insol.
Crockett concentrate	56.9	54.5	13.3	79.1	30.6
Crockett conc. o'flow *	9.4	26.4	32.6	6.3	12.4
Crockett tailing o'flow	9.2	19.1	37.3	4.5	13.9
Wilfley table concentrate	5.9	16.6	49.0	2.5	11.7
Wilfley table middling	6.8	12.7	48.6	2.2	13.3
Wilfley table slimes	11.8	18.1	38.0	5.4	18.1
Feed (calc'd)	100.0	39.2	24.7	100.0	100.0

* This product consists of magnetic slimes and gangue slimes that are carried over with the concentrate.

Conclusions from Test No. 3 -

The results from this test indicate that the tailing loss of iron is in the form of slimes and no gravity concentration of these iron losses is possible.

Test No. 4. - Magnetic Concentration.

A 12-pound composite sample, crushed to minus 150 mesh, was prepared by mixing equal parts by weight of samples Nos. 1, 2 and 3. This sample was fed to a Jeffrey-Steffensen wet magnetic separator.

Results of Test No. 4:

Product	Weight, per cent	Assays, per cent			Distribution, per cent		
		Fe	TiO ₂	SiO ₂	Fe	TiO ₂	SiO ₂
Jeffrey concentrate	36.7	62.4	4.30	2.0	57.7	25.7	4.3
Jeffrey middling	9.0	56.0	6.14	5.3	12.7	9.0	2.8
Combined conc. (calc'd)	45.7	61.1	4.66	2.6	70.4	34.7	7.1
Jeffrey tailing	54.3	21.6	7.40	29.2	29.6	65.3	92.9
Feed (calc'd)	100.0	39.7	6.15	17.1	100.0	100.0	100.0

In order to determine the size distribution of the iron in the tailing from magnetic concentration, an infrasizer analysis was carried out on a sample of the tailing from test No. 4, with the following results:

Product	Weight, per cent	Assays, per cent		Distribution, per cent	
		Fe	TiO ₂	Fe	TiO ₂
+56 microns	12.6	15.7	11.0	9.4	18.3
-56 +40 "	6.9	13.0	9.1	4.3	8.3
-40 +28 "	7.8	15.2	10.0	5.6	10.3
-28 +20 "	10.3	19.5	8.9	9.5	12.1
-20 +14 "	11.0	22.3	7.8	11.7	11.3
-14 +10 "	13.0	24.1	6.7	14.9	11.5
-10 "	38.4	24.4	5.6	44.6	28.2
Tailing, test No. 4 (calc'd)	100.0	21.0	7.6	100.0	100.0

Conclusions from Test No. 4 -

The results of the infrasizer analysis show that over 80 per cent of the iron tailing losses occurs in a size range finer than 28 microns. These results confirm the conclusions from Mineralogic Report M-1471-E, which states that the chief tailing losses may occur in the minus 325 mesh (minus 43 microns) fraction due to the presence of the extremely friable mineral, limonite.

Tests Nos. 5-8. - Magnetic Roasting Tests.

In the following tests, Nos. 5 to 8, magnetic roasting was carried out on samples of the Jeffrey magnetic tailing from test No. 4, to ascertain if the iron oxide could be reduced to artificial magnetite and the losses in iron oxide subsequently recovered by magnetic concentration.

Test No. 5. 1000 grams of the tailing from test No. 4 was roasted at 900°C for 1 hour under an atmosphere of producer gas.

Test No. 6. 500 grams of the tailing from test No. 4 was roasted at 600°C for 1 hour under an atmosphere of producer gas.

Test No. 7. 500 grams of the tailing from test No. 4 was roasted at 600°C for 2 hours under an atmosphere of producer gas.

Test No. 8. 500 grams of the tailing from test No. 4 was roasted at 600°C for 1/2 hour under an atmosphere of producer gas.

Magnetic Concentration of the Reduced Iron -

A 50-gram sample of the calcine from each of the above four tests was treated in a Davis Tube magnetic separator to determine the grade and the percentage of the iron which could be recovered magnetically from the calcines.

Results of Tests Nos. 5, 6, 7 and 8.

Test No.	Per cent Total Fe*	Per cent TiO ₂	Per cent ^{***} Ferric Fe	Per cent Ferrous Fe	Ratio, Ferric Fe / Ferrous Fe	Per cent Magnetic Fe	
						Grade	Recovered
5	24.8	8.1	3.3	21.5	0.15	35.4	36.5
6	22.8	7.8	11.8	11.0	1.07	39.6	34.0
7	23.4	7.9	9.9	13.5	0.73	38.4	34.4
8	22.8	7.9	11.1	11.7	0.95	36.2	42.2

*No metallic Fe detected.

***Calculated by difference

Conclusions from Tests Nos. 5 to 8 -

The ratio of ferric iron to ferrous iron should be 2:1 for pure magnetite. However, the above ferrous iron determination includes the ilmenite ferrous iron as well as the magnetite ferrous iron. On the basis of the TiO₂ assay the ilmenite iron could run as high as 5.6 per cent, and if this were subtracted from the ferrous iron assay the ratio of ferric to ferrous iron would be much higher and in tests Nos. 6 and 8 would be approaching 2:1. However, in tests Nos. 5 and 7 the samples were over-roasted, which was confirmed by the microscopic examination of these calcines.

Magnetic roasting of the iron oxide in the tailing offers little hope of lessening the tailing losses, due to the limonite being reduced to a slime coating of magnetite baked on the surface of the gangue minerals, as indicated by microscopic examination. An attempt was made to free this magnetite from the gangue by grinding, and then treating this product by magnetic concentration. This resulted in only 13.4 per cent of the iron being recovered in a magnetic concentrate assaying 51.4 per cent iron.

Test No. 9 - Ball-Norton Magnetic Separator.

Three 10-pound samples of ore crushed to minus 10 mesh, one

from each of samples Nos. 1, 2 and 3, were fed to a Ball-Norton dry belt magnetic separator.

Results of Test No. 9:

Product	Weight, per cent	Assays, per cent		Distribution, per cent	
		Fe	TiO ₂	Fe	TiO ₂
<u>Sample No. 1</u>					
Ball-Norton conc.	79.2	47.0	6.14	92.7	84.3
Ball-Norton tailing	20.8	14.1	4.34	7.3	15.7
Feed (calc'd)	100.0	40.2	5.77	100.0	100.0
<u>Sample No. 2</u>					
Ball-Norton conc.	90.1	49.4	5.99	96.1	86.0
Ball-Norton tailing	9.9	18.4	8.84	3.9	14.0
Feed (calc'd)	100.0	46.3	6.27	100.0	100.0
<u>Sample No. 3</u>					
Ball-Norton conc.	70.1	42.9	8.18	89.0	84.4
Ball-Norton tailing	29.9	12.4	3.54	11.0	15.6
Feed (calc'd)	100.0	33.8	6.79	100.0	100.0

Samples of the tailings were reground to 100 mesh, tested with a hand magnet, and examined under a binocular microscope. Only small amounts of magnetite appeared to be present in the three tailing products.

Test No. 10.

The Ball-Norton concentrate from test No. 9 was reground to minus 200 mesh and fed to a Jeffrey-Steffensen magnetic separator.

Results of Test No. 10

Product	Weight, per cent	Assays, per cent					Distribution, per cent		
		Fe	TiO ₂	SiO ₂	P	S	Fe	TiO ₂	SiO ₂
<u>Sample No. 1</u>									
Jeffrey conc.	54.7	62.9	3.83	4.05	0.07	0.02	72.9	36.0	14.6
Jeffrey midd.	7.3	52.7	6.87	10.48	0.21	0.03	8.1	8.6	5.0
Jeffrey tailing	38.0	23.6	8.49	32.18		0.06	19.0	55.4	60.4
Feed (calc'd)	100.0	47.2	5.82	15.21			100.0	100.0	100.0
<u>Sample No. 2</u>									
Jeffrey conc.	60.7	64.3	3.83	3.41	0.13	0.02	77.3	48.8	15.2
Jeffrey midd.	6.9	50.3	8.10	13.11	0.26	0.02	6.9	8.4	6.7
Jeffrey tailing	32.4	24.6	8.74	32.76		0.05	15.8	42.8	78.1
Feed (calc'd)	100.0	50.5	6.63	13.59			100.0	100.0	100.0
<u>Sample No. 3</u>									
Jeffrey conc.	47.6	60.9	5.30	5.54	0.08	0.01	66.0	35.9	14.9
Jeffrey midd.	10.3	54.1	7.61	11.29	0.15	0.01	12.7	11.1	6.6
Jeffrey tailing	42.1	22.3	8.84	33.02		0.05	21.3	53.0	78.5
Feed (calc'd)	100.0	43.9	7.03	17.70			100.0	100.0	100.0

Summary of Results of Tests Nos. 9 and 10:

The following table is the calculated results of combining the concentrates and the tailings from the three samples in Test No. 9 into composite products:

Product	Weight, per cent	Assays, per cent		Distribution, per cent	
		Fe	TiO ₂	Fe	TiO ₂
Composite conc.	79.8	46.7	6.68	93.0	87.0
Composite tailing	20.2	13.8	3.94	7.0	13.0
Feed	100.0	40.1	6.13	100.0	100.0

In the following table the concentrates and the middlings from each of the three samples in test No. 10 have been combined into a composite concentrate:

Product	Weight, per cent	Assays, per cent		Distribution, per cent	
		Fe	TiO ₂	Fe	TiO ₂
Composite conc.	62.5	61.5	5.17	81.4	49.8
Composite tailing	37.5	23.4	8.69	18.6	50.2
Feed	100.0	47.2	6.49	100.0	100.0

The results from tests Nos. 9 and 10 give a final composite concentrate assaying Fe 61.5 per cent, TiO₂ 5.17 per cent, SiO₂ 5.20 per cent, P 0.11 per cent and S < 0.02 per cent, with an overall recovery of 75.7 per cent of the iron from the original ore.

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R. W. Bruce

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