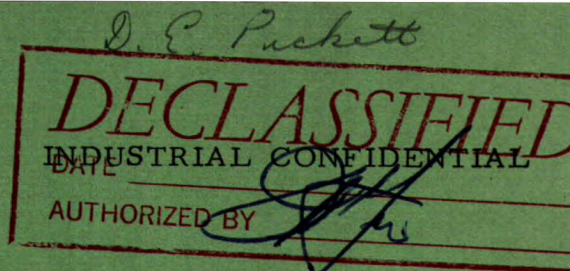


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CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 68-36

**CONCENTRATION OF IRON ORE FROM
AUGDOME CORPORATION LIMITED,
TISDALE TOWNSHIP, NORTHERN ONTARIO**

by

D. RAICEVIC

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The ore sample, designated as "Aug-3", contained about 25% soluble iron.

About 56% of this iron was present as magnetite while about 22% was present as siderite. The remainder was present as ilmenite and other iron oxides.

Magnetic cobbing of the ore and low-intensity magnetic separation of the ground cobber concentrate had the following results:

Ratio of concentration	5.66:1
% Soluble Fe (grade)	68.5
% Soluble Fe recovery	49.0
% Magnetic Fe recovery	86.5

Additional magnetic concentration after flotation and magnetic roasting of the siderite had the following results:

Ratio of concentration	19.6:1
% Soluble Fe (grade)	62.3
% Soluble Fe recovery	13.0

Combining the two concentrates gave the following results:

Ratio of concentration	4.4:1
% Soluble Fe (grade)	67.0
% Over-all soluble Fe recovery	62.0

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INTRODUCTION

Location of Property

This property is located in the southeast part of Tisdale Township, Porcupine area, Northern Ontario.

Ore Shipment

Four bags (about 200 pounds) of diamond drill core were received from Mr. A. Hopkins, Mining Engineer, consultant for Augdome Corporation Limited, 555 Burnhamthorpe Road, Etobicoke, Toronto, Ontario. This sample was designated as "Aug.-3".

Purpose of Investigation

The objective of this investigation was to develop a process which would produce an iron concentrate suitable for the iron and steel industry.

Analysis

After material from all four bags was crushed to minus 10 mesh, a representative sample was riffled out for chemical analysis. This sample assayed:

25.5% Soluble iron
27.2% Total iron

MINERALOGY OF NON-MAGNETIC PORTION OF THE ORE¹

Mr. Hopkin's letter of June 29, 1966 stated that the main iron-bearing mineral in this ore was magnetite. To identify the other minerals in the ore, a Davis-tube test was done on a sample of the ore ground to minus 200 mesh, the magnetic fraction (about 22% of the ore by weight) was removed and the non-magnetic portion submitted for mineralogical examination. It was found that siderite - FeCO_3 - was the main iron-bearing mineral comprising about 15% by weight of the non-magnetic portion or 11.5% by weight of the original ore. Since siderite contains 48.3% iron, the amount of the iron in the ore present as siderite was about 22%. Some soluble iron was also present as orthopyroxene (an iron silicate), magnetite, pyrite, hematite, pyrrhotite, arsenopyrite and ilmenite.

The non-iron-containing portion of the original ore was composed of quartz, mica and feldspar.

DETAILS OF INVESTIGATION

Davis-Tube Test

To determine the amount of the soluble iron in the ore present as recoverable magnetite, the head sample of the ore was ground to minus 200 mesh and separated by the Davis tube into magnetic (magnetite) and non-magnetic portions. The results are recorded in Table 1.

TABLE 1

Davis-Tube Test Results From Head Sample

Davis-tube Products	% Weight	Conc Ratio	% Soluble Fe	
			Analysis	Distn
Magnetics	22.6	4.43:1	61.8	56.0
Non-Magnetics	77.4		14.15	44.0
Feed*	100.0		24.92	100.0

* calculated

Procedure

The general procedure for the iron recovery from this low-grade iron ore consisted of the following steps:

- (1) Concentration of magnetite by low-intensity magnetic separation.
- (2) Concentration of iron from non-magnetic portion of the ore by flotation.
- (3) Upgrading of flotation concentrate.

The procedure and results of each step will be described separately.

Concentration of Magnetite by Low-Intensity Magnetic Separation

The first part of this step consisted of grinding the ore to minus 65 mesh and cobbing it with a Sala low-intensity magnetic separator. The results are listed in Table 2.

TABLE 2
Results of Magnetic Cobbing

Grind, Mesh	Products	% Weight	% Soluble Fe	
			Analysis	Distn
minus 65	Sala mag conc	29.8	50.5	57.0
	Sala non-mag tail	70.2	16.1	43.0
	Feed*	100.0	26.36	100.0

* Calculated

Based on the results of the Davis-tube test done on the head sample (Table 1), the results from Table 2 showed that cobbing of the minus 65-mesh ground ore recovered most of the magnetite from the ore in the cobber concentrate but with a lower grade than in the Davis-tube test.

Samples of the cobber concentrate were ground to minus 100 mesh and to minus 200 mesh and upgraded by a Jeffrey-Steffensen three-drum, low-intensity wet-magnetic separator. The magnetic fields of the separator's drums were kept at about 700 gauss (2.2 amperes) on the first two drums and about 350 gauss (0.7 amperes) on the third drum. The results are listed in Table 3.

TABLE 3
Results of Upgrading Cobber Concentrate

Sec Grind	Products	% Weight	Conc Ratio	Analysis, %			Distn, %
				Sol Fe	SiO ₂	P ₂ O ₅	Sol Fe
100 mesh	Jeff mag conc	20.7	4.93:1	64.2	5.73		52.1
	Jeff mid	3.6		43.0	26.25		6.1
	Jeff mag & mid	24.3	4.11:1	61.1	8.76		58.2
	Non-mags	75.7		14.1			41.8
	Feed*	100.0		25.51			100.0
mesh	Jeff mag conc	17.63	5.66:1	68.5	3.0	<0.01	49.0
	Jeff mid	3.07		56.3	15.52	0.035	7.0
	Jeff mag & mid	20.70	4.93:1	66.7	4.88	<0.02	56.0
	Non-mags	79.30		13.7			44.0
	Feed*	100.00		24.67			100.0

* Calculated

Recovery of Siderite From Non-Magnetic Portion of the Ore

The mineralogical examination of the non-magnetic portion of the ore¹ showed that siderite was the main iron-bearing mineral in this portion of the ore. Small amounts of orthopyroxene, iron sulphides and ilmenite were also present.

Concentration of siderite was done by flotation using the non-magnetic portion of the ore (Sala and Jeffrey-Steffensen tailings) as flotation feed. Siderite was floated by stage addition of a sulphonate collector in an acid pH (4-5). Flotation conditions and results are recorded in Table 4 and Table 5.

TABLE 4

Conditions For Flotation of Siderite

Operation	Reagents - lb/ton		Time	pH
	Flot Feed	Orig Ore		
<u>Conditioning:</u>				
Feed at 50% solids				
H ₂ SO ₄	3.5	2.1	1	4-5
Petroleum sulphonate (Cyanamid R-801)	2.1	1.3	5	5
<u>1st rougher flotation:</u>				
Feed at 28% solids				5.8
1st concentrate floated			3	5.9
<u>2nd rougher flotation:</u>				
Conditioning: R-801	1.0	0.6	5	6.1
2nd concentrate floated			7	6.2
<u>Cleaner flotation</u>	—	—	5	6.4

TABLE 5

Average Results of Concentration of Siderite by Flotation

Products	% Weight in Orig Ore	Analysis % Sol Fe	Distribution* % Sol Fe in Orig Ore
Cleaner conc	15.0	26.9	16.4
Cleaner tail	20.0	14.6	11.8
Rougher tail	44.3	9.0	16.2
Flot. Feed (Non-magnetics)	79.30	13.8	44.4

* Based on 24.67% soluble Fe in the original ore.

Similar results of siderite concentration from the non-magnetic portion of the ore were obtained by a wet high-intensity magnetic separation at 6,000 gauss (rougher and cleaner). Since flotation would be more economical than high-intensity magnetic separation, flotation was chosen for the laboratory procedure of this step of the process.

Upgrading of Siderite Concentrate

This part of the investigation consisted of two steps: conversion of siderite to iron oxides by roasting (calcination) and, concentration of the magnetic oxides formed during calcination by a low-intensity magnetic separation.

The calcination procedure used was as follows: the flotation (siderite) concentrate was heated to 300°C in a nitrogen atmosphere in a laboratory rotary kiln. At this temperature the reductant (natural gas) was fed to the kiln and the temperature raised gradually to 800°C. The reduction was carried out at this temperature for 15 minutes. Cooling of the calcine was done in a nitrogen atmosphere. The calcined siderite concentrate was then separated into magnetic and non-magnetic fractions by a Sala low-intensity wet-magnetic separator. The results are recorded in Table 6.

TABLE 6

Results of Upgrading Calcined Siderite

Products	% Weight in Orig Ore	Analysis	Distribution *
		% SolFe	% SolFe in Orig Ore
L.O. Ignition	4.4	—	—
Mag calcine	5.1	62.3	13.0
Non-mag calcine	5.5	15.0	3.2
Flotation cl conc	15.0	26.7	16.2

* Based on 24.67% soluble iron in the original ore.

The laboratory flowsheet of this process is presented in Figure 1.

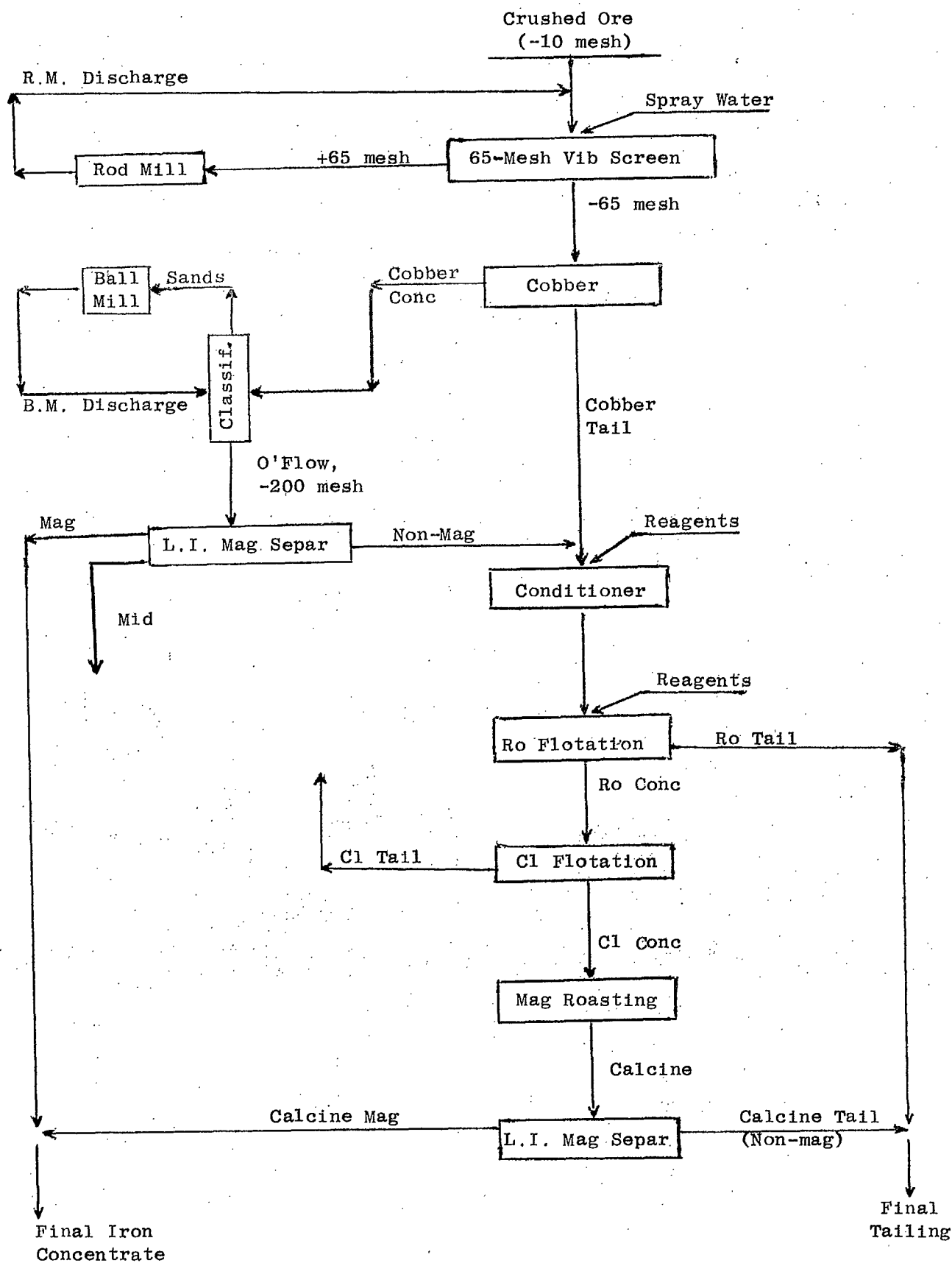


Figure 1. Laboratory Flowsheet.

Final Tailing

The waste material, the final tailing, was composed of the flotation rougher tailing assaying between 8.5 and 9.0% soluble iron and the non-magnetic calcine tailing assaying about 15% soluble iron.

To find out the reason for the relatively high amount of soluble iron in the flotation rougher tailing, a mineralogical examination² of this tailing was done to identify the type, mineralogical association and the amount of the minerals responsible for the high content of the soluble iron in this tailing. The results of this mineralogical investigation are presented in Table 7.

TABLE 7

Minerals in Flotation Rougher Tailing

Minerals	Per Cent Weight				
	Free	Combined			Total
		With Opaques	With Fe-Carbonate	With Fe-Carbonate plus Opaques	
Quartz	8.8	24.0	25.8	16.2	74.8
Ferruginous carbonate	1.5	0.6	-	-	2.1
Iron oxides	1.0	-	-	-	1.0
Iron sulphides	0.8	-	-	-	0.8
Orthopyroxene	6.6	10.4	-	-	17.0
Chlorite + Biotite	3.6	-	-	-	3.6
Garnet	0.7	-	-	-	0.7
White mica	<0.1	-	-	-	-
Amphibole	<0.1	-	-	-	-
					100.0

* Estimated weight per cent is based on examination of the 65 to 150-mesh fraction.

These results showed that free siderite comprised only 1.5% weight of the flotation rougher tailing containing about 1.3% of the soluble iron in the original ore. About the same amount of the soluble iron was lost as free iron oxides, sulphides and others combined.

The major loss of the soluble iron in the flotation

rougher tailing was in the form of inclusions of siderite in quartz and orthopyroxene as fine as 400 mesh (Figure 2).

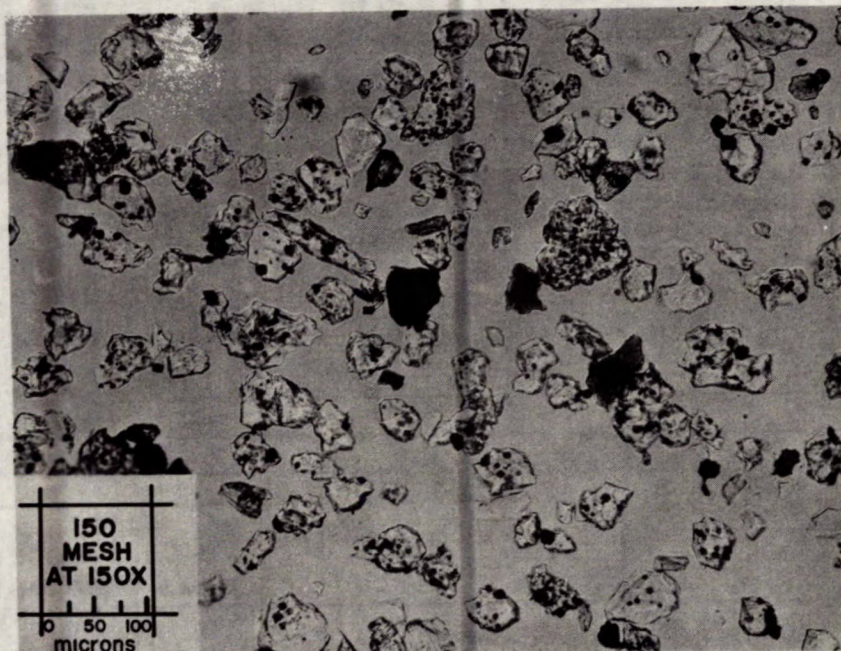


Figure 2 - Photomicrograph of an oil immersion mount made from the hand-magnetic portion of the 400-mesh fraction. The field shows numerous inclusions of opaque grains in quartz, orthopyroxene and ferruginous carbonate. A few free grains of iron oxides (black) and biotite-chlorite grains (dark grey) are also shown.

Small amounts of iron oxides, sulphides and siderite, are also present as inclusions in various gangue materials (Figure 3 and 4).

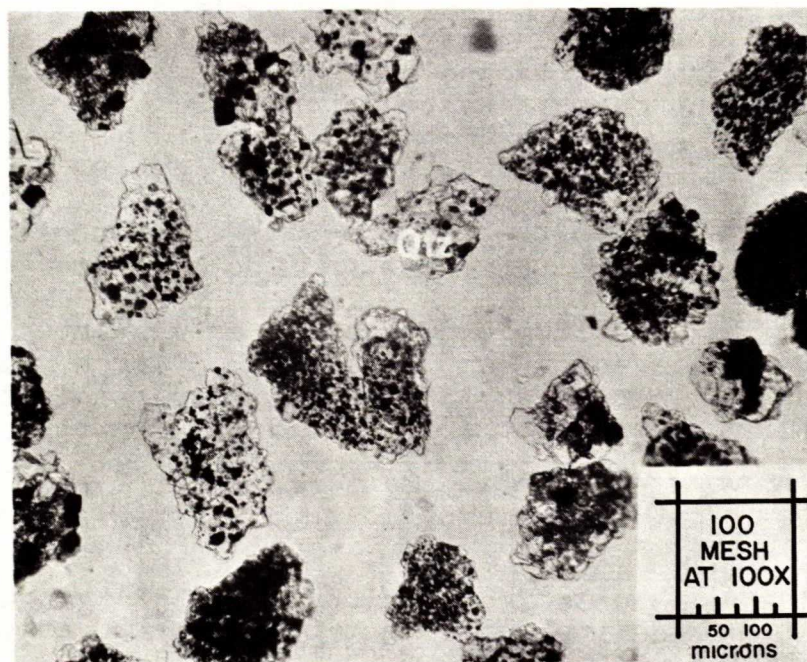


Figure 3 - Photomicrograph of an oil immersion mount showing grains of quartz (Qtz) saturated with opaque inclusions of magnetite and hematite.

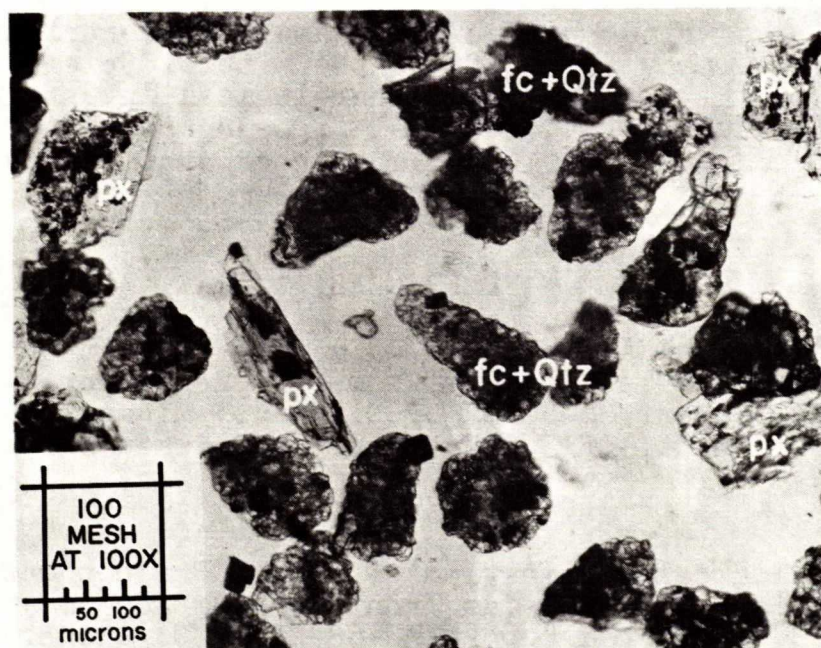


Figure 4 - Photomicrograph of an oil immersion mount showing grains of orthopyroxene (px) and combined grains of ferruginous carbonate and quartz (fc + Qtz) containing opaque inclusions of magnetite and hematite.

Although the non-magnetic portion of the calcined siderite (calcine tailing) assayed 15.0% iron, it contained only 3.2% of the soluble iron in the ore. A mineralogical examination was not carried out on this waste material.

CONCLUSIONS

The main iron-bearing minerals of economic value in this low-grade iron ore are magnetite and siderite.

The magnetic concentrate from low-intensity magnetic separation was satisfactory and assayed 68.5% iron grade. This represented only 49% recovery of the soluble iron in the ore, i.e. a low over-all recovery of the soluble iron from the ore.

Recovery of siderite by flotation followed by magnetic roasting and low-intensity magnetic separation was poor and would not be economical.

The soluble iron included in the gangue, as magnetite and siderite, could not be recovered even after very fine grinding.

The concentration of iron from this low-grade ore therefore, does not seem feasible.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge contributions to this investigation by the Staff of the Mineral Science Division for their chemical analyses and mineralogical investigations as well as to the staff of the Mineral Dressing Laboratory for their assistance in carrying out the magnetic separation and calcination.

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- (2) "Mineralogical Examination of a Mill Product Obtained From Beneficiation Test of an Iron Ore From Augdome Corporation Limited", Internal Report MS-68-20 by D. Owens, Mineral Sciences Division, Dept. of Energy, Mines and Resources, Ottawa.