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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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# MAGNETIC CONCENTRATION OF IRON ORE FROM A PROPERTY OF THE KELSEY LAKE DEVELOPMENT COMPANY LIMITED, TORONTO, ONTARIO, IN THE CHOICELAND AREA OF SASKATCHEWAN

by

W. S. JENKINS

MINERAL DRESSING AND PROCESS METALLURGY DIVISION

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MAGNETIC CONCENTRATION OF IRON ORE FROM A PROPERTY OF THE  
KELSEY LAKE DEVELOPMENT COMPANY LIMITED, TORONTO, ONTARIO,  
IN THE CHOICELAND AREA OF SASKATCHEWAN

by

W. S. Jenkins<sup>\*</sup>

SUMMARY OF RESULTS

Analysis of the shipment, total iron 28.22%; acid sol. iron 27.7%; silica 46.9%; titanium dioxide 0.26%; phosphorus 0.058%; sulphur 0.036%.

The concentrates were obtained by stage grinding the concentrates from -14 mesh and -20 mesh ore with magnetic concentration at various grinds. Typical results were as follows:

	<u>Acid Sol.</u> <u>Iron, %</u>	<u>Silica,</u> <u>%</u>	<u>Recovery, %</u> <u>Iron</u>	<u>Ratio of Concen-</u> <u>tration, %</u>
(1) Conc. -14 mesh	39.90	35.10	89.4	1.68:1
(2) Conc. -65 mesh	63.10	10.27	84.0	2.87:1
(3) Conc. 90% -325 mesh	69.16	2.48	82.8	3.24:1

Additional analyses of Conc. No. 3:

Sulphur, 0.017%; phosphorus, 0.018%; titanium dioxide, none detected;  $Al_2O_3 < 0.10\%$ ;  $CaO < 0.10\%$ ;  $MgO < 0.10\%$ .

Percolation tests of -14 + 325 mesh tailing gave a rate of 16.9 in./hr and for -20 + 325 mesh tailing, 13.6 in./hr.

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(17 pages, 20 tables, no illus.)

## INTRODUCTION

Shipment

On May 6, 1959, a shipment of 125 lb of iron ore was received at the Mines Branch laboratories, Ottawa, from Mr. E.W.S. Ward of A.H. Ross & Associates, Consulting Chemical and Metallurgical Engineers, Suite 811, 62 Richmond Street West, Toronto 1, Ontario.

In a letter dated June 18, 1959, Mr. Ward said, in part, "the sample submitted was a weighted composite of three drill cores from the iron deposit of the Kelsey Lake Development Company Limited".

Location of the Property

This iron deposit is located in townships 49 and 50, range 18W2 in the province of Saskatchewan; it is approximately 12 miles south of Choiceland, Saskatchewan.

Purpose of the Investigation

The shipment was made to determine the grades of concentrate from ore ground to various degrees of fineness in order to obtain a suitable commercial grade of concentrate.

Percolation tests were made on tailings from -14 and -20 mesh ore to obtain data for the design of a backfill reclamation system.

In the letter dated June 18, 1959, Mr. Ward said, in part, "that this sample is not the same as that submitted by the Irex Syndicate in 1957. It does, however, represent the same ore body".

Description of the Property

No description of the property was given beyond its location in Saskatchewan.

Sampling and Analysis of the ShipmentTable 1Chemical Analysis of the Head Sample

Total iron	28.22 %
Acid soluble iron	27.70 "
Iron (by potassium bisulphate fusion)	27.34 "
Silica	46.90 "
Titanium dioxide	0.26 "
Phosphorus	0.058"
Sulphur	0.036"

Semi-Quantitative Spectrographic Analysis Head Sample

Major constituents: Si, Fe

Intermediate constituents: Mg, Ca

Minor constituents: Al, Mn

Trace constituents: Ti, Pb, Cu, Ba, Ni

## MINERALOGICAL EXAMINATION

No mineralogical examination was made on this shipment.

Ore samples, as diamond drill cores, were received from the same property and location on October 22, 1956. A microscopic examination of polished sections prepared from four 1/4 in. fragments of the ore was made and reported as Mineragraphic Laboratory Report No. M-1475-E, November 20, 1956, by E.H. Nickel. This report was included in the Investigation No. MD 3176, March 7, 1957.

### DETAILS OF THE TESTS

The following programme was requested for tests Nos. 1 and 2 by Mr. Ward, on April 30, 1959, during his visit to the Mines Branch. The request was confirmed in a letter dated May 4, 1959.

In a letter dated May 14, 1959 Mr. Ward requested further tests, including the percolation tests to be made with -14 and -20 mesh cobber tailings.

Mr. Ward gave the following details for the tests:

- (a) Crush a representative portion of the sample to -14 mesh.
- (b) Concentrate in Davis tube or Crockett wet magnetic separator.
- (c) Grind concentrate from (b) to approximately -65 mesh.
- (d) Concentrate in Davis tube.
- (e) Grind concentrate from (d) to approximately 95% -200 mesh (80% -325 mesh).
- (f) Concentrate in Davis tube.
- (g) Obtain material balance for test; assay heads, all concentrates and all tails for total Fe; assay concentrate from (f) for total Fe, acid soluble Fe,  $TiO_2$ , P, S,  $SiO_2$ ,  $Al_2O_3$ , CaO and MgO.

Test No. 1 - Magnetic Concentration of -14 Mesh Ore Followed by Stage Grinding of the -14 Mesh Concentrate.

- (a) A representative portion was riffled from the shipment and crushed to -14 mesh.
- (b) Magnetic concentration was done by the Crockett wet belt laboratory size separator. The rougher concentrate was cleaned by repassing on the Crockett separator. The cleaner tailing is designated as middling.
- (c) The cleaner concentrate was ground in a ball mill to approximately -65 mesh.

(d) A portion of the concentrate (50 g) from (c) was concentrated by the Davis tube, the remainder of (c) was concentrated by the Crockett separator.

(e) The Crockett concentrate from (d) was reground in a ball mill to approximately 90% -325 mesh.

(f) A portion of the reground concentrate (100 g) from (e) was concentrated by the Davis tube.

(N.B. (e) this grind was finer than desired)

Results of Magnetic Concentration

Test No. 1 (Concluded)

Table 2

Sub-test No. 1 (b) - Magnetic Concentration by Crockett Separator of -14 Mesh Ore

Product	Wt., %		Analysis, %			Distribution, %		Ratio of concentration in orig. feed
	In test	In orig. feed	Total Fe	Acid Sol. Fe	SiO <sub>2</sub>	In test A.S. Fe	In orig. feed A.S. Fe	
Feed*	100.0			26.55		100.0		
Mag. conc. (1)	59.5			39.90	35.10	89.4		1.68:1
Midds.	4.1			19.80	--	3.0		
Tailing	36.4			5.50	--	7.6		

Table 3

Sub-test No. 2 (d) - Magnetic Concentration by Davis Tube of Concentrate of Sub-test No. 1 ground to -65 Mesh

Feed*	100.0	59.5		39.36		100.0	89.4	
Mag. conc.	58.6	34.9		63.10	10.27	94.0	84.0	2.87:1
Tailing	41.4	24.6		5.75		6.0	5.4	

Table 4

Sub-test No. 3 (f) - Magnetic Concentration by Davis Tube of Concentrate of Sub-test No. 2 ground to 90% -325 Mesh

Feed*	100.0	34.9		62.18		100.0	84.0	
Mag. conc.	88.6	30.9	60.16	69.16	2.48	98.5	82.8	3.24:1
Tailing	11.4	4.0	--	7.98		1.5	1.2	

\* Calculated

Sub-test No. 3 Mag. conc. - Additional Analysis

Sulphur	0.017%
Phosphorus	0.018"
Titanium dioxide	none detected
Al <sub>2</sub> O <sub>3</sub>	0.10 "
CaO	0.10 "
MgO	0.10 "

N.B. Sub-test No. 3 (f) the concentrate was higher in grade than desired because the feed was ground too fine. The test was repeated in Test No. 3 with a coarser grind.



Test No. 2 - Magnetic Concentration of -14 Mesh Ore Followed by  
Stage Grinding, Finer Than in Test No. 1, of the  
-14 Mesh Concentrate

For this test, Mr. Ward requested the following  
procedure:

Same as for test No. 1 with the following exceptions:

- (c) Grind concentrate from (b) to approximately  
-100 mesh.
- (e) Grind concentrate from (d) to approximately  
88% -325 mesh.

The method used for test No. 2 was the same as for  
test No. 1. The grind was to be finer than in test No. 1.

Results of Magnetic Concentration

Test No. 2 (Concluded)

Table 5

Sub-test No. 1 (b) - Magnetic Concentration by Crockett Separator of -14 Mesh Ore

Product	Wt., %		Analysis, %			Distribution, %		Ratio of concentration in orig. feed
	In test	In orig. feed	Total Fe	Acid Sol. Fe	SiO <sub>2</sub>	In test A.S. Fe	In orig. feed A.S. Fe	
Feed*	100.0			27.0		100.0		1.62:1
Mag. conc.	61.5			39.9	35.1	90.9		
Midds.	2.6			7.60		0.7		
Tailing	35.9			6.29		8.4		

Table 6

Sub-test No. 2 (d) - Magnetic Concentration by Davis Tube of Concentrate of Sub-test No. 1 ground to -100 Mesh

Feed*	100.0	61.5		38.9		100.0	90.9	2.88:1
Mag. conc.	56.4	34.7		64.6	8.69	94.0	85.4	
Tailing	43.6	26.8		5.36		6.0	5.5	

Table 7

Sub-test No. 3 (f) - Magnetic Concentration by Davis Tube of Concentrate of Sub-test No. 2 ground to 92.8% -325 Mesh

Feed*	100.0	34.7		63.58		100.0	85.4	3.21:1
Mag. conc.	89.8	31.2	69.74	69.74	2.20	98.5	84.2	
Tailing	10.2	3.5		9.35		1.5	1.2	

\*Calculated

Sub-test No. 3 Mag. conc.

Titanium dioxide - none detected

Screen Analysis of Products of Tests Nos. 1 and 2Test No. 1, Sub-test No. 1Screen Analysis of -14 Mesh TailingTable 8

Product	Wt., %		Analysis, %	Distribution, %	
	In test	In orig. feed	Acid So. Fe	In test A.S. Fe	In orig. feed A.S. Fe
Feed*	100.00	36.45	8.25	100.00	7.55
+ 20 mesh	6.93	2.53	8.54	7.18	0.54
+ 28 "	8.23	3.00	8.34	8.31	0.63
+ 35 "	7.06	2.57	7.37	6.29	0.47
+ 48 "	5.55	2.02	6.89	4.62	0.35
+ 65 "	5.55	2.02	6.40	4.29	0.33
+100 "	8.23	3.00	6.11	6.09	0.46
+150 "	6.43	2.34	2.82	3.07	0.23
+200 "	10.52	3.83	4.33	7.72	0.58
+325 "	11.11	4.05	4.24	8.00	0.61
-325 "	30.39	11.09	8.32	44.43	3.35

Test No. 1, Sub-test No. 3Screen Analysis of the Magnetic ConcentrateTable 9

Conc.*	100.0	30.9	68.90	100.0	82.8
+200 mesh	2.2	0.7	47.18	1.5	1.2
+325 "	13.4	4.1	61.56	12.0	9.9
-325 "	84.4	26.1	70.32	86.5	71.7

Test No. 2, Sub-test No. 3Screen Analysis of the Magnetic ConcentrateTable 10

Conc.*	100.0	31.2	69.48	100.0	84.2
+200 mesh	2.0	0.6	53.38	1.5	1.3
+325 "	11.1	3.5	61.95	9.9	8.4
-325 "	86.9	27.1	70.81	88.6	74.5

\* Calculated

Test No. 3 - Magnetic Concentration of -14 Mesh Ore Followed by  
Stage Grinding, Coarser Than in Test No. 1, of the  
-14 Mesh Concentrate

A coarser grind was requested by Mr. Ward for this test  
in order to lower the grade of the final concentrate.

Results of Magnetic Concentration

Table 11

Sub-test No. 1 (b) - Magnetic Concentration by Crockett Separator of -14 Mesh Ore

Product	Wt., %		Analysis, %		Distribution, %		Ratio of concentration in orig. feed
	In test	In orig. feed	Acid Sol. Fe	SiO <sub>2</sub>	In test A.S. Fe	In orig. feed A.S. Fe	
Feed*	100.0		28.44		100.0		1.6:1
Conc. No. 1	63.1		39.60		87.8		
Midds.	2.9		21.60		2.2		
Tailing	34.0		8.34		10.0		

Table 12

Sub-test No. 2 (d) - Magnetic Concentration by Davis Tube of Concentrate No. 1  
ground to 82.6% -200 Mesh

Feed*	100.0	63.1	36.64		100.0	87.8	2.72:1
Conc. No. 2	58.2	36.7	59.70	13.43	94.8	83.2	
Tailing No. 2	41.8	26.4	4.58		5.2	4.6	

Table 13

Sub-test No. 3 (f) - Magnetic Concentration by Davis Tube of Concentrate No. 2  
ground to 93.8% -200 Mesh

Feed*	100.0	36.7	55.26		100.0	83.2	3.3:1
Conc. No. 3	82.5	30.3	65.80	7.24	98.2	81.8	
Tailing No. 3	17.5	6.4	5.55		1.8	1.4	

\*Calculated

Test No. 4 - Magnetic Concentration of -20 Mesh Ore Followed by  
Stage Grinding of the -20 Mesh Concentrate

This test was also carried out at the request of Mr. Ward. The -20 mesh ore was concentrated by a Crockett separator. The concentrate and middling were sampled, then mixed and ground in a ball mill and concentrated by the Jeffrey-Steffensen 3-drum separator. The Jeffrey concentrate and middling were sampled, then mixed and ground in a ball mill; a 50 g portion of the reground concentrate and middling was concentrated by the Davis tube.

Results of Magnetic Concentration

Test No. 4 (Concluded)

Table 14Sub-test No. 1 - Magnetic Concentration by Crockett Separator of -20 Mesh Ore

Product	Wt., %		Analysis, %			Distribution, %		Ratio of concentration in orig. feed
	In test	In orig. feed	A.S. Fe	TiO <sub>2</sub>	SiO <sub>2</sub>	In test A.S. Fe	In orig. feed A.S. Fe	
Feed*	100.00		27.30			100.00		1.9:1
Mag. conc.	52.72		43.42		31.66	83.87		
Midds.	5.58		24.53			5.01		
*Combined conc. & midds. No. 1	58.30		41.62			88.88		1.73:1
Sand tailing	30.72		6.92			7.79		
Slime tailing	10.98		8.28			3.33		
Combined tailing	41.70		7.28			11.12		

Table 15Sub-test No. 2 - Magnetic Concentration by the Jeffrey-Steffensen Separator of Combined Concentrate and Middling No. 1

Feed*	100.00	58.30	42.0			100.00	88.88	3.4:1
Mag. conc.	50.50	29.44	66.6	0.02	6.30	80.07	71.17	
Midds.	8.42	4.91	51.2		22.96	10.26	9.12	
*Combined conc. & Midds No. 2	58.92	34.35	64.4	-	-	90.33	80.29	2.9:1
Sand tailing	22.30	13.00	11.0	-	-	5.84	5.19	
Slime tailing	18.78	10.95	8.57	-	-	3.83	3.40	
Combined tailing	41.08	23.95	9.89	-	-	9.67	8.59	

Table 16Sub-test No. 3 - Magnetic Concentration by the Davis Tube of Combined Concentrate and Middling No. 2

Feed*	100.0	34.35	64.4			100.0	80.29	3.69:1
Mag. conc.	92.8	31.88	68.8	n.d.	3.32	99.2	79.62	
Tailing	7.2	2.47	7.5			0.8	0.67	

\*Calculated

n.d. = none detected

Screen Tests

Sub-test No. 2, feed 88.2% -200 mesh, 63.8% -325 mesh  
 Sub-test No. 3, feed 98.4% -200 mesh.

Test No. 5 - Magnetic Concentration of -20 Mesh Ore Followed by  
Stage Grinding of the -20 Mesh Concentrate

This test was made to determine the grades and recovery of iron from slightly coarser grinds than were used in test No. 4.

A 10 lb sample of -20 mesh ore was concentrated by the laboratory size Crockett separator. The concentrate was not cleaned. After sampling the concentrate and tailing, a 2000 g portion of the concentrate was ground in a ball mill and concentrated by the Jeffrey-Steffensen separator.

The products were a concentrate, a middling and a tailing. The concentrate and tailing were sampled, then the concentrate and middling were mixed. A sample of the mixture was riffled out, and a 500 g portion was ground in a ball mill. A 50 g sample of the reground concentrate was concentrated by the Davis tube.



Results of Magnetic Concentration

Test No. 5 (Concluded)

Table 17Sub-test No. 1 - Magnetic Concentration by the Crockett Separator

Feed -20 Mesh Ore

Product	Wt., %		Analysis, %			Distribution, %		Ratio of concentration in orig. feed
	In test	In orig. feed	A.S. Fe	SiO <sub>2</sub>	TiO <sub>2</sub>	In test A.S. Fe	In orig. feed A.S. Fe	
Feed <sup>*</sup>	100.00		26.73			100.00		1.68:1
Mag. conc. (1)	59.67		40.16	35.2	-	89.66		
Tailing	40.33		6.85			10.34		

Table 18Sub-test No. 2 - Magnetic Concentration by the Jeffrey-Steffensen Separator

Feed, Conc. (1) Grind 80.4% -200 Mesh; 54.6% -325 Mesh

Feed <sup>*</sup>	100.00	59.67	39.07			100.00	89.66	3.1:1
Mag. conc. (2)	53.50	31.92	65.46	8.76	0.08	89.62	80.35	
Midds.	6.10	3.64	15.82			2.47	2.22	
Combined conc. & midds.	59.60	35.56	60.38	13.08	0.12	92.09	82.57	2.81:1
Tailing	40.40	24.11	7.65			7.91	7.09	

Table 19Sub-test No. 3 - Magnetic Concentration by the Davis Tube Separator

Feed, Conc. + Midds, Sub-test No.2 Grind 93.8% -200 Mesh; 74.2% -325 Mesh

Feed <sup>*</sup>	100.0	35.56	60.46			100.00	82.57	3.13:1
Mag. conc.	90.0	32.00	66.43	6.36	0.02	98.63	81.60	
Tailing	10.0	3.56	7.05			1.17	0.97	

\* Calculated

Screen Tests

<u>Mag. Conc. (2)</u>		<u>Feed of Sub-test No. 3</u>	
+100	0.8 %		0.4 %
+150	3.2 "		0.8 "
+200	15.6 "		5.0 "
+325	25.8 "		19.6 "
-325	54.6 "		74.2 "
	100.0 "		100.0 "
-200	80.4 "		93.8 "

Test No. 6 - Percolation Tests on Non-Magnetic Tailings

In a letter dated May 14, 1959, Mr. Ward requested that percolation tests be made on the cobber tailings (-14 and -20 mesh tailings) using the procedure developed by Kerr-Addison and described in an article, titled "The Preparation of Hydraulic Backfill at Kerr-Addison Gold Mines Ltd., Virginiatown, Ontario", published in the January 1955, issue of the Canadian Mining Journal.

If the percolation rate through the cobber tailing is less than 4 in. per hr, a second test should be run on tailings from which the -325 mesh has been removed by wet screening.

This information is required for the design of a backfill reclamation system for the proposed concentrator.

The apparatus as described by Mr. Ward for percolation tests consisted of a glass tube 15 in. long, 1 3/8 in. diameter, fitted with a filter cloth bottom. The depth of the column of tailing was 12 in. A 1/2 in. head of water was to be maintained on top of the tailing by filling a litre flask and inverting it at the 1/2 in. mark.

As no 1 3/8 in. glass tubing was available, a piece 15 in. long and 1 5/8 in. in diameter was used. It was fitted with a bottom made of standard filter cloth.

The following percolation measurements were obtained from the -14 mesh tailing, 1.04 in./hr, with the -325 mesh screened out the rate for -14 + 325 mesh tailing, average of 3 tests, 16.9 in./hr.

Percolation measurements on -20 mesh sand tailing was 5.28 in./hr. The tailing contained 18% of -325 mesh material. With the -325 mesh screened out, the resulting sands had a percolation rate of 13.6 in./hr.

Table 20

Screen Tests on Tailings

Mesh No.	Wt., %	Wt., %	Wt., %
	-14 mesh tailing	-20 mesh sand tailing	-20 mesh slime tailing
+ 20	7.5	0.1	
+ 28	9.7	5.2	
+ 35	8.0	10.2	0.3
+ 48	5.6	9.4	0.5
+ 65	5.2	8.6	1.0
+100	6.3	9.1	2.0
+150	7.6	10.4	3.8
+200	9.0	11.7	6.2
+325	14.1	17.3	15.9
-325	27.0	18.0	70.3
	100.0	100.0	100.0

## CONCLUSIONS

The results of the tests show that the grade of concentrate can be controlled by grinding the ore to a required mesh size. The company wishes to avoid too fine a grinding and at the same time to obtain the maximum amount of acid soluble iron from the ore.

It is expected that the fineness of the grind of the ore represented by the shipment will have to be determined in practice with commercial machines.

It is apparent that either -14 or -20 mesh cobber tailings should be deslimed before the required percolation rate for backfill material could be obtained.

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