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AN INVESTIGATION OF LOSSES, AND METHODS OF RECOVERY OF IRON VALUES FROM TAILING PRODUCTS FROM WABUSH MINES, WABUSH, LABRADOR

by

D. Raicevic, G.W. Riley, G.O. Hayslip

Mineral Processing Division

Mines Branch Investigation Report IR 72-3

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SUMMARY OF RESULTS

Several possible flowschemes for treating the spiral tailings have been developed. Each flowscheme differs in complexity and the amount of equipment required.

Recovery of iron values from the spiral tailings was between 18% for treating 45% of the spiral tailings by flotation alone and 42% after various portions of the total tailing had been treated by combinations of jigging, flotation, and dry high-intensity magnetic separation.

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INTRODUCTION

In October 1968, Wabush Mines submitted information that their tailings losses were too high and invited the Mines Branch to help solve the problem(s). After a visit to the plant, officers of the Mineral Processing Division decided to establish suitable methods for recovering iron minerals from the spiral tailings and from the high-tension tailings.

Shipments

Six hundred pounds of dried tailings was received on November 18, 1968. The shipment was in four drums and consisted of air-dried spiral tailings and dry high-tension tailings. In February 1969, an additional 200 pounds of the air-dried spiral tailings and 150 pounds of wet spiral tailings were received.

History of Company

Wabush Mines leases an iron-ore deposit in the Wabush Lake area of Labrador. The company is managed by Pickands Mather & Company for a consortium of steel companies. The rated capacity of the plant is about six million tons of pellets per year. Concentration is done with Humphreys spirals and the dried spiral concentrate is upgraded by high-tension electrostatic separators.

Sampling and Analysis

Samples were riffled out of the different lots of tailings for test purposes and for gravimetric and size analyses. The analysis of the original sample was calculated from the products of the various tests. All chemical analyses for the investigation were done by the Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch.

Characteristics of the Material

The company supplied the screen analysis of spiral concentrator tailings shown in Table 1.

TABLE 1

Screen Analysis of Plant Spiral Tailings

Mesh	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
+28	10.6	34.96	20.2
35	8.5	16.06	7.4
48	16.9	9.97	9.2
65	16.0	7.34	6.4
100	15.4	7.68	6.4
150	9.8	11.90	6.4
200	6.1	21.04	7.0
-200	16.7	40.71	37.0
Total (calcd)	100.0	18.36	100.0

From this information it can be seen that the main iron losses are in the plus 28-mesh and the minus 200-mesh material.

Mineralogical examination* of polished sections revealed that the principal iron minerals were hematite and limonite, in approximately equal proportions. In the coarse fractions (plus 28 mesh), the values occur mainly as hematite intergrowths with gangue and as relatively free limonite. The hematite is progressively liberated as the grain size decreases so that, in the 200 to 325-mesh fraction, the hematite is almost free of gangue. Limonite appears to predominate slightly over hematite in the coarser fractions, whereas the reverse is true in the finer fractions.

From each of the shipments of spiral tailings, samples were cut out and gravimetric and chemical analyses were done on the size fractions. A similar examination was made also on the high-tension tailings. Results of these gravimetric and chemical analyses are given in Tables 2, 3, and 4.

*Iron Ore Minerals in a Sample of Spiral Tailings from Wabush Mines, E.H. Nickel, Internal Report MS-68-82, Mineralogy Section, Mineral Sciences Division, Mines Branch, Department of Energy, Mines & Resources.

TABLE 2

Wabush Mines Spiral Tailings No. 1 Shipment

Mesh Size Tyler	Gravimetric Analysis at S.G. 3.3						Size - Assay		
	Weight, %		Assay, % Sol Fe		Distn, % Sol Fe		Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
	Sink	Float	Sink	Float	Sink	Float			
-8+14	2.00	0.80	47.20	12.13	5.76	0.59	2.8	37.18	6.35
-14+20	2.29	1.01	45.30	11.35	6.32	0.70	3.3	34.91	7.02
-20+28	2.76	2.44	47.11	5.64	7.93	0.84	5.2	27.65	8.77
-28+35	3.03	9.17	48.31	1.68	8.92	0.94	12.2	13.26	9.86
-35+48	2.21	16.39	48.71	2.62	6.56	2.62	18.6	8.10	9.18
Sub-total	12.29	29.81	47.37	3.13	35.49	5.69	42.1	16.05	41.18
-48+65							18.9	6.22	7.17
-65+100							11.4	7.37	5.12
Sub-total							30.3	6.65	12.29
-100+150	1.61	7.19	57.78	2.10	5.67	0.92	8.8	12.29	6.59
-150+200	2.15	3.65	58.23	1.40	7.63	0.31	5.8	22.47	7.94
-200+270	2.06	1.64	62.64	2.61	7.87	0.26	3.7	36.03	8.13
-270+325	1.39	0.71	59.74	5.61	5.06	0.25	2.1	41.44	5.31
Sub-total	7.21	13.19	59.68	2.16	26.23	1.74	20.4	22.49	27.97
-325							7.2	42.30	18.56
Grand Total							100.0	16.40	100.00

TABLE 3

Wabush Mines Spiral Tailings No. 2 Shipment

Mesh Size Tyler	Gravimetric Analysis at S.G. 3.8						Size - Assay		
	Weight, %*		Assay, % Sol Fe**		Distn, % Sol Fe		Weight, %	Assay,*** % Sol Fe	Distn, % Sol Fe
	Sink	Float	Sink	Float	Sink	Float			
-8+14	0.65	0.45	49.56	25.21	1.76	0.61	1.10	39.60	2.37
-14+20	1.24	0.97	50.77	20.09	3.43	1.07	2.21	37.30	4.50
-20+28	2.05	2.18	52.12	12.85	5.83	1.53	4.23	31.88	7.36
-28+35	2.75	6.88	51.72	5.41	7.76	2.03	9.63	18.64	9.79
-35+48	2.55	15.70	54.63	3.23	7.60	2.77	18.25	10.41	10.37
-48+65	1.73	16.29	56.13	2.69	5.30	2.39	18.02	7.82	7.69
Sub-total	10.97	42.47	52.93	4.49	31.68	10.40	53.44	14.43	42.08
-65+100	1.56	13.27	57.82	3.32	4.92	2.41	14.83	9.06	7.33
-100+150	2.10	9.59	61.44	5.28	7.04	2.76	11.69	15.37	9.80
-150+200	2.48	4.49	63.40	7.47	8.58	1.83	6.97	27.37	10.41
-200+325	4.02	2.27	63.20	1.84	13.86	0.22	6.29	41.05	14.08
Sub-total	10.16	29.62	62.06	4.47	34.40	7.22	39.78	19.18	41.62
-325							6.78	44.04	16.30
Grand total							100.00	18.33	100.00

*MS-69-20
**MS-69-454
***Calculated

TABLE 4

Wabush Mines High-Tension Tailings

Mesh Size Tyler	Gravimetric Analysis at S.G. 3.8						Size - Assay		
	Weight, %*		Assay, % Sol Fe**		Distn, % Sol Fe		Weight, %	Assay, % Sol Fe***	Distn, % Sol Fe
	Sink	Float	Sink	Float	Sink	Float			
-10+35	1.92	0.28	60.79	6.31	4.32	0.07	2.20	53.86	4.39
-35+48	1.73	3.67	59.41	1.87	3.81	0.25	5.40	20.30	4.06
-48+65	3.51	22.79	55.91	2.17	7.27	1.83	26.30	9.36	9.10
Sub-total	7.16	26.74	58.06	2.17	15.40	2.15	33.90	13.98	17.55
-65+100	3.92	17.98	61.13	2.22	8.88	1.48	21.90	12.76	10.36
-100+150	6.39	10.31	62.81	4.14	14.87	1.58	16.70	26.59	16.45
-150+200	9.99	3.41	63.30	6.41	23.42	0.81	13.40	48.82	24.23
-200+270	6.59	0.61	65.17	3.11	15.91	0.07	7.20	59.91	15.98
-270+325	3.63	0.27	64.39	14.59	8.66	0.15	3.90	60.94	8.81
Sub-total	30.52	32.58	63.45	3.39	71.74	4.09	63.10	32.44	75.83
-325	2.71	0.29	63.60	22.78	6.38	0.24	3.00	59.66	6.62
Grand Total	40.39	59.61	62.25	2.94	93.52	6.48	100.00	27.00	100.00

*MS-69-15
**MS-AC-69-218
***Calculated

Outline of Investigation

As shown in Tables 1, 2, and 3 the operation of the spirals is most efficient in the 35 to 100-mesh range which accounts for nearly half of the tailings; ideally this material should be removed and discarded as a finished product.

From microscopic examination of size fractions and from heavy-liquid studies of these size fractions, it has been shown that the iron values in the fines are present as free hematite and that middling particles of hematite and limonite are present in the coarser fractions.

The problem, then, is the treatment of three fractions of the spiral tailings, either singly or in some combination. The coarse fraction needs to be treated to recover the iron values which then require further treatment to obtain a satisfactory grade of product, the middle size fraction requires no treatment, and the fines fraction can be directly concentrated to a satisfactory grade.

The high-tension tailings, as shown in Table 4, follows the trend of the spiral tailings although the grade of each corresponding size fraction is higher and a greater percentage of the losses are in the minus 65-mesh fraction. It was felt that this material would be treated either separately or in combination with the spiral tailings.

Initially it was decided to screen the material on a 65-mesh screen to obtain a coarse and a fine fraction. The coarse fraction could be treated by jigging and the fine fraction by flotation. When the company expressed a desire for jigging only, the procedure was changed. Jigging and other methods of treatment were tried on various fractions of the tailings to point out the problems involved and to suggest methods of treating this material.

GRAVITY CONCENTRATION OF SPIRAL TAILINGS

Shipment No. 1

A sample of the as-received spiral tailings was treated in a No. 1-M Denver Laboratory mineral jig operating under the conditions shown in Table 5. The results of the test are given in Table 6.

TABLE 5

Jig Operating Conditions

Speed	260 rpm
Stroke	3/16-in.
Ragging:	
Type	Steel shot
Size	3 to 4-mesh
Weight	86.0 g
Supporting Screen	8-mesh

TABLE 6

Results of Jigging Spiral Tailing

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Jig conc	14.8	41.98	38.1
Jig bed	3.5	20.03	4.3
Jig tailings	81.7	11.50	57.6
Feed (calcd)	100.0	16.32	100.0

To determine the characteristics of the jig products, screen sizings were done on the concentrate and tailing and reported in Table 7. These size analyses showed that the best recovery by the jig was in the coarsest sizes and that the recovery decreased as the size of material became progressively smaller.

TABLE 7

Results of Size Analyses of Jig Products

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Jig concentrate			
8 to 35-mesh	8.1	44.93	22.3
to 100-mesh	4.3	32.71	8.6
to 270-mesh	2.3	48.59	6.9
minus 270-mesh	0.1	48.98	0.3
Jig tailings			
8 to 35-mesh	10.8	8.19	5.4
to 100-mesh	46.9	5.06	14.6
to 270-mesh	19.0	20.64	24.1
minus 270-mesh	5.0	44.02	13.5
Jig bed	3.5	20.03	4.3
Feed (calcd)	100.0	16.29	100.0

A second test was done with the purpose of obtaining a higher grade of concentrate. Operating conditions were changed slightly as shown in Table 8. The plus 48-mesh jig tailing was removed by screening and the finer tailing fraction was jigged again to improve the recovery. The results of this test are given in Table 9.

TABLE 8

Jig Operating Conditions

	Primary Jigging	Scavenger Jigging	
Speed	260 rpm	260 rpm	
Stroke	1/8-in.	1/8-in.	
Ragging			
Type	Hematite	Steel shot	Hematite
Size	4 to 6-mesh	4 to 6-mesh	14 to 20-mesh
Weight	128 g	176 g	88 g
Supporting Screen	8-mesh	35-mesh	

TABLE 9

Results of Jigging Test

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Primary jig conc	10.2	47.77	29.9
minus 48-mesh scav jig conc	2.0	63.74	7.8
plus 48-mesh jig tailings	27.4	4.88	8.2
minus 48-mesh jig tailings	53.9	13.46	44.4
Primary jig bed	4.3	28.74	7.6
Scav jig bed	2.2	15.58	2.1
Feed (calcd)	100.0	16.32	100.0
Primary + scav conc	12.2	50.39	37.7

To show the effect of size of material on jigging results a sample of the spiral tailing was screened at 48 mesh and the plus 48-mesh fraction was jigged. The results of jigging this material are given in Table 10. A gravimetric analysis of the jig concentrate is reported in Table 11. The size distribution of the 3.8 specific gravity sink product is reported in Table 12.

TABLE 10

Results of Jigging Plus 48-Mesh Spiral Tailings

Product	Weight, %		Assay, % Sol Fe	Distn, % Sol Fe	
	in test	in plus 48-mesh fraction		in test	in plus 48-mesh fraction
Jig conc	23.1	8.8	45.91	60.6	24.8
" bed	5.2	2.0	23.15	6.9	2.8
" tailing	71.7	27.3	7.94	32.5	13.3
Feed (calcd)	100.0	38.1	17.51	100.0	40.9

TABLE 11

Gravimetric Analysis of Jig Conc

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Float @ 2.96 sp gr	5.5	1.40	0.1
" " 3.30 " "	3.9	24.05	2.1
" " 3.80 " "	47.0	44.93	46.8
Sink " 3.80 " "	43.6	52.77	51.0
Total (calcd)	100.0	45.13	100.0

TABLE 12

Size Distribution of Sink Product
at 3.80 Sp Gr

Mesh, Tyler	Weight, %
+10	5.1
-10+14	10.2
-14+20	17.0
-20+28	21.7
-28+35	24.7
-35+48	20.4
-48	0.9
Total	100.0

From the results of these tests it can be seen that a satisfactory grade of concentrate cannot be made only by jigging the coarse material. The gravimetric analysis of the concentrate shows that the sink product at a specific gravity of 3.80 must be either limonite or middling particles of hematite. Most of this material is in the 20 to 48-mesh range.

To show the effect of size on the grade of concentrate produced,a sample of the spiral tailings was screened to remove the 35 to 100-mesh fraction. The plus 35-mesh material was ground to minus 35 mesh, combined with the minus 100-mesh material and jigged under the conditions shown in Table 13. The results of the test are shown in Table 14 and a size distribution of the jig feed and concentrate are given in Table 15.

TABLE 13

Jig Operating Conditions

Speed	260 rpm	
Stroke	1/8-in.	
Ragging		
Type	Steel shot	Hematite
Size	4 to 6-mesh	14 to 20-mesh
Weight	150 g	58 g
Supporting Screen	28-mesh	

TABLE 14

Results of Jigging

Product	Weight, %		Assay,% Sol Fe	Distn, % Sol Fe	
	in test	in total tailings		in test	in total tailings
Jig conc	15.1	7.7	62.34	35.6	28.1
Jig bed	10.6	5.4	13.53	5.4	4.2
Jig tailings (plus 270-mesh)	39.9	20.4	7.92	12.0	9.5
" " (minus 270-mesh)	34.4	17.6	36.13	47.0	37.1
Jig feed (calcd)	100.0	51.1	26.43	100.0	78.9
35 to 100-mesh spiral tailings		48.9	7.37		21.1
Total spiral tailings (calcd)		100.0	17.09		100.0

TABLE 15

Relative Size Distributions
of Jig Concentrate and Feed

Mesh, Tyler	Feed, Weight, %	Conc, Weight, %
-35+48	2.8	0.5
-48+65	8.0	1.2
-65+100	9.5	2.2
-100+150	16.6	3.5
-150+200	16.6	4.5
-200+270	9.2	2.2
-270+325	7.8	0.9
-325	29.5	0.1
Total	100.0	15.1

From the results of this test, it can be seen that a high grade of concentrate can be made by jigging finer feed and that the losses are higher.

Shipment No. 2

To determine the amount of iron recoverable under ideal operating conditions, a sample of the spiral tailings was tabled under closely controlled operating conditions. A high-grade concentrate was recovered along with a large middling product to ensure maximum recovery. The concentrate and middling were combined, ground to minus 35 mesh, and tabled. The results are given in Table 16.

TABLE 16

Results of Tabling

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Table ro conc	5.63	63.84	20.9
" ro midd	20.31	39.73	46.0
" ro tailings	74.06	7.70	33.1
Feed (calcd)	100.00	17.23	100.0
1st table cl conc	3.73	66.97	14.5
2nd " cl conc	10.85	59.84	37.7
Table cl tailings	11.36	22.35	14.7
Combined table ro conc + midd	25.94	44.45	66.9
Combined table cl concs	14.58	61.70	52.2

To compare jigging with tabling, a test was made by jigging a sample of the spiral tailings. Operating conditions were adjusted so that a large concentrate was obtained in an attempt to obtain maximum recovery of the iron values. The jig concentrate obtained was ground to minus 35 mesh and tabled to obtain a high-grade table concentrate, a middling, and a tailings product. The table middling and table tailings were ground to 65 mesh and tabled separately. The jig rougher tailing was tabled also to show the amount of fine hematite lost in the jigging operation. The jig operating conditions are shown in Table 17 and the results of jigging and tabling are shown in Table 18.

TABLE 17

Jig Operating Conditions

Speed	260 rpm	
Stroke	3/16-in.	
Ragging		
Type	Steel shot	
Size	4 to 6-mesh	6 to 8-mesh
Weight	101 g	15 g
Supporting Screen	8-mesh	

TABLE 18

Results of Jigging and Tabling

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Jig conc	35.2	27.24	56.0
" bed	1.5	15.20	1.0
" tailings	63.3	11.62	43.0
Feed (calcd)	100.0	17.12	100.0
Jig conc ground to 35 mesh			
Table conc	1.7	68.31	6.8
" midd	10.3	55.07	33.1
" tailings	23.2	11.87	16.1
Table midd ground to 65 mesh			
Table conc	7.5	63.22	27.7
" tailings	2.8	33.22	5.4
Table tail ground to 65 mesh			
Table conc	0.6	62.90	2.2
" tailings	22.6	10.52	13.9
Jig tail tabled			
Table conc	2.6	62.29	9.5
" tailings	60.7	9.45	33.5

A sample of the spiral tailings was divided into minus and plus 65-mesh fractions. Each fraction was jigged and the concentrate from jigging the plus 65-mesh fraction was ground to 35 mesh and tabled. Jig operating conditions are shown in Table 19 and the results of the test in Table 20.

TABLE 19

Jig Operating Conditions

	+65 m fraction	-65 m fraction	
Speed	260 rpm	260 rpm	
Stroke	3/16 in.	1/8-in.	
Ragging			
Type	chromite	Ni shot	chromite
Size	-4+6 m	10 to 28-mesh	20 to 28-mesh
Weight	35 g	72 g	45 g
Supporting Screen	8 mesh	50-mesh	

TABLE 20

Results of Jigging Tests

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Plus 65-mesh fraction			
Jig conc	9.3	47.15	25.3
" bed	4.3	28.87	7.2
" tailings	44.4	6.30	16.1
Total (calcd)	58.0	14.52	48.6
Jig conc ground to 35 mesh			
Table conc	3.9	63.46	14.3
" midd	0.8	51.49	2.4
" tailings	4.6	34.03	8.6
Combined table conc + midd	4.7	61.42	16.7
Minus 65-mesh fraction			
Jig conc	5.3	67.13	20.5
" bed	3.3	13.94	2.6
" tailings	33.4	14.67	28.3
Total (calcd)	42.0	21.23	51.4
Combined conc	10.0	64.45	37.2

FLOTATION

With the idea of treating the coarse fraction of the spiral tailing by jigging, the minus 65-mesh material was removed by screening and used as flotation feed in the preliminary stages of this investigation.

Several preliminary tests were made on the first shipment of tailings using an hydroxamate as the collector for the iron minerals. This reagent had been publicized recently as an excellent collector for iron oxides. In these tests, the results were not satisfactory even after heavy desliming, and the use of this reagent was abandoned. For the remaining flotation, petroleum sulphonate collectors, Reagents 801 and 825 mixed 1:1 were used. The flotation was done at a natural pH of 8.4 to 8.5.

A few preliminary tests were done on tailings from the first shipment. This material did not respond readily to treatment. The quartz was stained with iron oxide and it was thought that this might be due to the material having been air-dried. A second shipment was received in a damp state and it was similarly iron-stained. It was learned later that this was a characteristic of some of the material. Most of the investigation was then carried out on the second shipment.

Shipment No. 1

A sample of the minus 65-mesh spiral tailing was deslimed and then floated in three stages using petroleum sulphonate collectors. The rougher flotation concentrates were then deslimed,using Aerosol-OT as a desliming aid, to make a final iron product. Flotation conditions of the test are given in Table 21 and the results of the test are given Table 22.

TABLE 21

Flotation Conditions

Point of Addition	pH	R800 + R825 (1:1) - lb/ton		Flot time, Minutes
		Flot feed*	Spiral tail	
1st ro stage	8.4	1.25	0.60	1
2nd ro stage	8.4	0.47	0.22	1
3rd ro stage	8.4	0.47	0.22	2

*48.3% weight of spiral tail

TABLE 22

Results of Flotation of Spiral Tailing Fines

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe	
			In test	In spiral tailing
Final conc	14.3	60.5	37.2	18.8
Flot tailing	74.7	14.2	45.5	22.9
Slimes (comb)*	11.0	36.5	17.3	8.8
Flot feed (calcd) (minus 65-mesh spiral tailings)	100.0	23.3	100.0	50.5

*Pre-flotation slimes and slimes from rougher concentrate.

Shipment No. 2

A sample of the minus 65-mesh spiral tailings from Shipment No. 2 was treated similarly to the sample from Shipment No. 1. The results of the test are given in Table 23.

TABLE 23

Results of Flotation of Spiral Tailing Fines

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe	
			In test	In spiral tailing
Final conc	13.7	64.5	37.2	18.1
Flot tailing	71.2	13.8	41.2	20.1
Slimes (comb)*	15.1	33.9	21.6	10.5
Flot feed (calcd) (minus 65-mesh spiral tailings)	100.0	23.7	100.0	48.7

*Pre-flotation slimes and slimes from rougher concentrate.

A sample of the plus 65-mesh spiral tailings was jigged to produce a concentrate assaying 47.7% Sol Fe and containing 24.6% of the iron in the tailing. This concentrate was ground to minus 65 mesh, combined with the minus 65-mesh spiral tailing, and then floated. Details of flotation were the same as in Table 21, and the results of the test are given in Table 24.

TABLE 24

Results of Flotation of Spiral Tailings Fines Plus Jig Concentrate

Product	% Weight in test	Assay, % Sol Fe	Distn, % Sol Fe	
			In test	In spiral tailing
Ro conc No. 1	21.1	62.37	27.7	22.4
Ro conc No. 2	10.3	54.15	11.7	9.5
Combined Ro conc	31.4	59.68	39.4	31.9
Slimes (comb)*	15.4	44.96	14.5	11.7
Flot Ro tailings	53.2	41.21	46.1	37.2
Flot feed	100.0	47.58	100.0	80.8
Jig bed + tailings				19.2
Spiral tailings				100.0

*Pre-flotation slimes and slimes from rougher concentrate.

A sample of the tailings from the Carpco high-tension electrostatic separator was screened on 100 mesh, and the minus 100-mesh material was treated by flotation after having been deslimed. The details of flotation were the same as in Table 21 and the results of the test are given in Table 25.

TABLE 25

Results of Flotation of -100 Mesh H.T. Tailings

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe	
			In test	In H.T. tailings
Fe conc	49.8	65.35	66.1	46.4
Ro flot tailings	49.4	33.1	33.2	23.3
Slimes (comb)*	0.8	43.7	0.7	0.5
Flot feed (calcd)	100.0	49.2	100.0	70.2
plus 100-mesh H.T. tailings				29.8
Total H.T. tailings				100.0

*Pre-flotation slimes and slimes from rougher concentrate.

Both the fine spiral tailings and the fine high-tension tailings were separately amenable to flotation; therefore, it was decided to combine the two products in the ratio of 30 parts of spiral tailings to one part high-tension tailings and to float the resulting product after desliming. The details of the flotation test were the same as in Table 21, and the results of the test are given in Table 26.

TABLE 26

Results of Flotation of Fine Spiral Tailings and Fine High-Tension Tailings

Product	Weight, %		Assay, % Sol Fe	Distn, % Sol Fe	
	In test	In combined tailings		In test	In combined tailings
No. 1 Ro conc	4.7		67.96	13.3	
No. 2 Ro conc	6.2		64.85	16.7	
No. 3 Ro conc	4.6		54.07	10.3	
Combined conc	15.5	7.5	62.59	40.3	20.0
Ro tailing	73.4	35.6	14.28	43.6	21.5
Slimes (comb)*	11.1	5.4	34.97	16.1	8.0
Flot feed (calcd)	100.0	48.5	24.1	100.0	49.5

*Pre-flotation slimes and slimes from rougher concentrate.

The high-tension tailings was then combined, in the proportion in which it had been produced, with the minus 65-mesh portion of the spiral tailings and with the ground jig concentrate from the plus 65-mesh portion of the spiral tailing. The pulp was deslimed before rougher flotation. In one test, the rougher flotation concentrate was cleaned by flotation and deslimed with Aerosol. In another test, an initial finished rougher concentrate was produced. Flotation was then continued to produce a second concentrate which was upgraded by desliming with Aerosol, dried, and was cleaned by high-intensity magnetic separation. The details of flotation were the same as in Table 21 and the results of the tests are given in Table 27.

TABLE 27

Results of Tests on Combined Jig Concentrate, Minus 65-Mesh Portion of Spiral Tailings, and High-Tension Tailings

Product	Weight, %		Assay, % Sol Fe	Distn, % Sol Fe	
	In test	In total tails		In test	In total tails
Flot cl conc	18.06	10.3	60.91	41.6	34.2
" " tailings	10.08	5.7	37.79	14.4	11.8
" ro tailings	58.76	33.8	11.66	25.9	21.2
Slimes (comb)*	13.10	7.5	36.73	18.1	14.8
Flot feed (calcd)	100.00	57.3	26.47	100.0	82.0
Jig bed + tailings		42.7	7.7		18.0
Total spiral tailings + H.T. tailings		100.0	18.34		100.0
No. 1 flot ro conc	9.6	5.5	67.08	24.5	20.2
H.I. conc	10.9	6.3	64.57	26.6	21.8
Total Fe conc	20.5	11.8	65.95	51.1	42.0
H.I. tailings	7.6	4.3	17.18	4.9	4.0
Flot ro tailings	58.8	33.7	11.66	25.9	21.2
Slimes (comb)*	13.1	7.5	36.73	18.1	14.8
Flot feed (calcd)	100.0	57.3	26.48	100.0	82.0
Jig bed + tailings		42.7	7.7		18.0
Total spiral tailings + H.T. tailings		100.0	18.34		100.0

*Pre-flotation slimes and slimes from cleaner or rougher concentrates.

A somewhat similar set of tests was done on the total spiral tailings combined with the high-tension tailings. The coarse material was ground to minus 65 mesh, combined with the original minus 65-mesh material, deslimed, and then floated. In flotation, an initial finished rougher concentrate was produced. Flotation was continued to produce a second concentrate which was upgraded either by flotation or dry high-intensity magnetic separation. Desliming of the concentrates produced with Aerosol was done in the same manner as in the test reported in Table 27. Details of the tests were similar to Table 21 except for a slightly higher amount of collector. The results of the tests are given in Table 28.

TABLE 28

Results of Flotation Tests on Combined Spiral Tailings and High-Tension Tailings

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
No. 1 flot ro conc	4.3	64.70	16.0
No. 2 flot cl conc	6.0	58.60	20.2
Combined conc	10.3	61.2	36.2
No. 2 flot cl tailings	3.6	31.30	6.5
Flot ro tailings	72.0	9.28	38.5
Slimes (comb)*	14.1	23.15	18.8
Feed (calcd)	100.0	17.37	100.0
No. 1 flot ro conc	4.3	64.70	16.0
No. 2 flot H.I. conc	6.7	62.84	24.5
Combined conc	11.0	63.60	40.5
No. 2 flot H.I.tailings	2.9	12.78	2.2
Flot ro tailings	72.0	9.28	38.5
Slimes (comb)*	14.1	23.15	18.8
Feed (calcd)*	100.0	17.31	100.0

*Pre-flotation slimes and slimes from rougher or cleaner concentrates.

Treatment of High-Tension Tailings

Flotation of these tailings, alone and in combination with different fractions of the spiral tailings, had been successful. However, because these tailings had been dried, it was felt that, if at all possible, a dry process should be used.

From the gravimetric analysis of these tailings, Table 4, it can be determined that the sink product at a specific gravity of 3.8 does not have a high iron content but that it contains some middling particles. Recirculation of this material to the spiral circuit or the high-tension circuit without some additional treatment probably would result in the build-up of a circulating load.

One dry method which has received some publicity recently is the use of an air sluice. This apparatus is similar to the hydraulic pinched-sluice except that air is used as the medium with the air being fed through a porous plate in the bottom of the sluice.

Unfortunately the use of this apparatus was not successful. It appeared to have some use as a scavenger, but grades and recoveries were not satisfactory, and only a few tests were done with this apparatus.

A sample of the high-tension tailings was passed over the air-sluice after it had been adjusted to give what appeared to be the best results. A primary concentrate was recovered and the tailings was repassed to recover a scavenger concentrate. The results of a size-assay test are reported in Table 29 and the results of a size-assay test of the sluice tailing are reported in Table 30.

TABLE 29

Results of Air Sluice Test

Product	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
Primary conc	17.0	54.70	35.0
Scavenger conc	5.8	42.86	9.4
Scavenger tailings	77.2	19.10	55.6
Feed (calcd)	100.0	26.53	100.0

TABLE 30

Size-Assay Results of Air-Sluice Tailing

Mesh, Tyler	Weight, %	Assay, % Sol Fe	Distn, % Sol Fe
+48	4.7	2.86	0.7
-48+100	48.6	3.65	9.4
-100+200	30.6	24.21	38.7
-200	16.1	60.93	51.2
Total (calcd)	100.0	19.10	100.0

Size of material seemed to affect the results and most of the losses were in the finer sizes, therefore it was decided to size the material before testing. A sample of the high-tension tailings was screened on 48 and 100 mesh and the three screen products were passed over the air sluice. Each concentrate was repassed over the sluice. The results of the test are reported in Table 31.

TABLE 31

Results of Air-Sluice Tests on
Screened Fractions of High-Tension Tailings

Product	Weight, %		Assay, % Sol Fe	Distn, % Sol Fe	
	In test	Total tailing		In test	Total tailing
Plus 48-mesh fraction					
concentrate	41.0	3.4	56.41	80.3	7.2
middling	6.5	0.5	24.84	5.6	0.5
tailings	52.5	4.3	7.80	14.1	1.3
Total (calcd)	100.0	8.2	28.89	100.0	9.0
48 to 100-mesh fraction					
concentrate	2.7	1.7	63.66	11.4	4.1
middling	30.1	18.8	22.45	44.9	15.9
tailings	67.2	41.9	9.78	43.7	15.5
Total (calcd)	100.0	62.4	15.05	100.0	35.5
Minus 100-mesh fraction					
concentrate	17.7	5.2	62.41	22.1	12.3
middling	42.2	12.4	48.64	41.0	22.7
tailings	40.1	11.8	45.95	36.9	20.5
Total (calcd)	100.0	29.4	50.00	100.0	55.5
Combined conc (calcd)		10.3	61.25		23.6
Total tailings (calcd)		100.0	26.46		100.0

DISCUSSION

The spiral tailings can be divided roughly into three parts, the coarse (+34-mesh), the intermediate (35 to 100-mesh), and the fine (minus 100-mesh) fraction.

Examination by microscope and heavy-liquid tests have shown that the iron values in the fine fraction consist mainly of free hematite particles; therefore concentration of this material should give an acceptable product.

The intermediate fraction, amounting to 50% of the weight of the tailings, is low in iron values and can be considered to be a finished product.

The coarse fraction contains iron values which are present mainly as middling particles and so require grinding. If grinding is done after concentration, further concentration will be required.

The only method found for satisfactory concentration of the fine fraction was flotation. This method gave good recovery of iron values and a good grade of concentrate. By screening the spiral tailings, on a DSM screen or using a sand-slime splitter on the tailings end of the spirals the amount of spiral tailings to be treated could be reduced to between 30 and 40% of the total weight of the spiral tailings.

The coarse fraction could be treated by jigging, by grinding of the jig concentrate, and flotation; or the whole fraction could be ground and then floated along with the fine portion. If it is desirable to reduce the amount of coarse material treated in either of the above steps, a second screening could eliminate the middle fraction, which is low grade and which amounts to between 50 and 50% of the weight of the spiral tailings.

Jigging gave satisfactory results on the coarse material but was not successful on the finer material. However, it is felt that even the results obtained with the coarse material might not apply to plant operations. An attempt is to be made to test this process at a pilot-plant scale.

The high-tension tailings have somewhat the same characteristics as the spiral tailings except that the grade is higher and the values are concentrated more in the finer size ranges. Any method suitable for the spiral tailings should be suitable for the high-tension tailings.

The results from using dry high-intensity magnetic separation to clean flotation rougher concentrates (Tables 31, 33) showed that most of the material can be recovered with a good grade and good recovery and that further "cleaner" flotation must be done to obtain the same results.

REMARKS AND RECOMMENDATIONS

Several possible flowschemes for treating the spiral tailings have been outlines. The flowschemes vary in complexity and in the equipment that would be required; therefore it would be necessary to do a feasibility study to determine the procedure giving the best return.

Recovery of iron values from the tailings was between 18% when treating 45% of the spiral tailings by flotation alone and 42% after portions of the total spiral tailings had been treated by combination of jigging, flotation, and dry high-intensity magnetic separation.

This investigation was done under closely controlled laboratory conditions, therefore the results obtained should be checked in a larger-scale pilot operation.

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