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TABLING TESTS ON BARITE-FLUORITE SAMPLES FROM LAKE AINSLIE, NOVA SCOTIA (PROJECT MP-MIL-207)

by

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MINERAL PROCESSING DIVISION

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SUMMARY

At the request of Yale Lead and Zinc Mines Limited, Toronto, the Mineral Processing Division undertook to provide several hundred pounds of barite concentrate from samples originating in the Lake Ainslie district of Nova Scotia, for market survey purposes. In order to provide some metallurgical data, this project was developed in the form of test runs rather than straight bulk tabling.

The tests performed gave an average recovery of 43% of the barite as a high grade product, containing 94.3% $BaSO_4$ with a specific gravity of 4.36 and a reflectance of 94.3%. The same tests showed that if drilling mud grade was the objective rather than high grade, then an average of 64% of the barite could be recovered at 91.0% $BaSO_4$ and with a specific gravity of 4.30.

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INTRODUCTION

The Mineral Processing Division was first approached in May, 1965, regarding process development work on barite-fluorite ore from the Lake Ainslie district on Cape Breton Island, Nova Scotia. Consolidated Mogul Mines Limited, Toronto, proposed reassessing old properties with the object of outlining ore reserves which could be brought into production.

It was pointed out to the company that the Division had made extensive studies of Lake Ainslie ore in the past, including pilot plant operations, and that successful process development projects had already been completed. Copies of the reports covering these projects were handed over to the company.

In March, 1966, the matter was reopened by Yale Lead and Zinc Mines Limited, Toronto, presumably associated with Consolidated Mogul Mines Limited since the officers involved were the same. It was reported to the Division that 1.5 million tons of barite-fluorite ore had been outlined by drilling. The average grade indicated was approximately 56% barite and 15% fluorite. A request was made that the Division produce several hundred pounds of barite concentrate, from samples to be provided, for use in market surveys.

In response to this request, the Division undertook to recover whatever barite could be readily concentrated by tabling 1000 lb of feed. To this end Yale Lead and Zinc Mines Limited, sent along 500 lb of material from each of the two veins outlined by drilling. The samples contained soil and other debris, and were possibly contaminated by grease. Since products for market survey were requested, it was considered desirable to have a second set of more carefully collected samples to replace the originals. A second set was therefore sent in by the company.

SAMPLES

Sample Number A-66 originated in the MacMillan vein. It consisted of 5 bags with a combined weight of 503 lb. Bags 1 to 4 contained average ore; bag 5, "manganese-bearing" ore. The latter was kept separate in case it required special treatment. However, Yale Lead and Zinc Mines Limited indicated that the manganese content was probably a fraction of 1 per cent, and subsequent analysis showed it to be approximately 0.02%.

Sample Number B-66 originated in the Upper Johnston vein and consisted of 5 bags with a combined weight of 501 lb.

Table 1 compares drilling program results with the samples received by the Division.

TABLE 1

Drill Results Versus Samples Received

Source	Drilling				Samples		
	Tons	Wt %	$BaSO_4$, %	CaF_2, %	No.	$BaSO_4$, %	CaF_2, %
MacMillan	975,000	63	49.08	16.77	A-66	57.50	24.84
Johnston	575,000	37	67.62	10.89	B-66	82.50	10.34
Combined	1,550,000	100	56.10	14.60	Ave	70.00	17.59

ANALYSES

Determinations for $BaSO_4$ and CaF_2 were made on all test fractions. Specific gravity, and reflectivity (in comparison with magnesium carbonate as 100%), determinations were made on barite concentrates. The determinations for MnO_2 were made only on selected samples.

TEST PROGRAM

It was decided that some metallurgical data could be provided on the tabling of this material without much more effort than bulk tabling the entire lot. Such information would be of use to the submitter. Preliminary tests included several sizes of feed and were made on both a Wilfley rectangular deck table and a Holman diagonal deck table. The two most significant results were obtained with the Holman table and are given in Table 2. Material from the MacMillan vein, with the lowest barite content, was used.

TABLE 2

Preliminary Tests: Holman Table

Feed (mesh)	Fraction	Wt, %	Analysis, %		Distribution, %	
			$BaSO_4$	CaF_2	$BaSO_4$	CaF_2
-35+100	Product Tails	42 58	92.23 49.28	5.30 36.20	57.3 42.7	9.6 90.4
	Combined	100	67.50	23.22	100.0	100.0
-100	Product Tails Slimes	26.9 55.4 17.7	95.14 41.02 58.58	2.95 45.28 27.74	43.6 38.7 17.7	2.6 81.5 15.9
	Combined	100.0	58.70	30.80	100.0	100.0

These results suggested that two sizes of table feed would be necessary, -35+100 and -100 mesh. In addition, separate tests would be required with feed from each source and with mixed feed.

The samples, A-66(1 to 4), A-66(5) and B-66, were separately reduced to -35 mesh in the following comminution sequence:

1) Jaw crusher to -1 in.
2) -1 in. screened on 3/8 in.
3) +3/8 in. jaw crushed to -3/8 in.
4) Head sample of -3/8 in. riffled out.
5) -3/8 in. screened on 35 and 100 mesh.
6) +35 mesh rolls crushed and rescreened on 35 and 100 mesh till rolls'limit reached.
7) Remaining +35 mesh dry ground in a jar mill and screened on 35 and 100 mesh.
8) Head samples of -35 and -100 mesh riffled out.

Table 3 gives a summary of the various feed materials tested. The two mixed feeds, A+B, were prepared on the basis of their proportions as indicated by drilling (Table 1), i.e. A----63%, B----37%.

TABLE 3

Feeds Tested

Sample	Size (mesh)	Wt, %	$BaSO_4$, %	CaF_2, %	MnO_2, %
A + B	-100	16.4	75.12	14.43	
A + B	-35+100	18.4	71.56	15.28	
A(1-4)	-100	15.7	61.21	23.82	
A(1-4)	-35+100	12.5	53.48	25.94	
A(5)	-100	6.0	62.80	24.30	0.004
A(5)	-35+100	4.5	64.27	21.71	0.010
B	-100	11.8	83.87	9.49	
B	-35+100	14.7	81.46	11.06	
Combined		100.0	70.27	17.36	0.01

In the first series of tests the -100 mesh feeds were used. A vibrating tube feeder was employed to obtain a steady feed to the table. The tests were performed on the Holman diagonal deck table. Feed rate and deck slope were recorded for each test. Wash water was adjusted to develop the best separation; water flow rates were moderate. Material discharged from the table was cut to produce 4 fractions, the product, a narrow middling, the tails, and the slimes. Tails and slimes were sampled separately but pumped to one filter as a combined tailing. The middling was dried, weighed and sampled. Because the product invariably contained a number of dark particles (presumably manganese) it was sent to a Jones High Intensity Wet Magnetic Mineral Separator which successfully removed them. The Jones' non-magnetics were then dried, weighed, sampled and stored as finished products.

The middling from each test, except for those with A(5) feeds, from which there was too small a quantity, was rerun to determine whether additional product could be removed, and whether recycling to original feed would be worthwhile. The products from these reruns were kept separate, the middlings and tails being added to the primary test tailings.

Test data are given in Table 4 and the test results in Tables 5 to 8.

TABLE 4

Table Test Data, -100 mesh Feeds
(Deck slops 6°, wash water moderate)

Test No.	Feed		Fractions, (weight,%)						
	Source	Rate lb/hr	Prod	Jones N-mag*	Jones Mag**	Midd	Tail Slime	Loss	Total
1	A+B	122	(36.4)	35.7	0.7	18.2	44.7	0.7	100.0
1A	Midd	100	2.8			3.4	12.0		18.2
2	A(1-4)	117	(26.7)	26.6	0.1	20.8	51.8	0.7	100.0
2A	Midd	114	2.2			3.5	15.1		20.8
7	A(5)	137	(22.8)	22.7	0.1	11.4	65.8	0.0	100.0
3	B	126	(37.3)	36.9	0.4	16.5	45.2	1.0	100.0
3A	Midd	115	3.0			4.0	9.5		16.5

* Non-magnetic
** Magnetic

TABLE 5

Results of Tests 1 and 1A

Test No.	Fraction	Wt, %	Analyses, %				Distribution, %	
			$BaSO_4$	CaF_2	Sp gr	Refl	$BaSO_4$	CaF_2
1	N-mag	35.7	96.30	1.38	4.39	94.8	50.0	2.7
	Mag	0.7	95.64	1.19	-	-	1.0	-
	Midd*	18.2	51.91	35.89	-	-	13.8	36.0
	T & S	44.7	54.00	24.90	-	-	35.2	61.3
	Loss	0.7	-	-	-	-	-	-
	Comb	100.0	69.1	18.3	-	-	100.0	100.0
1A	Prod	2.8	90.81	6.13	4.36	88.0	3.5	1.0
	Midd	3.4	83.21	13.58	-	-	3.8	2.7
	Tails	12.0	39.39	46.23	-	-	6.5	32.3
	Comb*	18.2	55.41	33.96	-	-	13.8	36.0

* Combined 1A fractions should equal 1 Middling

TABLE 6

Results of Tests 2 and 2A

Test No.	Fraction	Wt, %	Analyses, %				Distribution, %	
			$BaSO_4$	CaF_2	Sp gr	Refl	$BaSO_4$	CaF_2
2	N-mag	26.6	94.42	3.48	4.34	95.6	45.8	3.4
	Mag	0.1	92.22	2.54	-	-	0.1	-
	Midd*	20.8	35.94	47.93	-	-	13.6	36.7
	T & S	51.8	43.10	31.40	-	-	40.5	59.9
	Loss	0.7	-	-	-	-	-	-
	Comb	100.0	55.32	27.32	-	-	100.0	100.0
2A	Prod	2.2	82.55	13.84	4.18	85.5	3.2	1.1
	Midd	3.5	69.03	26.66	-	-	4.2	3.6
	Tails	15.1	23.70	55.41	-	-	6.2	32.0
	Comb*	20.8	37.60	46.00	-	-	13.6	36.7

* Combined 2A fractions should equal 2 Middling

TABLE 7

Result of Test 7

Fraction	Wt, %	Analyses, %					Distribution, %	
		$BaSO_4$	CaF_2	MnO_2	Sp gr	Refl	$BaSO_4$	CaF_2
N-mag	22.7	95.36	2.06	0.004	4.42	88.2	34.6	2.0
Mag	0.1	93.58	1.90	0.012	-	-	0.2	-
Midd	11.4	83.14	13.90	-	-	-	15.1	6.6
T & S	65.8	47.80	33.80	-	-	-	50.1	91.4
Comb	100.0	62.80	24.30	-	-	-	100.0	100.0

TABLE 8

Results of Tests 3 and 3A

Test No.	Fraction	Wt, %	Analyses, %				Distribution, %	
			$BaSO_4$	CaF_2	Sp gr	Refl	$BaSO_4$	CaF_2
3	N-mag	36.9	97.49	0.73	4.38	94.5	43.5	2.6
	Mag	0.4	96.38	0.68	-	-	0.5	-
	Midd*	16.5	81.59	13.88	-	-	16.3	21.6
	T & S	45.2	72.64	17.68	-	-	39.7	75.8
	Loss	1.0	-	-	-	-	-	-
	Comb	100.0	83.40	10.67	-	-	100.0	100.0
3A	Prod	3.0	95.04	2.63	4.44	88.6	3.6	0.6
	Midd	4.0	92.44	4.83	--	-	4.6	1.6
	Tails	9.5	68.47	24.78	-	-	8.1	19.4
	Comb*	16.5	79.23	15.89	-	-	16.3	21.6

* Combined 3A fractions should equal 3 Middling

In the second test series the -35+100 mesh feeds were used. The arrangements were similar to those for the first series except that there was very little slime to deal with. Such fine material as developed from abrasion during the tests was sent to waste. It was found necessary to use a somewhat steeper slope for the deck, and a little more wash water, especially on the middling reruns. Primary products were again passed through the Jones Separator. Middlings for A(5) material were not rerun due to the small amount involved.

Test data are given in Table 9, and results in Tables 10 to 13.

TABLE 9

Table Test Data, -35+100 mesh Feeds

Test No.	Feed		Deck Slope, deg	Fractions (weight, %)						
	Source	Rate, lb/hr		Prod	Jones, N-mag	Jones, Mag	Midd	Tails	Loss	Total
4	A+B	278	10	(28.9)	27.8	1.1	31.5	38.4	1.2	100.0
4A	Midd	260	12	13.1	-	-	15.6	2.8	-	31.5
5	A(1-4)	262	10	(30.3)	29.4	0.9	25.7	42.2	1.8	100.0
5A	Midd	265	12	7.4	-	-	7.8	10.5	-	25.7
8	A(5)	292	10	(34.2)	34.1	0.1	24.0	41.6	0.2	100.0
6	B	320	10	(33.7)	33.6	0.1	41.4	23.3	1.6	100.0
6A	Midd	300	12	16.1	-	-	17.4	7.9	-	41.4

TABLE 10

Results of Tests 4 and 4A

Test No.	Fraction	Wt, %	Analyses, %				Distribution, %	
			$BaSO_4$	CaF_2	Sp gr	Refl	$BaSO_4$	CaF_2
4	N-mag	27.8	94.42	3.33	4.33	97.5	38.0	5.5
	Mag	1.1	94.70	2.67	-	-	1.5	0.2
	Midd*	31.5	85.15	11.29	-	-	38.7	20.9
	Tails	38.4	39.33	32.58	-	-	21.8	73.4
	Loss	1.2	-	-	-	-	-	-
	Comb	100.0	70.01	17.23	-	-	100.0	100.0
4A	Prod	13.1	88.65	8.23	4.30	94.5	16.8	6.5
	Midd	15.6	83.81	12.25	-	-	18.9	11.4
	Tails	2.8	74.57	17.76	-	-	3.0	3.0
	Comb*	31.5	85.04	11.07	-	-	38.7	20.9

* Combined 4A fractions should equal 4 Middling.

TABLE 11

Results of Tests 5 and 5A

Test No.	Fraction	Wt,	Analyses, %				Distribution, %	
			$BaSO_4$	CaF_2	Sp gr	Refl	$BaSO_4$	CaF_2
5	N-mag	29.4	90.48	6.85	4.25	97.3	46.0	8.3
	Mag	0.9	90.20	5.78	-	-	1.4	0.2
	Midd*	25.7	71.82	21.64	-	-	31.9	23.0
	Tails	42.2	28.39	39.37	-	-	20.7	68.5
	Loss	1.8	-	-	-	-	-	-
	Comb	100.0	58.85	24.67	-	-	100.0	100.0
5A	Prod	7.4	81.64	14.73	4.18	89.7	10.1	4.6
	Midd	7.8	74.80	20.80	-	-	9.9	6.9
	Tails	10.5	66.55	25.30	-	-	11.9	11.5
	Comb*	25.7	73.29	20.92	-	-	31.9	23.0

* Combined 5A fractions should equal 5 Middling.

TABLE 12

Result of Test 8

Fraction	Wt, %	Analyses, %					Distribution, %	
		$BaSO_4$	CaF_2	MnO_2	Sp gr	Refl	$BaSO_4$	CaF_2
N-mag	34.1	91.90	5.40	0.010	4.24	89.6	48.9	8.5
Mag	0.1	90.47	4.88	0.021	-	-	1.4	-
Midd	24.0	76.75	18.59	-	-	-	28.6	20.5
Tails	41.6	32.42	36.86	-	-	-	21.1	71.0
Loss	0.2	-	-	-	-	-	-	-
Comb	100.0	64.27	21.71	-	-	-	100.0	100.0

TABLE 13

Results of Tests 6 and 6A

Test No.	Fraction	Wt, %	Analyses, %				Distribution, %	
			$BaSO_4$	CaF_2	Sp gr	Refl	$BaSO_4$	CaF_2
6	N-mag	33.6	96.16	1.80	4.40	96.0	38.9	6.2
	Mag	0.1	94.69	1.79	-	-	0.1	-
	Midd*	41.4	88.54	7.92	-	-	44.1	33.1
	Tails	23.3	60.00	25.74	-	-	16.9	60.7
	Loss	1.6	-	-	-	-	-	-
	Comb	100.0	84.50	10.06	-	-	100.0	100.0
6A	Prod	16.1	92.85	4.57	4.34	87.2	18.0	7.5
	Midd	17.4	88.72	8.22	-	-	18.5	14.5
	Tails	7.9	79.78	13.87	-	-	7.6	11.1
	Comb*	41.4	88.65	7.87	-	-	44.1	33.1

* Combined 6A fractions should equal 6 Middling.

At the end of the full test program various fractions had been accumulated. Jones non-magnetics composed the primary concentrates, and the products from retabling of middlings the secondary concentrates. The tailings for each test were made up of first run tails and slimes combined with rerun middlings and tails. The Jones magnetics were not included in the combined tailings since they represented a very small portion of the whole, and contained some material undesirable in the products. Loss was also excluded. A summary of the accumulated material is given in Table 14.

In Table 15, the primary concentrates from all of the tests have been averaged. Similarly, all the secondary concentrates, tails and loss.

TABLE 14

Summary of Tabling Results
(magnetics and loss omitted)

Test No.	Material	Size (mesh)	Source	Wt, %	Analyses, % BaSO$_4$	CaF$_2$	Sp gr	Refl
1	N-mag	-100	A + B	35.7	96.30	1.38	4.39	94.8
1A	Prod			2.8	90.81	6.13	4.36	88.0
	Tails*			60.1	52.00	27.60	-	-
				98.6				
2	N-mag	-100	A(1-4)	26.6	94.42	3.48	4.34	95.6
2A	Prod			2.2	82.55	13.84	4.18	85.5
	Tails			70.4	40.36	36.33	-	-
				99.2				
7	N-mag	-100	A(5)	22.7	95.36	2.06	4.42	88.2
	Tails			77.3	53.00	30.85	-	-
				100.0				
3	N-mag	-100	B	36.9	97.49	0.73	4.38	94.5
3A	Prod			3.0	95.04	2.63	4.44	88.6
	Tails			58.7	73.28	18.07	-	-
				98.6				
4	N-mag	-35+	A + B	27.8	94.42	3.33	4.33	97.5
4A	Prod	100		13.1	88.65	8.23	4.30	94.5
	Tails			56.8	53.35	25.90	-	-
				97.7				
5	N-mag	-35+	A(1-4)	29.4	90.48	6.85	4.25	97.3
5A	Prod	100		7.4	81.64	14.73	4.18	89.7
	Tails			60.5	41.00	34.58	-	-
				97.3				
8	N-mag	-35+	A(5)	34.1	91.90	5.40	4.34	89.6
	Tails	100		65.6	48.68	30.12	-	-
				99.7				
6	N-mag	-35+	B	33.6	96.16	1.80	4.40	96.0
6A	Prod	100		16.1	92.85	4.57	4.34	87.2
	Tails			48.6	73.51	17.49	-	-
				98.3				

* e.g. From Table 5 Wt % 60.1 = 44.7 + 3.4 + 12.0

TABLE 15

Summary of Product Distribution

Product	Average Wt, % *	$BaSO_4$		CaF_2		Sp gr, Av	Refl, Av
		%	Dist	%	Dist		
Primary	30.8	94.3	43.1	3.06	5.0	4.36	94.3
Secondary	5.6	89.3	7.4	7.78	2.3	4.29	90.0
Tails	62.2	53.6	49.5	28.2	92.7	-	-
Loss	1.4	-	-	-	-	-	-
Combined	100.0	67.5	100.0	18.9	100.0	-	-

* Arithmetical average. All other figures are weighted averages.

REMARKS

1) Table cuts on barite have to be made by eye. As there are no sharp indicators, the best point of cut is difficult to judge. This is reflected in the results, e.g. Tables 6 and 7, both with A sample (MacMillan vein), -100 mesh feed, show a recovery of 45.8% at 94.42% $BaSO_4$ and a recovery of 34.6% at 95.36% $BaSO_4$. Some difference in judgement of the cut point made a considerable difference in the recovery for a slight difference in grade.

2) The average recovery of high grade product from tests with -100 mesh feed (Tables 5 to 8) was 1.3% higher than from tests with -35+100 mesh feed (Tables 10 to 13) and the overall grade of product was nearly 3% higher from the -100 mesh feed. Considering this factor, the fact that barite remaining in tests would probably have to be recovered by flotation, and the fact that barite products require final fine grinding, it might pay to prepare all table feed at -100 mesh if high grades were the objective.

3) With mud grade as the objective, a much higher overall recovery was indicated by the test work. Moreover, recovery for tests using -35+100 mesh feed was considerably higher than for tests using -100 mesh feed: 73.6% compared with 53.2%. Primary non-magnetics and magnetics, and secondary products and middlings, were included as mud grade product. The combination of Test 1 (-100 mesh, Table 5) and Test 4 (-35+100 mesh, Table 10) on mixed A and B material gave an overall recovery of 68% at mud grade. Test 1 produced a 58.2% recovery

and Test 4 a 74.1% recovery. With mud grade as the objective, it would appear preferable to table the two sizes separately and to have as much of the feed as possible in the -35+100 mesh size.

4) The question of whether it would be preferable to recirculate middlings back to table feed is debatable. The group of secondary, "A", tests, in which middlings were retabled, was initiated to reveal indications of this. On -35+100 mesh feed with mixed A and B material, and with the B (Johnston vein) material, additional recovery of mud grade was obtained. With the latter, this additional recovery almost equalled that from primary tabling. With -100 mesh feed the retabling recoveries were comparatively small, that for B (Johnston vein) feed again being the highest, and that for mixed A and B the next highest. Recirculation would not appear to be profitable except on high barite feed. Retabling might give better control.

5) Sufficient barite remained in table tails to warrant additional recovery by flotation, prior to floating fluorite. If the results of test work being performed as part of another program give indications of improved recovery of fluorite and barite, the results will be forwarded to the company concerned.

6) It was noted that sample assays did not always check the recalculated figures closely. The largest difference was between A+B -100 mesh (Table 3) and Combined, Test 1 (Table 5). In general agreement was within reasonable limits.

7) On July 22, 1966, the non-magnetic material from Tests 1, 2, and 3 (Table 14), representing -100 mesh final products, was blended and packaged for shipment. At the same time the non-magnetic material from Tests 4, 5, and 6 (Table 14), representing the -35+100 mesh final products, was blended and packaged separately for shipment. The former totaled 126 lb of 96.0% $BaSO_4$ at 4.38 sp gr and 95% reflectance. The latter totaled 120 lb of 94.0% $BaSO_4$ at 4.33 sp gr and 96.7% reflectance. Both were sent to the submitting company.

8) On October 3, 1966, the remaining products were packaged, as indicated below, and sent to the submitting company.

a) 155 lb of -20+100 mesh at 92.6% $BaSO_4$, 4.30 sp gr, and 88.6% reflectance. This was a mixture of the products from Tests 4A, 8, and 6A, (Table 14), together with any suitable products from the preliminary testing. About 25% of this material was -20+35 mesh in particle size.

b) 85 lb of -100 mesh at 94.0% $BaSO_4$, 4.44 sp gr, and 86% reflectance. This was a mixture of the products from Tests 1A, 7, and 3A, (Table 14), together with any similar material from preliminary testing.

c) 50 lb of -35 mesh grading approximately 83% $BaSO_4$. This was a mixture of the products from Tests 2A and 5A, (Table 14), and similar material from preliminary testing.

d) 420 lb of tailings, representing all of the combined tailings, (Table 14), but less 100 lb which was retained for fluorite flotation tests. This material graded 53.5% $BaSO_4$ and 29.8% CaF_2.

CONCLUSIONS

1) Approximately 43% of the barite content of the samples supplied was recovered by a single tabling operation and magnetic separation as a high grade product with good reflectivity. By tabling all -100 mesh feed and a mixture of the two samples, this recovery would probably be increased.

2) Approximately 64% of the barite content of the samples was shown to be recoverable by tabling, and retabling of middlings, at drilling mud or better grade (91% $BaSO_4$, 4.3 sp gr). The highest recovery at this grade was 68% from the mixed feed when the -100 and -35+100 mesh was tabled separately. Comparable recovery, 66%, was obtained from the B sample (Johnston vein) with a similar procedure. Recovery from the lower grade sample (MacMillan vein) was 64%.

3) Tabling alone was not sufficient to concentrate all the recoverable barite. Additional recovery could be obtained by flotation.

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RAW/lm