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EXPERIMENTAL WORK ON BARITE FROM YARROW TOWNSHIP, ONTARIO (PROJECT MP-IM-6815)

by

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Mineral Processing Division

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Mines Branch Investigation Report IR 70-51

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SUMMARY OF RESULTS

Barite of above 95% $BaSO_4$ grade may be mined from a Yarrow Township, Ontario, property, controlled by Extender Minerals of Canada Ltd. Markets exist for this grade of material in a finely ground state. Experimental work conducted by the Mineral Processing Division of the Mines Branch indicates that autogenous milling will reduce lump ore from this source to essentially all minus 10 mesh; vibration milling will further reduce the minus 10-mesh material to about 65% minus 10 µm; specific air classification methods will produce a product that is substantially all minus 10 µm.

Photometric sorting can be used to isolate the lighter-coloured portion of the ore. Sorting plus 3-mesh feed resulted in a product with a reflectance of above 95% that of magnesium carbonate. The minus 10-µm product from grinding and classification had a reflectance of 88%.

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INTRODUCTION

A barite deposit in Yarrow Township, northern Ontario, is of sufficiently high grade that acceptable products may be obtained by grinding and classification alone. Early in 1968, the Mineral Processing Division of the Mines Branch was asked by Extender Minerals of Canada Ltd., through Robert A. Hill, P.Eng., to participate in working out a satisfactory method for accomplishing this end. The project was accepted and during its progress through 1968 and 1969 Extender Minerals of Canada Ltd. was kept regularly informed of the experimental results obtained. Because prompt communication of results was desirable in order to advance development of this barite source and because a limited amount of material was available for experimentation, the results obtained are indicative rather than definitive.

MATERIAL

The materials provided for this study consisted of eleven boxes of split diamond-drill core and eight boxes of bulk ore. The core was combined to form a representative sample weighing 300 pounds. The bulk ore, essentially lump barite to 6-inch size, weighed 900 pounds.

The barite was white, bluish, pink, and buff in colour and it contained minor amounts of calcite and silicates. The bulk ore assayed 95.6% $BaSO_4$ with < 1.0% CaF_2. The core sample assayed 86.12% $BaSO_4$ and 0.10% CaF_2. It was assumed that a small amount of wall rock would be introduced during mining. A quantity of wall rock, picked from the core, assayed 13.0% $BaSO_4$ and 0.31% CaF_2.

EXPERIMENTAL WORK

Comminution

(a) Autogenous Milling

Because barite reduces in size very readily, it was decided to try autogenous grinding. The objective was not to obtain a final product but rather to provide a minus 20-mesh feed for fine grinding in a later step. The amount of material available did not allow full exploration of the method (known as ore pebble milling) but did allow indicative results to be obtained.

As a preliminary step, one half of the bulk sample was reduced to minus ½ inch. The remainder was sorted into lumps ranging in size from 4 inches to ½ inch. Plus 4-inch pieces were broken. For this experiment, material larger than ½ inch was considered to be grinding medium, and the minus ½-inch was considered to be feed.

Following preliminary trials to outline a general range of operation, a test run was performed. A 2-foot-diameter mill, 3 feet long, and lined with fused alumina brick, was used in the experiment. The mill revolved at 50 rpm, and its outlet consisted of a grating with ½-inch holes. Because the feed inlet was not large enough to accept 4-inch lumps, a fixed grinding-media charge had to be used to which the minus ½-inch feed was introduced. Most of the lump material and more than half of the minus ½-inch feed were consumed in this trial.

The lump charge was placed in the mill with an amount of feed calculated to fill the voids and provide immediate discharge. The run was conducted on a dry basis and the feed was introduced continuously from the start. The discharge was sampled every 10 minutes of the 40-minute run.

Table 1 indicates the lump charge to the mill at the start and at the end of the run. Table 2 gives the size distributions of feed and product for the various time intervals. Table 3 shows a material balance for the run.

TABLE 1

Grinding Charge

Size	Charge In		Charge Out	
	lb	%	lb	%
+3 inch	264	70.6	24.5	9.7
-3+2 "	45	12.0	150.5	59.7
-2+1 "	45	12.0	67.3	26.6
-1+½ "	20	5.4	10.0	4.0
Totals	374	100.0	252.3*	100.0

*122 lb of charge (32.6%) was reduced to minus ½ inch

TABLE 2

Mill Feed and Discharge

Size (Mesh)	Feed %	Discharge (%) after: 10 min	20 min	30 min	40 min
-½ in.+4	55.9			0.1	
-4+8	13.1	0.4	0.3	0.2	0.1
-8+10	4.0	0.5	0.4	0.3	0.2
-10+20	5.8	3.1	2.8	2.0	1.4
-20+48	7.6	17.9	16.3	14.8	14.0
-48+100	4.7	20.2	20.2	20.7	20.6
-100+200	3.3	18.3	18.9	20.6	20.4
-200+325	1.8	8.6	8.7	7.6	8.2
-325	3.8	31.0	32.4	33.7	35.1
Totals	100.0	100.0	100.0	100.0	100.0
% -20 mesh	21.3	96.0	96.5	97.4	98.3

TABLE 3

Material Balance

Factor	Wt (lb)
Weight of charge (+½ in.)	374.0
" " feed (-½ in.)	105.5
Mill content at start	479.5
Feed to mill (-½ in. for 40 min at approx 3 lb/min)	114.5
Total input to mill	594.0
Total discharged in 40 min	80.0
Approx weight in mill at end of run	514.0
Recovered on dumping mill	508.7
Loss	5.3

A number of observations may be made from the above tables:

Table 1 - The largest lump size, plus 3-inch, deteriorated rapidly to below 3 inches. Approximately 1/3 of the lump charge reduced to feed size, minus ½-inch, during the short duration of the run.

Table 2 - The desired result was reduction to minus 20 mesh. The mill discharge from the start was essentially all minus 20 mesh.

Table 3 - During 40 minutes of operation, 34.5 pounds less was discharged from the mill than was fed to it. Feed and discharge rates were, however, beginning to equalize.

It was inferred from these observations that coarse ore with minimum crushing, say to 8-inch, could be fed to a rotating mill shell to produce sufficient comminution under its own weight to provide a 14 to 20-mesh discharge. In an attempt to substantiate this and to produce sufficient feed for subsequent fine-grinding trials, the 508.7 pounds of charge, remaining from the first run, plus all remaining lump material were returned to the mill. The mill was then operated with an input of minus ½-inch feed at approximately 3 pounds per minute until all the feed was used and, for an additional 15 minutes, until the discharge rate had substantially tapered off. The entire discharge was similar in composition to that from the original trial, substantially all minus 20 mesh. The remaining mill content was nearly 90% minus ½ inch and 45% was minus 20 mesh.

These results strongly suggest that ore pebble grinding would be practical for this material.

(b) Fine Grinding

The end objective of fine grinding was to produce a minus 10-micrometer (μm) product. Comparison was made between a vibrating mill and a conventional rotating-shell mill for this purpose. The vibrating mill, a Humboldt Palla 20 U, was operated at three different feed rates. The rotating shell was the same machine as was used for autogenous grinding. It was operated at only one feed rate but with two different weights of grinding media.

The vibrating mill had plastic liners and was charged with 93 pounds of ½-inch Burundum cylpebs in each of the upper and lower sections. The operating settings used were selected to produce a maximum of minus 10-μm product, i.e., 1200 rpm at amplitude 2 off maximum. The mill was operated first for 1¼ hour at a feed rate of 25 pounds per hour, then for 45 minutes at 37.5 pounds per hour, and for 45 minutes at 50 pounds per hour. The feed was minus 20-mesh from autogenous milling. The products were sampled by riffling and the finenesses were determined by Coulter Counter. Results appear in Table 4.

The shell mill rotated at 50 rpm and was lined with fused alumina brick. The grinding medium was Burundum cylpebs and the feed was minus 20-mesh autogenous mill product. The first run was for 2¼ hours, with a feed rate of 50 lb per hour and using 285 lb of medium. The second run was for 2¼ hours, with a feed rate of 50 lb per hour and using 335 lb of medium. Samples of products were obtained by riffling and their finenesses were determined by Coulter Counter. These results also appear in Table 4.

TABLE 4

Fine Grinding
(Comparison of vibration and rotating-shell mills)

Particulars	Mill Type				
	Vibrating			Rotating	
	1	2	3	1	2
Weight of charge (lb)*	186	186	186	285	335
Speed (RMP)	1200	1200	1200	50	50
Amplitude	2 off max	2 off max	2 off max	-	-
Feed Rate (lb/hr)	25	37.5	50	50	50
Duration of run (min)	90	45	45	135	135
-10μm in product (%)	66	64	46	50	42

* Burundum ½-inch cylpebs used.

It was curious that a greater production of minus 10-μm product was obtained with the rotating mill when the lighter charge weight was used. The best overall efficiency of minus 10-μm production was derived from the vibrating mill while fed at 37.5 pounds per hour (Run No. 2). The weight of grinding media required for the vibrating mill was less than for the rotating mill and, after the start, the power requirement for the vibrating mill was comparatively low.

Classification

With a minus 10-μm product as objective, it was evident from the fine grinding trials that classification would be necessary. An Alpine Mikroplex Spiral Air Classifier, 132 MP, was employed for this purpose. It was required to provide a quantity of product for use in market exploration as well as to establish the validity of the classification method. Also, the quantity of feed available introduced a limiting factor. However, the general area for control settings was established and the equipment proved suitable for producing a minus 10-μm product.

All the finely ground products from the fine-grinding trials were combined and blended. A Coulter Counter analysis indicated a content of 45% minus 10-μm, with 94% minus 30-μm. The total feed, amounting to 260 pounds, was divided into two lots and each lot was classified using different settings for the quipment. The coarse products from these trials were recombined and re-run as a scavenging step. The coarse product derived in this step was again re-run as a second scavenging step. The Alpine classifier, like other classification devices, does not make absolute separations at a specific size. To ensure a minus 10-μm product, it was run at settings below maximum efficiency, thus necessitating the scavenging steps. In practice, such equipment would be run at more selective settings and with some recirculation.

A final trial was made in which all the fine products from the primary and scavenging runs were combined as feed. This removed only a small amount of "coarse" product, without a marked improvement in the "fine" product.

The coarse and fine products from each run were analyzed by Coulter Counter. Some checks were made by wet sieving, using a screen with 11-µm openings. The classification trials are summarized in Table 5.

TABLE 5

Classification Trials
(Alpine)

	Run Number				
	1	2	3	4	5
Feed Source	Fine grind	Fine grind	1+2 coarse	3 coarse	Combined 1-4 Fines
" Size (% -10-µm)	45	45	40	32	97
Feeder Setting	5.75	7.5	5.0	7.5	7.5
Feed Rate (lb/hr)	80	114	115	182	63
Vane Setting	20	30	30	30	15
% Coarse	86.4	75.9	90.0	92.1	7.6
% -10-µm in Coarse*	40	40	32	28	82
% Fine	13.6	24.1	10.0	7.9	92.4
% -10-µm in Fine*	97	98	96	97	98**
% Rec. - 10-µm	27.8	43.8	25.6	23.0	93.7

* Determined by Coulter Counter

** 100% passes an 11-µm sieve

Primary separation, as indicated by Run No. 2, is probably approaching optimum for the equipment used. Larger equipment, with two machines in series and with recirculation, would enhance recovery. While any of the fine products might be acceptable as minus 10-µm material, that from Run No. 5 was shown to be all 10-µm by means of a micro-sieve.

Photometric Sorting

The barite comprising this ore appears in shades of light brown, pink, purplish grey, and white. The minus 10-µm product, though bright at 87.7% in comparison with magnesium carbonate, would not satisfy all markets. Photometric sorting was applied to test the possibility of improving brightness by isolating the approximately 20% of white barite.

The initial step was to select by eye small groups of pieces from each of the shades present. For this purpose the light brown and the purplish grey materials, comprising more than half of the total, were taken as one group. The pink and white materials were taken as additional separate groups. Reflectance curves representing the light reflected from the surfaces of material in each group were prepared as indicated in Figure 1.

A 3/8-inch to 3-mesh fraction was employed as feed with sufficient testing (33 trials) to derive indicative results. Three methods of isolating the lighter shades were outlined. It was observed that a small amount of pink material associated with the white did not reduce the reflectance of the product but tended to improve it. An examination of Figure 1 shows that the darker shades should be readily separable from the white and the pink but, because the white and the pink curves approximately coincide, separation of these shades would be more difficult. They do show some divergence, however, in the yellow region of the spectrum.

By using a yellow filter to produce largely monochromatic light, it was possible to isolate most of the white pieces and some pink pieces by one pass through the sorting machine. Blue-sensitive photocells were used. It was also found possible to isolate the white material in one pass, with the inclusion of some dark shades, by using blue-sensitive photocells and no filter. The dark shades could be removed, to leave a practically all-white product, by a second pass through the equipment.

The third method employed red-sensitive photocells, again with no filter. This produced a better general separation of dark from light in one pass than the second method but some dark pieces reported with the light. A second pass removed these dark pieces but retained a good deal of the pink material. A higher overall recovery resulted with slightly better brightness. A summary of this work is given in Table 6.

TABLE 6

Photometric Sorting

	Run Number				
	10	3	3A	20	20A
Feed Size	-3/8+3m	-3/8+3m	-3/8+3m	-3/8+3m	-3/8+3m
" Used	new	new	3 rej	new	20 rej
" Brightness (%)	87.7	87.7	-	87.7	-
Background	2	3	3	2	2
Filter	yellow	-	-	-	-
Rejected	light	light	dark	light	dark
Sensitivity	6.5	6.5	6.5	4.5	6.5
Photo Tube	blue	blue	blue	red	red
Air (psi)	30	30	30	30	30
% Rejected	22	50	28	43	9
Brightness (%)	95.7	-	-	-	-
Appearance	some pink	some dark	dark	some dark	dark
% Accepted	78	50	22	57	32
Brightness	-	-	95.7	-	96.7
Appearance	dark	dark	white	dark	some pink

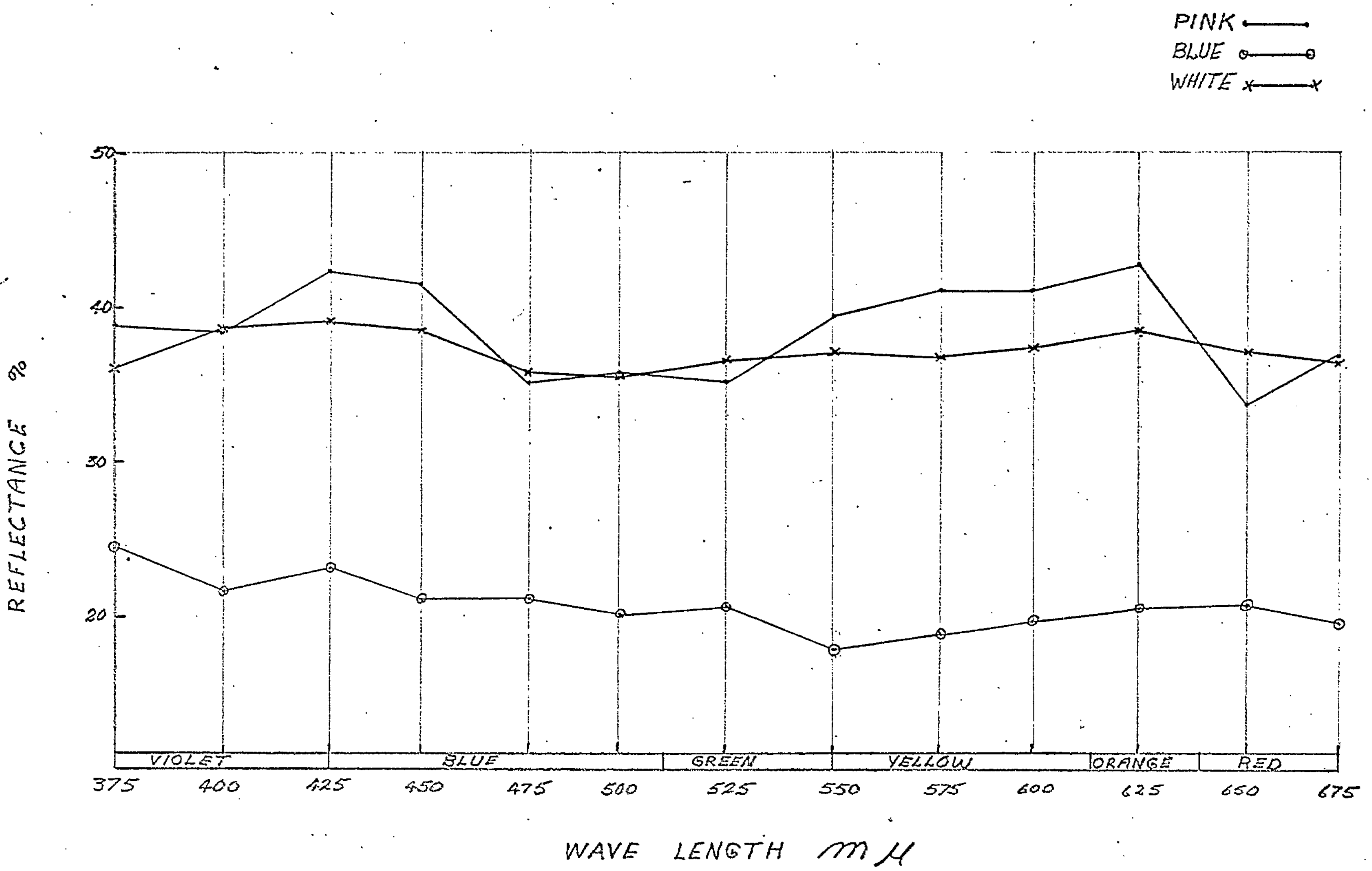
PINK
BLUE
WHITE
REFLECTANCE %
50
40
30
20
VIOLET
BLUE
GREEN
YELLOW
ORANGE
RED
375
400
425
450
475
500
525
550
575
600
625
650
675
WAVE LENGTH mμ

FIGURE 1

SUMMARY

The results of this investigation may be summarized as follows:

(1) Autogenous grinding trials indicate that it should be possible to achieve comminution to minus 14 mesh with this material simply by causing the mined ore to grind itself in a rotating cylindrical mill.

(2) Fine-grinding trials suggest that vibration milling would be more efficient than rotating-shell milling for the production of a minus 10-μm product.

(3) A product that is practically all minus 10 μm may be obtained by using specific air-classification methods to classify the finely ground ore.

(4) Photometric sorting of the 3/8-inch to 3-mesh fraction develops products with reflectance of approximately 96% of that for magnesium carbonate, the reflectance of the feed being close to 88%.

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