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BENEFICIATION TESTS ON VERMICULITE FROM THE SUDBURY AREA, ONTARIO (PROJECT MP-IM-6103)

by

R. A. WYMAN

MINERAL PROCESSING DIVISION

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ADDENDUM

The location of the deposit was stated to be
Township 107 and 108
District of Sudbury, Ontario.

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SUMMARY OF RESULTS

Beneficiation tests on a bulk sample of vermiculite-bearing material from the Sudbury area, Ontario, were not successful in developing a satisfactory processing method. The sample was very low in grade, containing about 16% vermiculite, and was comparatively fine in particle size, more than 20% being -48 mesh. The vermiculite did not delaminate readily, and broke down rapidly to fines during handling.

Bench scale agglomeration tests produced the best results, but pilot plant scale operations by this method were unsuccessful. Both magnetic and electrostatic separation showed some promise. Gravity methods also produced partial upgrading.

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INTRODUCTION

Early in 1961, a request was received by the Chief of the Mineral Processing Division, from Messrs. Kaye, Bjarnason and Copeland of Toronto, Ont., that beneficiation trials be made on a sample of vermiculite-bearing material originating near Sudbury, Ont. It was suggested that plaster grade, ie, 4 mesh to about 35 mesh with less than 15% impurity, would be the easiest product to obtain, and would probably be the most profitable. A shipment, in bags, of material considered to be representative of the deposit was received on Feb. 15, 1961. A brief indication of progress was made by letter on June 20, 1961.

DESCRIPTION OF SAMPLE

The sample consisted of rotten granite, sandy clay and vermiculite, the bulk being rather fine, 78% minus 10 mesh and 21% minus 48 mesh. The vermiculite content was determined at 15.7%. The total weight of sample received was about 1200 pounds.

ANALYSES

Accurate determination of vermiculite present in a sample is difficult. A method devised by Mr. H. S. Wilson of the Construction Materials Section was used throughout the investigation.

The method consists of exfoliating the vermiculite contained in 50 to 100 grams of material riffled from the sample being evaluated. The vermiculite is then carefully separated from the rock portion by blowing it off into a separate container. The vermiculite portion and the rock portion are weighed, and the percent of vermiculite calculated.

Mr. H. S. Wilson and three technicians, Messrs. J. H. Colborne, F. E. Noccey and S. T. Lepage were responsible for all the determinations made.

TEST WORK

Preliminary

A quick assessment of possible procedures was attempted using one bag of the sample as feed. Unfortunately, the bag, although a random selection, turned out to be much higher than the average in vermiculite content (about 45%). Results of the quick tests were more encouraging than those of later tests with composites of the whole sample used as feed.

Table 1 shows the vermiculite content of screen fractions from the original one-bag lot.

TABLE 1

Vermiculite in Random Bag of Sample

Fraction	Weight %	Verm %
-¼ in. +8 mesh	8.6	82
-8 +10 mesh	6.8	83
-10 +14 "	7.5	79
-14 +20 "	9.3	61
-20 +28 "	11.9	43
-28 +35 "	12.4	49
-35 mesh	43.5	21
	100.0	44.7

A pebble mill grind of the $-\frac{1}{4}$ in. +8 mesh fraction using 5 pounds of pebbles for 15 minutes produced the fractions shown in Table 2.

TABLE 2

Results of Pebble Mill Grind

Fraction	Weight %	Verm %
+4 mesh	0.31	79.5
-4 +6 "	1.23	96.0
-6 +8 "	2.76	96.0
-8 +10 "	1.53	91.0
-10+14 "	0.62	89.5
-14+20 "	0.31	84.0
-20 mesh	1.84	43.0
($-\frac{1}{4}$ in. +8 mesh)	8.60	82.0

Plus 20 mesh material produced in the above grind contained 93% vermiculite, representing 14% of the vermiculite in the one-bag lot. If the -8 +10 and -10 +14 mesh fractions, Table 1, were combined with the +20 mesh fractions, Table 2, a product containing 85% vermiculite, representing 40% of the vermiculite in the one-bag lot, would be developed.

The -35 mesh fraction, Table 1, was further separated by wet screening into -35+48, -48+100, and -100 mesh fractions. Some of the -48+100 mesh material was used for a Jones Wet Magnetic Separator test. The magnetic fraction at 15 amp was virtually all vermiculite. The results are given in Table 3.

TABLE 3

Jones Separator Test on -48+100 Mesh Fraction

Fraction	Weight %	Verm %
Mags	64.6	100.0
Non-mags	35.4	3.1

A recovery of 28% of the vermiculite in the one-bag lot is represented.

Very poor separation was obtained with the Whippet Air-table on the -8+10 and -10+14 mesh fractions, Table 1.

Jones Separator Tests

As it had now become apparent that the one-bag lot was comparatively higher in grade than the entire sample, further testing of this lot was abandoned and a second lot was secured by removing a good-sized scoopful from each bag of the entire sample. After hammer mill preparation, this lot contained only 3% of +20 mesh particles.

Three Jones Separator tests were made on material from the composite lot as follows:

1. Direct magnetic fractionation at 1, 2, 3, 5 and 10 amp.
2. Ground for 15 min in a pebble mill. Magnetic separation at 25 amp and one cleaning step at 10 amp.
3. Direct separation at 25 amp. Magnetics cleaned at 15 amp. Magnetics from this cleaned at 10 amp, and magnetics from the 10 amp run cleaned at 5 amp.

The results of these tests are given in Table 4.

TABLE 4

Magnetic Separations on Lot No. 2 (composite)

Test No.	Fraction	Weight %	Verm %	Distn %
1	Non-mags	32.8	6.3	13.1
	Mags - 0 amp	7.8	12.0	5.6
	" - 1 "	7.1	16.0	6.8
	" - 2 "	6.2	13.0	5.0
	" - 3 "	9.6	13.0	7.5
	" - 5 "	18.8	25.3	30.1
	" -10 "	17.7	28.7	31.9
	Calculated Heads	100.0	100.0	100.0
2	Non-mags - 25 amp	55.5	1.9	6.1
	Mags - 10 amp	33.7	35.6	69.1
	Non-mags - 10 amp	10.8	40.0	24.8
	Calculated Heads	100.0	17.4	100.0
3	Non-mags - 25 amp	49.1	1.4	4.3
	Mags - 15 amp	9.1	36.5	21.0
	" - 10 "	8.7	57.0	31.3
	" - 5 "	11.4	9.0	6.5
	Non-mags - 5 amp	21.7	26.9	36.9
	Calculated Heads	100.0	15.8	100.0

The above lot had been prepared as essentially all -20 mesh in order to provide feed for Jones Separator tests. As plaster grade specifications include material coarser than 20 mesh, some action was required to secure +20 mesh vermiculite. A comparison was made of three types of grinding: rod mill, pebble mill and rolls crusher on +20 mesh feed.

Grinding Tests

Feed for these trials was secured by making up a 100 lb composite lot by removing equal amounts from each bag of the original sample with the exception of one bag (composed chiefly of rock fragments containing little or no vermiculite). This 100 lb lot was separated into fractions as shown in Table 5.

TABLE 5

Screen Fractions of 100 Pound Composite

Fraction	Wt %	Verm %	Distn %
+½ inch	2.8	1.0	0.3
-½ +20 mesh	36.4	26.0	59.7
-20 mesh	60.8	10.4	40.0
Calculated Heads	100.0	15.8	100.0

The -½ +20 mesh fraction was riffled into 8 portions in order to provide amounts of suitable size for the grinding trials. The comparative grinds were made as follows:

1. 1 lot dry ground in a pebble mill with 5 pounds of pebbles for 15 min.
2. 1 lot dry ground in a rod mill with 10 pounds of ¼ inch rods for 5 min.
3. 1 lot passed through a rolls crusher with rolls set at 1/32 inch clearance.

The results of these trials are given in Table 6.

TABLE 6

Results of Grinding Tests

Test No.	Fraction	Wt %	Verm %	Distn %
1	+3/8 inch	0.2	0	0
	-3/8 +4 mesh	3.2	14.1	1.7
	-4 +8 mesh	5.5	20.5	4.3
	-8 +14 "	13.4	28.8	14.6
	-14 +28 "	33.1	28.0	35.0
	-28 +48 "	21.8	33.2	27.5
	-48 mesh	22.8	19.7	16.9
	Calculated Heads	100.0	26.5	100.0
2	+3/8 inch	0	0	0
	-3/8 +4 mesh	1.3	10.0	0.5
	-4 +8 mesh	5.8	21.6	4.6
	-8 +14 "	18.9	30.4	21.2
	-14 +28 "	40.6	27.0	40.6
	-28 +48 "	16.5	31.2	19.0
	-48 mesh	16.9	22.6	14.1
	Calculated Heads	100.0	27.0	100.0
3	+3/8 inch	0	0	0
	-3/8 +4 mesh	0.3	100.0	1.1
	-4 +8 mesh	2.7	61.0	6.2
	-8 +14 "	34.7	32.4	41.8
	-14 +28 "	42.9	22.8	36.4
	-28 +48 "	10.4	22.1	8.6
	-48 mesh	9.0	17.7	5.9
	Calculated Heads	100.0	26.8	100.0

Agglomeration Tests

A number of small scale agglomeration tests were tried using laboratory equipment and skimming the float with a wire cloth. The fraction used for these tests was -8+10 mesh except for the final trial which was -8+48 mesh. In this final test a cleaning step was also used. In each test the feed was barely dampened with water and the reagents were mixed in by hand. To effect separation, the conditioned material was placed in a pan of water.

The reagents used in these tests are listed below:

1. Armac T, kerosene.
2. H_2SO_4, Armac T, kerosene.
3. HF, Armac T.
4. HF, Coco Amine Acetate.
5. H_2SO_4, Armac T.

Results obtained are given in Table 7.

TABLE 7

Results of Bench Scale Agglomeration Tests

Test No.	Fraction	Wt %	Verm %	Distn. %
1	No separation			
2	No separation			
3	Conc	10.0	90.0	32.0
	Tails	90.0	21.1	68.0
		100.0	28.0	100.0
4	Conc	15.0	82.0	43.5
	Tails	85.0	18.8	56.5
		100.0	28.3	100.0
5	Conc	9.1	90.0	61.2
	Midds	9.1	49.2	33.3
	Tails	81.8	.9	5.5
		100.0	13.4	100.0

It was noted that the material did not float readily in any test. If the pan was tilted so that most of the sample was exposed to air, and then gently lowered so the water gradually again covered it, a good deal of vermiculite would float on the water surface and could be recovered. Similarly, if some treated sample was placed on a screen cloth and gently lowered into the water, some vermiculite would float. There were no strong indications of successful separation by agglomeration as a practical step.

Flotation Tests

While there was some indication that flotation might be effective, slimes were created by attrition in the flotation cell at such a rate that good results were not obtained. Desliming is important for success in the amine flotation system. An indication of the amount of new fines created in various tests is given in Table 8. In each test the feed was not only a sized fraction, but was also deslimed prior to beginning the test.

TABLE 8

Creation of Fines During Flotation Tests

Test No.	Feed Size (mesh)	-48 mesh in conc (% of feed)
3	-8+10	6.0
4	-8+10	6.3
5	-10+14	3.9
6	-14+20	6.2
7	-20+28	2.8

Seven flotation tests were made, as described below. In each case the feed was deslimed prior to conditioning with reagents. In tests 3-7, HF was added prior to desliming. In all tests new fines, created by attrition in the flotation cell, appeared immediately on the froth, quickly depleting the reagents and interfering with the flotation of coarser particles. In tests 3-7 the concentrate was screened on 48 mesh. The -48 mesh portion could not be satisfactorily assessed for vermiculite content, although under the microscope it appeared to be largely rock fragments with possibly 10% vermiculite present.

1. Feed: -20 mesh. Reagents: H_2SO_4, $Al_2(SO_4)_3$, Armac T, fuel oil, pine oil.
2. Feed: -8 mesh. Reagents: H_2SO_4, Armac T, pine oil.
3. Feed: -8+10 mesh. Reagents: HF, Armac T, pine oil.
4. Feed: -8+10 mesh. Reagents: HF, Coco Amine Acetate, pine oil.
5. Feed: -10+14 mesh. Reagents: HF, Coco Amine Acetate, pine oil. (Rougher plus 1 cleaning step).
6. Feed: -14+20 mesh. Reagents: HF, Coco Amine Acetate, pine oil. (Rougher plus 1 cleaning step).
7. Feed: -20+28 mesh. Reagents: HF, Coco Amine Acetate, pine oil. (Rougher plus 1 cleaning step).

The results of these tests are given in Table 9.

TABLE 9

Results of Flotation Tests

Test No.	Product	Wt %	Verm %
1	Slimes	7.8	-
	Conc	7.1	47.0
	Tails	85.1	8.6

TABLE 9 (cont'd)

Results of Flotation Tests

Test No.	Product	Wt %	Verm %
2	Slimes	25.6	-
	Conc	21.7	36.0
	Tails	52.7	13.4
3	Slimes	0.7	-
	Conc +48	0.7	77.5
	" -48	6.0	-
	Tails	92.6	19.4
4	Slimes	2.8	-
	Conc +48	0.5	91.0
	Conc -48	6.3	-
	Tails	90.4	19.2
5	Slimes	0.8	-
	Conc +48	0.8	82.5
	" -48	3.9	-
	Cleaner tails	7.6	44.2
	Rougher "	86.9	12.3
6	Slimes	0.4	-
	Conc +48	0.3	47.0
	" -48	6.2	-
	Cleaner tails	9.6	25.8
	Rougher "	83.5	9.5
7	Slimes	0.7	-
	Conc +48	0.1	33.4
	" -48	2.8	-
	Cleaner tails	1.9	20.5
	Rougher "	94.5	11.0

Electrostatic Separation

Laboratory results achieved with electrostatic separation were somewhat more promising than flotation in that recoveries were higher. For this work fractions from the bulk lot prepared for pilot plant scale testing were used.

The bulk lot consisted of the entire sample with the exception of approximately 250 pounds removed for earlier testing (ie the original 1-bag lot and the batch test composites). Screen fractions were made as indicated in Table 10.

TABLE 10

Screen Fractions of Bulk Lot

Fraction	Wt %	Verm %	Distn %
+1/2 inch	3.6	nil	-
-1/2 in. +10 mesh	18.4	22.7	26.7
-10 +48 mesh	56.8	17.1	61.8
-48 "	21.2	8.4	11.5
Calculated Heads	100.0	15.7	100.0

The +1/2 inch oversize contained practically no vermiculite. The -1/2 inch +10 mesh was passed through a rolls crusher with the results shown in Table 11.

TABLE 11

Products from Rolls Crushing

Fraction	Wt %	% of Lot	Verm %	Distn (% of Lot)
+3/8 inch	.2	.1	100.0	.2
-3/8 +4 mesh	1.8	.3	64.0	1.4
-4 +8 "	35.0	6.4	31.6	13.2
-8 +10 "	14.2	2.6	28.3	4.7
-10+48 "	41.0	7.6	12.9	6.2
-48 "	7.8	1.4	11.9	1.0
Calc Heads	100.0	18.4	22.7	26.7

Some of the -3/8 +4 mesh fraction, Table 11, was given a second pass through the rolls. Results as set forth in Table 12 were obtained.

TABLE 12

Results of Further Rolls Crushing

Fraction	Wt %	% of Lot	Verm %	Distn (% of Lot)
+4 mesh	26.7	0.08	99.2	0.6
-4+8 "	25.3	0.08	87.6	0.5
-8+10 "	7.2	0.02	55.8	0.1
-10+48 "	30.3	0.09	30.3	0.2
-48 "	10.5	0.03	14.1	0.0
Calc Heads	100.0	0.30	63.4	1.4

The -10+48 mesh material, Tables 10 and 11, was combined and screened into further fractions as indicated in Table 13.

TABLE 13

Screen Fractions of -10+48 Mesh Material

Fraction	Wt (% of Lot)	Verm %	Distn (% of Lot)
-10+14 mesh	11.5	24.3	18.9
-14+20 "	14.4	19.4	18.9
-20+28 "	12.2	13.0	10.8
-28+48 "	26.3	11.0	19.4
Calc Heads	64.4	15.5	68.0

The first group of electrostatic separation tests was exploratory in nature, and consisted of making a series of cuts at various voltages on sized fractions of feed. The nature of the material suggested that negative polarity would be the most likely to succeed and this was used for the first series. Work was done on a Coronatron machine.

Results obtained from this series of tests are presented in Table 14, the best recovery and grade being obtained on -20+28 mesh material.

TABLE 14

Exploratory Tests with Electrostatic Separator

Fraction	Voltage	Wt (% of lot)	Verm %	Distribution %	Distribution (% of lot)
-8 +10 mesh	20000	.83	48.5	54.1	2.6
	25000	.86	28.2	32.4	1.5
	Tails	.91	11.1	13.5	.6
Calculated Heads		2.60	28.7	100.0	4.7
-10+14 mesh	15000	2.2	47.1	33.9	6.4
	20000	3.9	32.9	42.7	8.1
	Tails	5.4	13.0	23.4	4.4
Calculated Heads		11.5	26.3	100.0	18.9
-14 +20 mesh	12000	1.5	61.0	27.8	5.3
	15000	2.1	46.8	30.9	5.8
	20000	4.3	20.4	27.8	5.3
	Tails	6.5	6.7	13.5	2.5
Calculated Heads		14.4	22.3	100.0	18.9
-20 +28 mesh	12000	1.3	61.2	37.2	4.0
	15000	1.9	38.5	35.4	3.8
	20000	3.7	10.8	18.6	2.0
	Tails	5.3	3.5	8.8	1.0
Calculated Heads		12.2	17.2	100.0	10.8
-28 +48 mesh	12000	4.5	43.6	47.3	9.2
	15000	5.8	22.2	31.4	6.1
	20000	7.3	6.8	11.5	2.2
	Tails	8.7	4.6	9.8	1.9
Calculated Heads		26.3	15.6	100.0	19.4

The tests recorded in Table 14 suggested that cleaning stages might bring up the grade to a desirable level. Accordingly, a second series of tests was run, employing multiple stage operation, and using the -20+28 mesh size fraction. A description of the tests is given below:

1: Feed was passed over the machine 3 times at 20,000 volts. Concentrate was cleaned by 3 passes at 12,000 volts. Negative polarity.

2: Feed was passed over the machine 3 times at 12,000 volts. Concentrate was cleaned once at 12,000 volts. Negative polarity.

3: Similar to 2 with the exception that polarity was positive.

Results of the second series tests are given in Table 15. Even with the multiple stage testing, the results are not indicative of a suitable process.

TABLE 15

Second Series of Electrostatic Separator Tests

Test No.	Fraction	Wt (% of lot)	Verm %	Distribution %	Distribution (% of lot)
1	Conc 12000 volts	2.8	41.0	59.0	6.4
	Tails " "	7.6	9.5	37.2	4.0
	Tails 20000 "	1.8	4.1	3.8	0.4
	Calc Heads	12.2	16.0	100.0	10.8
2	Concentrate	0.7	76.7	26.3	2.8
	Cleaner Tails	2.1	46.6	48.5	5.3
	Rougher "	9.4	5.4	25.2	2.7
	Calc Heads	12.2	16.6	100.0	10.8
3	Concentrate	0.5	86.0	21.0	2.3
	Cleaner Tails	1.4	61.0	40.6	4.4
	Rougher "	10.3	7.8	38.4	4.1
	Calc Heads	12.2	17.2	100.0	10.8

Pilot Plant Scale Testing

On a pilot plant scale a variety of gravity methods was tried without notable success. Jigging failed to effect a satisfactory separation on -3/8 +4 mesh. Humphrey Spiral trials using -8 +10 mesh and -10 +14 mesh fractions also failed to produce much concentration.

1) Wet Tabling

Wet tabling of fractions above 14 mesh in size did not yield separations worth sampling on either the diagonal or regular decks. Wet tabling on the regular deck of -14 mesh fractions gave evidence of some separation. Results are given in Table 16.

TABLE 16

Results from Wet Tabling

(All tests at 10° slope, medium wash water & shaking speed)

Test No.	Deck Type	Fraction	Wt (% of lot)	Verm %	Distribution (%)	Distribution (% of lot)
1 (-28+48 mesh)	Regular	Light	4.0	58.9	54.1	10.5
		Midds	16.4	11.3	43.0	8.3
		Heavy	5.9	2.1	2.9	0.6
		Calc Heads	26.3	16.5	100.0	19.4
2 (-20+28 mesh)	Regular	Light	1.5	58.2	40.8	4.4
		Midds	8.2	14.3	53.6	5.8
		Heavy	2.5	4.7	5.6	0.6
		Calc Heads	12.2	17.9	100.0	10.8
3 (-14+20 mesh)	Regular	Light	1.1	56.1	19.1	3.6
		Midds	9.6	24.9	73.8	14.0
		Heavy	3.7	6.2	7.1	1.3
		Calc Heads	14.4	22.5	100.0	18.9
4 (-10+14 mesh)	Regular	Insufficient conc to sample				
5 (-10+14 mesh)	Diagonal	Insufficient conc to sample				
6 (-4+8 mesh)	Diagonal	Insufficient conc to sample				

2) Agglomeration

Agglomeration trials were made on -10 +14 mesh and -14 +20 mesh fractions. The system consisted of a dry ore feeder, and a reagent feeder (Amine), discharging into a mixer operating at 75% solids. The mixer discharged to a Holman Flotation Table. Very little flotation was secured and no selective separation. Typical of the tests is that recorded in Table 17.

TABLE 17

Typical Agglomeration Results

Fraction	Verm (%)
Light	17.2
Midds	36.7
Heavy	16.5

3) Air Tabling

Of the pilot plant scale tests, air tabling proved the most effective, but efficiency dropped rapidly with finer mesh sizes. While a fair concentrate was obtained with -3/8 +4 mesh feed with one pass over the table, the next size, -4 +8 mesh, required multiple steps and recovery was poor. Satisfactory concentration was not obtained on the -8 +10 mesh fraction.

These effects were due partly to the feed size and partly to the feed grade. The -3/8 +4 mesh was both comparatively coarse in size and contained well over 60% vermiculite to begin with. On the other hand, the succeeding sizes were smaller, -4 +8 mesh and -8 +10 mesh, and contained considerably less vermiculite, 32% and 28% respectively.

Typical tests for the three sizes of feed are described below:

1. -3/8 +4 mesh: 1 pass over air table. Three products collected.

2. -4 +8 mesh: 6 tabling steps, each producing 4 products -

   (a) Roughing step - product 2 used as feed to,

   (b) 1st cleaning step - products 2 and 3 used as feed to,

   (c) 2nd cleaning step - product 2 used as feed to,

   (d) 3rd cleaning step - very little separation secured,

   (e) 4th cleaning step - feed, product 3 from rougher plus product 3 from 2nd cleaner - product 3 from this step used as feed to,

   (f) 5th cleaning step.

3. -8 +10 mesh: 4 tabling steps, each producing 4 products.

   (a) Roughing step - product 3, used as feed to,

   (b) 1st cleaning step - product 3 used as feed to,

   (c) 2nd cleaning step - product 3 and 4 used as feed to,

   (d) 3rd cleaning step.

In Table 18 the results of these tests are presented.

TABLE 18

Results of Air Tabling Tests

Test No.	Fraction	Wt (% of lot)	Verm %
1 (-3/8+4 mesh)	Conc	0.08	86.7
	Midds	0.15	70.8
	Tails	0.07	37.4
2 (-4+8 mesh)	4-5th Cl	0.02	67.2
	3 "	0.08	89.2
	2 "	0.30	59.3
	1 "	0.10	67.3
3 (-8+10 mesh)	4-3rd Cl	0.02	61.2
	3 "	0.17	74.8
	2 "	0.34	64.3
	1 "	0.05	55.3

REMARKS

The sample submitted has the advantage that very little comminution is required. The coarsest fraction, +½ inch, is also sufficiently low in vermiculite (about 3.5% by weight) that it may be discarded. These advantages are, however, offset by the fact that the material contains over 20% of fines (-48 mesh) and is very low grade.

There is a second unfavourable factor. The vermiculite in the sample is not well delaminated and it does not delaminate readily on further comminution. This greatly reduces the possible effectiveness of gravity methods of working, which are enhanced by thin, flat flakes. The results obtained from such operations as dry or wet tabling, Humphrey Spirals, and jigging, confirm this.

The fortuitous selection of the one high grade bag in the sample for some preliminary testing provided a contrast between what may be accomplished with high grade feed as opposed to low grade. This bag contained 44.7% vermiculite, almost high grade. (Deposits are roughly classified as above 45% vermiculite, high; 25 to 45%, average; and less than 25%, low). Some of the coarser fractions in this bag were already almost up to grade, and a little grinding produced material of good quality. Moreover, fines from this bag reacted very favourably to magnetic separation.

In contrast the composite, containing about 16% vermiculite, did not react favourably to magnetic separation or to grinding, although a small amount of vermiculite was secured by rolls crushing and screening.

Another unfavourable physical aspect of the vermiculite in this sample and one probably related to the failure to delaminate easily was its brittleness or tendency to reduce easily to fines during handling. This factor worked strongly against flotation where "slimes" were produced so quickly that "clean" floats could not be effected. It also worked against agglomeration for the same reason. When done by hand in bench scale operation, "agglomeration" methods had some effect. In such handling fines were not produced at a quick rate, and material which had become delaminated to any degree of flatness could be manoeuvred into floating on water. In the bulk agglomeration tests, fines obscured the separation just as they had in flotation, despite utilization of well-sized feeds.

Electrostatic separation showed some promise of producing satisfactory grade although recovery was not particularly high. This method might be developed.

CONCLUSIONS

1. The sample was too low in vermiculite content to be competitive, unless a very simple recovery process could be developed.

2. The vermiculite in the sample does not delaminate readily, and at the same time tends to break up into fines easily under abrasive action. Both factors increase the difficulties of beneficiation.

3. If sections of the deposit which are high grade (45% or better) could be mined selectively, good products at reasonable recovery appear to be readily obtainable.

4. No single beneficiation method was effective in producing a satisfactory recovery and grade of vermiculite from the sample submitted. Some concentration was obtained by most methods tried.

RAW:EBM