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MINES BRANCH INVESTIGATION REPORT IR 61-39

INVESTIGATION OF VERMICULITE-BEARING SAMPLES FROM OLYMPUS MINES LIMITED, STANLEYVILLE, ONTARIO

by

H. S. WILSON

MINERAL PROCESSING DIVISION

NOTE: THIS REPORT RELATES ESSENTIALLY TO THE SAMPLES AS RECEIVED. THE REPORT AND ANY CORRESPONDENCE CONNECTED THEREWITH SHALL NOT BE USED IN FULL OR IN PART AS PUBLICITY OR ADVERTISING MATTER.

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SUMMARY OF RESULTS

Thirty samples of split diamond drill core, and two other samples reported to be from the surface of the pit on the company's property near Stanleyville, contained an average of approximately 25 per cent vermiculite. Another sample reported to be cuttings from several auger holes drilled in the floor of the pit contained approximately 12 per cent vermiculite. In nearly all the samples, over 65 per cent of the vermiculite flake was recovered from the minus 14 plus 48 mesh fractions. The exfoliated vermiculite obtained from these samples, when graded for use in gypsum plaster, did not meet ASTM specifications for unit weight. However, unit weight of a separate sample from the company's stockpile when exfoliated in moist condition was within the specification. Some exploratory work was attempted on possible approaches to beneficiation.

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INTRODUCTION

Mr. J. H. Kenny, President of Olympus Mines Limited, requested the Mines Branch to investigate samples of vermiculite-bearing material to establish the percentage of vermiculite contained and its particle size distribution. Mr. Kenny stated that the samples had been taken from the Company's property located in the north half of Lot 17, Range 8, Township of North Burgess, Lanark County, Ontario.

On January 11, 1961, thirty samples of splittings from BXT diamond drill core were received. These samples were stated to be from a single diamond drill hole collared immediately east of a pit opened on the property. The bearing of the hole was approximately N W at an angle of inclination of 45°, normal to the long axis of the open pit. The sampled section was between 127' and 400' true length. These samples were designated 0-12 to 0-41 inclusive.

On the same date a sample of minus 2 inch material weighing 150 pounds and reported to be a composite of material from several auger holes from the pit floor was also received. For this investigation, three portions were cut out at the Mines Branch and identified in this report as Auger 1, Auger 2 and Auger 3.

Two samples weighing about 15 pounds each were reported to have been taken from the surface of the pit. The material was minus 3/4 inch in size. These were identified as Pit 1 and Pit 2, and were received in early March 1961.

SCOPE AND PURPOSE OF THE INVESTIGATION

It was the object of the investigation to determine the percentage vermiculite and size distribution in each sample, and the proportion of vermiculite suitable for its more important uses. Other factors investigated were bulk density of the exfoliated product, and the effect of firing temperature on exfoliation. The principal mineral constituents were determined and several methods of beneficiating the raw material were explored.

PREPARATION OF SAMPLES

All diamond drill core samples were reduced to minus 1/2 inch by a jaw crusher, and further reduced to minus 1/4 inch by a double roll crusher. The products were separated into the following size fractions by a vibratory screen: +8 mesh, -8+14 mesh, -14+28 mesh, -28+48 mesh, -48+100 mesh, and -100 mesh. The proportion of material in each size fraction was determined, and is shown in Table 1.

The auger sample, which weighed about 150 pounds, was repeatedly mixed and quartered to obtain three five pound samples. The first and second (Auger 1 and Auger 2) were passed once through the jaw crusher and once through the double roll crusher, which reduced the material to minus 1/4 inch in size. The third sample (Auger 3) was passed repeatedly through the jaw crusher until it was minus 1/4 inch in size. The three samples were separated into the above mentioned size fractions, and the proportion of each determined as shown in Table 1.

About 5 pounds of material were cut from each of the two samples taken from the surface of the pit (Pit 1 and Pit 2). They were reduced to minus 1/4 inch by one pass through the jaw crusher and were separated into size fractions as shown in Table 1.

A representative part of all size fractions except the minus 100 mesh was obtained by riffling. These were used for exfoliation. Little vermiculite was visually identifiable in the minus 100 mesh fractions.

EXFOLIATION AND CONCENTRATION

The riffled portion of each fraction was exfoliated in an electrically heated tube furnace. A 2 inch diameter stainless steel tube, extending through the furnace, was vibrated to cause the material to pass through the furnace with about a 25 second retention time, allowing about 10 seconds in the hot zone. The maximum temperature of the tube was maintained between 1925 and 1975°F.

The exfoliated vermiculite was removed from the non-exfoliated material in each fraction by air separation. Weight percentages of vermiculite in each fraction and in each sample were calculated. Results are shown in Table 1.

Further evaluation was undertaken on core samples that contained at least 20 per cent vermiculite, on the three auger samples, and the two pit samples. The percentages by weight of exfoliated vermiculite coarse enough to meet size requirements for insulation grade were determined. The concentrated exfoliated vermiculite was separated into plus 10 and minus 10 mesh fractions by hand screening. The coarser fraction might be considered insulation grade. The results are shown in Table 1.

TABLE 1

Evaluation of Vermiculite

Sample No. and Depth (ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-12	+8	10.8	1	0.1	
	-8+14	30.7	2	0.6	
	-14+28	28.7	11	3.2	
127-140	-28+48	14.2	18	2.5	
	-48+100	6.9	12	0.8	
	-100	8.7			
	Total	100.0		7.2	-
0-13	+8	8.5	1	0.1	
	-8+14	25.4	4	1.0	
	-14+28	33.8	14	4.7	
140-150	-28+48	17.8	20	3.6	
	-48+100	8.4	23	1.9	
	-100	6.1			
	Total	100.0		11.3	-
0-14	+8	9.6	10	0.1	
	-8+14	25.1	6	1.5	
	-14+28	33.2	25	8.4	
150-160	-28+48	16.9	45	7.6	
	-48+100	7.3	38	2.8	
	-100	7.7			
	Total	100.0		20.4	7
0-15	+8	3.5	5	0.2	
	-8+14	22.3	38	8.5	
	-14+28	30.2	34	10.3	
160-170	-28+48	20.2	46	9.3	
	-48+100	10.7	39	4.2	
	-100	13.1			
	Total	100.0		32.5	11

TABLE 1 (cont'd)

Evaluation of Vermiculite

Sample No. and Depth (ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-16	+8	8.7	15	1.3	
	-8+14	26.4	8	2.1	
	-14+28	31.2	8	2.5	
170-	-28+48	16.5	15	2.5	
173½	-48+100	7.7	15	1.2	
	-100	9.5			
	Total	100.0		9.6	-
0-17	+8	6.3	10	0.6	
	-8+14	25.9	21	5.4	
	-14+28	36.7	43	15.8	
173½-	-28+48	18.0	44	7.9	
180	-48+100	6.5	36	2.3	
	-100	6.6			
	Total	100.0		32.0	7
0-18	+8	3.8	9	0.3	
	-8+14	22.5	20	4.5	
	-14+28	38.7	36	13.9	
180-	-28+48	19.6	42	8.2	
190	-48+100	7.6	37	2.8	
	-100	7.8			
	Total	100.0		29.7	13
0-19	+8	7.4	10	0.7	
	-8+14	29.1	11	3.2	
	-14+28	32.5	40	13.0	
190-	-28+48	16.7	43	7.2	
200	-48+100	6.9	38	2.6	
	-100	7.4			
	Total	100.0		26.7	9
0-20	+8	5.7	9	0.5	
	-8+14	28.3	19	5.4	
	-14+28	34.7	28	9.7	
200-	-28+48	17.4	40	7.0	
210	-48+100	7.0	25	1.8	
	-100	6.9			
	Total	100.0		24.4	18

TABLE 1 (cont'd)

Evaluation of Vermiculite

Sample No. and Depth (ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-21	+8	4.0	7	0.3	
	-8+14	25.3	18	4.6	
	-14+28	39.3	26	10.2	
210-	-28+48	17.2	26	4.5	
220	-48+100	6.9	21	1.4	
	-100	7.3			
	Total	100.0		21.0	26
0-22	+8	5.2	7	0.4	
	-8+14	27.2	17	4.6	
	-14+28	36.7	27	9.9	
220-	-28+48	16.3	31	5.1	
230	-48+100	6.4	21	1.3	
	-100	8.2			
	Total	100.0		21.3	17
0-23	+8	7.6	9	0.7	
	-8+14	26.0	5	1.3	
	-14+28	30.3	13	4.0	
230-	-28+48	16.0	15	2.4	
232½	-48+100	8.3	12	1.0	
	-100	11.8			
	Total	100.0		9.4	-
0-24	+8	5.0	22	1.1	
	-8+14	30.7	26	8.0	
	-14+28	36.1	33	11.9	
232½-	-28+48	15.4	36	5.6	
240	-48+100	6.1	12	0.7	
	-100	6.7			
	Total	100.0		27.3	13
0-25	+8	6.8	19	1.3	
	-8+14	15.9	26	4.1	
	-14+28	46.5	28	13.0	
240-	-28+48	17.5	33	5.8	
250	-48+100	6.6	28	1.8	
	-100	6.7			
	Total	100.0		26.0	21

TABLE 1 (cont'd)

Evaluation of Vermiculite

Sample No. and Depth (ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-26	+8	3.2	11	0.4	
	-8 +14	22.8	23	5.2	
	-14+28	43.3	28	12.1	
250-260	-28+48	16.8	36	6.0	
	-48+100	6.8	26	1.8	
	-100	7.1			
	Total	100.0		25.5	17
0-27	+8	3.0	6	0.2	
	-8 +14	25.8	19	4.9	
	-14+28	40.0	23	9.2	
260-270	-28+48	17.0	26	4.4	
	-48+100	7.3	28	2.0	
	-100	6.9			
	Total	100.0		20.7	22
0-28	+8	4.5	7	0.3	
	-8 +14	25.5	20	5.1	
	-14+28	38.7	44	17.0	
270-280	-28+48	15.9	40	6.4	
	-48+100	7.2	27	1.9	
	-100	8.2			
	Total	100.0		30.7	7
0-29	+8	4.9	4	0.2	
	-8 +14	26.3	14	3.7	
	-14+28	38.6	28	10.8	
280-290	-28+48	17.2	31	5.3	
	-48+100	6.4	24	1.5	
	-100	6.6			
	Total	100.0		21.5	14
0-30	+8	2.9	7	0.2	
	-8 +14	23.4	16	3.7	
	-14+28	40.9	32	13.1	
290-300	-28+48	18.6	31	5.8	
	-48+100	6.4	25	1.6	
	-100	7.8			
	Total	100.0		24.4	11

TABLE 1 (cont'd)

Evaluation of Vermiculite

Sample No. and Depth (ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-31	+8	5.6	7	0.4	
	-8 +14	30.3	22	6.7	
	-14+28	33.4	37	12.4	
300-310	-28+48	17.9	54	9.7	
	-48+100	6.2	31	1.9	
	-100	6.6			
	Total	100.0		31.1	4
0-32	+8	7.1	10	0.7	
	-8 +14	21.6	15	3.2	
	-14+28	34.8	20	7.0	
310-320	-28+48	19.9	26	5.2	
	-48+100	7.9	28	2.2	
	-100	8.7			
	Total	100.0		18.3	-
0-33	+8	4.1	9	0.4	
	-8 +14	23.1	10	2.3	
	-14+28	39.6	21	8.3	
320-333	-28+48	16.2	30	4.9	
	-48+100	8.2	22	1.8	
	-100	9.0			
	Total	100.0		17.7	-
0-34	+8	6.3	22	1.4	
	-8 +14	29.0	35	10.2	
	-14+28	36.5	27	9.9	
335-338½	-28+48	14.8	15	2.2	
	-48+100	6.3	15	0.9	
	-100	7.1			
	Total	100.0		24.6	30
0-35	+8	4.5	13	0.6	
	-8 +14	24.6	19	4.7	
	-14+28	38.0	27	10.3	
340-350	-28+48	18.1	25	4.5	
	-48+100	7.3	27	2.0	
	-100	7.5			
	Total	100.0		22.1	24

TABLE 1 (cont'd)

Evaluation of Vermiculite

Sample No. and Depth(ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-36	+8	2.4	6	0.1	
	-8 +14	22.2	9	2.0	
	-14+28	35.0	21	7.4	
350-	-28+48	24.3	28	6.8	
360	-48+100	7.2	23	1.7	
	-100	8.9			
	Total	100.0		18.0	-
0-37	+8	4.8	7	0.3	
	-8 +14	20.8	18	3.7	
	-14+28	39.1	30	11.7	
360-	-28+48	19.5	34	6.6	
370	-48+100	7.7	31	2.4	
	-100	8.1			
	Total	100.0		24.7	13
0-38	+8	7.2	25	1.8	
	-8 +14	28.4	21	6.0	
	-14+28	36.9	31	11.4	
370-	-28+48	15.3	31	4.7	
380	-48+100	6.1	18	1.1	
	-100	6.1			
	Total	100.0		25.0	19
0-39	+8	5.1	20	1.0	
	-8 +14	29.7	40	11.9	
	-14+28	37.5	40	15.0	
380-	-28+48	15.9	45	7.2	
390	-48+100	5.8	39	2.3	
	-100	6.0			
	Total	100.0		37.4	13
0-40	+8	5.9	22	1.3	
	-8 +14	22.8	30	6.8	
	-14+28	36.5	46	16.8	
390-	-28+48	20.3	62	12.6	
396	-48+100	7.4	57	4.2	
	-100	7.1			
	Total	100.0		41.7	5

TABLE 1 (cont'd)

Evaluation of Vermiculite

Sample No. and Depth (ft)	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
0-41	+8	6.4	10	0.6	
	-8 +14	21.6	10	2.2	
	-14+28	30.6	26	8.0	
396-400	-28+48	20.4	28	5.7	
	-48+100	9.3	30	2.8	
	-100	11.7			
	Total	100.0		19.3	-
Auger 1	+8	1.4	7	0.1	
	-8 +14	20.2	7	1.4	
	-14+28	21.8	17	3.7	
	-28+48	20.3	26	5.3	
	-48+100	13.5	16	2.2	
	-100	21.8			
	Total	100.0		12.7	14
Auger 2	+8	2.3	4	0.2	
	-8 +14	13.4	7	0.9	
	-14+28	23.7	15	3.6	
	-28+48	23.0	23	5.3	
	-48+100	15.6	22	3.4	
	-100	22.0			
	Total	100.0		13.4	12
Auger 3	+8	7.4	3	0.2	
	-8 +14	23.2	7	1.6	
	-14+28	21.3	17	3.6	
	-28+48	20.3	17	3.5	
	-48+100	16.9	11	1.9	
	-100	10.9			
	Total	100.0		10.8	19

TABLE 1 (concl'd)

Evaluation of Vermiculite

Sample No.	Size Fractions Raw Sample (wt %)		Vermiculite Content of Size Fractions (wt %)	Vermiculite Content of Whole Sample (wt %)	Per Cent Vermiculite as Insulation Grade (wt %)
Pit 1	+8	3.3	16	0.4	14
	-8 +14	22.7	17	3.9	
	-14+28	30.9	36	11.1	
	-28+48	22.2	36	8.0	
	-48+100	10.7	29	3.1	
	-100	10.2			
	Total	100.0		26.5	
Pit 2	+8	3.6	22	0.8	16
	-8 +14	25.3	18	4.6	
	-14+28	28.3	30	8.5	
	-28+48	21.6	34	7.3	
	-48+100	10.7	25	2.7	
	-100	10.5			
	Total	100.0		23.9	

UNIT WEIGHT OF EXFOLIATED VERMICULITE

Unit weight of representative samples of the exfoliated products was determined. Two of the drill core samples and one of the pit samples were selected because they contained a relatively high percentage of vermiculite.

The exfoliated concentrate was screened by hand into various size fractions. The fractions were recombined to meet ASTM grading specifications for Inorganic Aggregates For Use In Gypsum Plaster (C35-57T). Each graded aggregate was thoroughly mixed and the unit weight determined. The gradings and unit weights are shown in Table 2.

TABLE 2

Grading and Unit Weight of Plaster Aggregate

Sieve Size	ASTM Limits Retained, vol %		0-17 Retained volume %	0-28 Retained volume %	Pit 2 Retained volume %
	max	min			
4	0	-	0	0	0
8	10	0	2	5	10
14	75	40	40	40	45
28	95	65	70	65	80
48	98	75	85	85	90
100	100	90	100	100	100
Unit Weight (lb/cu ft)	10	6	21	23	24

Because of this, a separate sample from the stockpile at the property was supplied for confirmatory tests. The stockpile had been exposed to at least six months weathering.

Three 5 pound portions were cut from the material submitted: one designated Stock A was exfoliated as received, ie, in a moist state (17 per cent moisture); the portion designated Stock B was dried at 175°F before exfoliation; the portion designated Stock C was dried at room temperature before exfoliation.

To obtain feed for the exfoliating furnace the +8 mesh fraction was discarded by hand screening. The -8 mesh material was passed through the tube furnace at a temperature between 1750° and 1800°F. The exfoliated product was recovered by air separation and screened by hand into various size fractions. These were recombined to meet ASTM grading specifications for plaster aggregate. Very little of the vermiculite was minus 28 mesh in size, consequently a part of the minus 8 plus 14 mesh fraction of each sample was crushed to satisfy the grading requirements. In the unit weight determination, the volume occupied by a portion of the aggregate was measured by pouring into a graduated 1000 cc cylinder. Because of inherent experimental errors, the unit weight figures recorded in Table 3 are to an accuracy of approximately ± 0.5 lb/cu ft.

TABLE 3

Grading and Unit Weight of Aggregate

Sieve Size	ASTM Limits Retained, vol %		Stock A Retained, volume %	Stock B Retained, volume %	Stock C Retained, volume %
	max	min			
4	0	-	0	0	0
8	10	0	5	5	5
14	75	40	40	40	40
28	95	65	70	70	70
48	98	75	90	90	90
100	100	90	100	100	100
Unit Weight (lb/cu ft)	10	6	9	14	$13\frac{1}{2}$

EFFECT OF TEMPERATURE ON EXFOLIATION

A limited number of tests were carried out to determine whether the firing temperature had any marked effect on the degree of exfoliation of the vermiculite. A part of the minus 28 plus 48 mesh fraction of Auger Sample 2 was chosen arbitrarily for testing in the tube furnace. Firing temperatures of 1700°, 1800°, 1900° and 2000°F were selected. Above 2000° the vermiculite began to fuse. The exfoliated vermiculite was removed from each product by air separation. The unit weights of the concentrated vermiculites were determined and are shown in Table 4.

TABLE 4

Unit Weight at Various Temperatures

Firing Temperature (°F)	Unit Weight (lb/cu ft)
1700	19.1
1800	18.5
1900	19.5
2000	18.7

MINERALOGICAL EXAMINATION

Parts of one drill core sample and of the auger-drill sample were examined to determine the constituent minerals. Microscopic and X-ray diffractometer methods for mineral identification were used. The three principal constituents were identified as vermiculite, diopside and talc. Minor minerals identified were pyrite, calcite and magnetite. It is believed that the talc is an alteration product of the diopside.

BENEFICIATION

Various methods were tried to beneficiate the raw material by separating the vermiculite and the non-exfoliating material.

Magnetic Separation

Two laboratory model magnetic separators were used in these tests: a Carpco, and a Franz Isodynamic separator. Neither of these machines accomplished any separation of the principal constituents.

Electrostatic Separation

Two laboratory model electrostatic separators were used: a Coronatron, and a parallel plate separator. The Coronatron separator was used with both a low intensity revolving drum electrode, and a high intensity stationary electrode. Neither of these separators were successful in beneficiating the vermiculite.

Heavy Liquid Separation

Several liquids of specific gravity between 2.60 and 2.80 were prepared by mixing carbon tetrachloride and tetrabromoethane. Parts of the minus 14 plus 28 mesh fraction of drill-core sample 0-39, which contained 40 per cent vermiculite, and the minus 28 plus 48 mesh fraction of Auger 1 sample, which contained 26 per cent vermiculite, were used for these tests.

About 50 grams of the raw material were put into the liquid, stirred, and allowed to stand until separation into sink and float fractions was complete. The two fractions were dried, and the weights obtained. Each fraction was passed through the tube furnace to exfoliate the vermiculite which was then removed from the non-exfoliated material by air separation. The percentage of vermiculite was determined. The results are shown in Table 5.

TABLE 5

Heavy Liquid Separation

Specific Gravity of Liquid	Float, wt %	Sink, wt %	Vermiculite Content, wt %	
			Float	Sink
Sample 0-39				
2.70	47	53	65	20
2.75	54	46	70	10
2.80	64	36	65	5
Sample Auger 1				
2.60	17	83	50	30
2.71	50	50	50	20
2.75	58	42	40	10
2.80	65	35	40	5

Examination of the sink and float fractions obtained from separation revealed that the float fractions contained mainly vermiculite and talc, whereas the sink fractions were composed mainly of diopside and vermiculite.

DISCUSSION OF RESULTS

The 30 core-drill samples contained an average of 23.4 per cent vermiculite, with extremes of 7.2 and 41.7 per cent. Twenty two of these samples contained at least 20 per cent, and 12 contained at least 25 per cent vermiculite. In 24 of the 30 samples, over 65 per cent of the vermiculite was minus 14 plus 48 mesh in size.

The percentage of exfoliated vermiculite that was coarser than 10 mesh, varied from 4 to 30 per cent, with an average of 15. One commercial producer of insulation grade vermiculite designates minimum size as 16 mesh, and a maximum size of plaster aggregate as 4 mesh. The 10 mesh sieve was chosen, because it is intermediate between these two mesh sizes, to determine the proportion of vermiculite coarse enough to meet size requirements of insulation grade vermiculite.

The three auger-drill samples contained an average of 12.3 per cent vermiculite. The average of Auger 1 and Auger 2, which were prepared for testing in the same manner, was 13.1 per cent. Microscopic examination of the minus 100 mesh fractions revealed negligible amounts of vermiculite in Auger 1 and Auger 2 samples, and 1 to 2 per cent of vermiculite in Auger 3 sample. This would account for the lower vermiculite content in the plus 100 mesh part of Auger 3 sample. Auger 1 and Auger 2 samples were crushed finer than Auger 3, resulting in about double the amount of minus 100 mesh material. As in the most of the core-drill samples, over 65 per cent of the vermiculite flake was minus 14 plus 48 mesh in size. The proportion of exfoliated vermiculite, coarse enough to meet size requirements for insulation grade vermiculite, averaged 13 per cent in Auger 1 and 2 samples, and was 19 per cent in Auger 3. The difference was probably caused by the crushing methods.

The two pit samples contained an average of 25.2 per cent vermiculite. An average of 69 per cent of the flake was minus 14 plus 48 mesh in size. The proportion of exfoliated vermiculite, coarse enough to meet size requirements for insulation grade, averaged 15 per cent.

Three methods of beneficiating the raw material were tried; of the three, only the heavy liquid method (an analytical method) appeared to have promise. This method did not produce a vermiculite concentrate but separated the vermiculite and talc from the diopside contained in the samples. A liquid of specific gravity of 2.80 gave the optimum results. The product obtained by beneficiation of the diamond drill core sample 0-39 contained 65 per cent vermiculite, compared with 40 per cent before beneficiation. Sample Auger 1 was improved by beneficiation from 26 to 40 per cent vermiculite. A liquid of lower specific gravity, in some cases, produced a float fraction of higher vermiculite content, but a greater proportion of the vermiculite was lost in the sink fraction. It is possible that a more comprehensive investigation of wet milling methods would result in elimination of a part of the diopside.

Unit weights of the graded products obtained from samples 0-17, 0-28 and Pit 2 were more than double the limit specified by ASTM. However, the unit weight of the product from sample Stock A was within the specification, and from Stock B and Stock C only slightly above the maximum. These three samples originally came from a level in the deposit above the existing floor of the pit and were stockpiled for at least six months. The lower unit weights recorded for these samples may result from surface weathering or the six month exposure to the elements, or a combination of the two. Moist material fed to the tube furnace was lower in unit weight than the product obtained by exfoliating either of the dried samples. The tube furnace, used in exfoliation tests, has a limited range of retention time and atmospheric control. Other means of exfoliating might improve unit weights of all samples tested. Varying the temperature of the tube furnace between 1700 and 2000°F did not appreciably affect the exfoliated unit weight of Auger 2 sample.

CONCLUSIONS

The diamond drill core samples, and the two samples reported to be from the floor of the pit contained an average of approximately 25 per cent vermiculite. The sample reported to be from auger holes drilled in the floor of the pit contained approximately 12 per cent. In nearly all samples, over 65 per cent of the vermiculite flake was in the size range minus 14 plus 48 mesh. About 15 per cent of the vermiculite met size requirements for insulation grade, but most was of a size suitable for plaster aggregate.

Unit weights of the exfoliated products from the stockpile samples, when graded as aggregate for gypsum plaster, were close to the upper limit of ASTM specification. The unit weights of materials taken from below the level of the pit floor were much above the specified limit. Either long term weathering near the surface of the deposit, or short term exposure on the stockpile might account for the difference. Variation of temperature from 1700° to 2000°, in the tube furnace, had no appreciable affect on the degree of exfoliation.

Neither electrostatic nor magnetic separation were effective in concentrating vermiculite flake from individual size fractions. Since a large proportion of the diopside could be separated in a liquid of 2.80 specific gravity, it is possible that intensive investigation of wet milling might effect a partial separation of this major gangue material.

It was not possible within the scope of this investigation and the equipment available to establish the optimum conditions necessary for effective exfoliation.

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