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July 29, 1969

H. A. Brown

Zonolite Vermiculite
Ore Review

Attached is a copy of the above report which went to Graf for forwarding to Peter Grace. The original went out in a cover with index tabs.

I hope none of the changes made here resulted in a change of fact or commitment from what you intended.

H. A. BROWN

HAB/im
Attachment

CONFIDENTIAL

TO: C. N. Graf
FROM: R. M. Vining

DATE: July 24, 1969
SUBJECT: Vermiculite Report
for Mr. Grace

Attached is the report on vermiculite ore which was requested in your letter of June 23, 1969. If you have any questions, please let me know.



R. M. Vining

RMV/pc
Attachment

ZONOLITE VERMICULITE ORE REVIEW

Harry A. Brown/O. Floyd Stewart
July 24, 1969

ZONOLITE VERMICULITE ORE REVIEW

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ZONOLITE VERMICULITE ORE REVIEWI. SUMMARY

The purpose of this report is to review Zonolite's vermiculite ore position. The following questions were asked in C. N. Graf's memorandum dated June 23, 1969, to R. M. Vining:

- (1) Where are the commercial vermiculite deposits?
- (2) How long are our present deposits good for?
- (3) What special bottlenecks do we see?
- (4) What programs do we have now?

Zonolite is the largest producer of vermiculite in the world, producing approximately 67% or 267,000 tons of the free world's total vermiculite ore tonnage during 1968. Essentially, all the ore produced by Zonolite is sold in the United States and Canada.

Zonolite maintains a vermiculite mining and milling operation at Libby, Montana and Enoree, South Carolina. Both of these operations are presently running at full capacity with Libby supplying 60% of the vermiculite ore requirements and South Carolina 40%.

The Libby mine has a minimum of 75 to 100 years of ore reserves, while the Enoree mine has 6 to 10 years of ore reserves available at the 1969 usage rate of 120,000 tons. Libby ore is

expensive (\$16 per ton) to recover in relation to South Carolina ore (\$10 per ton) and has a higher freight cost (\$5 to \$10 per ton) to ship to the eastern U.S. market. Nevertheless, Libby is still a profitable operation.

An extensive program is underway at Libby to substantially reduce mining and milling costs by improving the recovery of vermiculite ore concentrate from the ore. However, the cost reductions to be achieved will only partially offset the ore concentrate cost and freight disadvantages as compared with South Carolina ore, particularly for the eastern U.S. market. A major expansion of production capacity is in the planning stage in conjunction with the cost reduction program.

The only other significant producer of vermiculite is the Palabora Mining Company located in Transvaal, Union of South Africa. Palabora markets vermiculite mostly in Europe with small amounts going to the United States and Canada. The Palabora ore offers no outstanding economic advantages to United States vermiculite users compared with Zonolite's ore and is primarily used for certain low volume special uses.

Zonolite maintains a surveillance program of all vermiculite occurrences as they are reported and conducts prospecting as warranted. The objective of this prospecting program is (1) to locate additional reserves for the eastern United States markets and (2) to protect Zonolite's control of the largest and most economically workable deposits of vermiculite ore in the United States.

Although there are numerous occurrences of vermiculite ore reported world wide, no information is presently available to evaluate their commercial value which can only be determined by an exploratory drilling program. The exceptions are those where exploratory work has been conducted by Zonolite in the United States. At the present time, none of the locations investigated would be of interest to Zonolite with the exception of ore reserves in Ware Shoals, South Carolina and Louisa, Virginia.

Zonolite is presently conducting an exploratory drilling program near Louisa, Virginia. By late 1970, it is expected that these results will be far enough along to make a determination whether or not the Virginia vermiculite deposits will be large enough and of usable quality to warrant further commercialization of the site.

The ore deposits at Ware Shoals are small with relatively low vermiculite content. Therefore, no decision will be made concerning the commercialization of these deposits until the Virginia drilling program is completed.

II. VERMICULITE PRODUCERS

Approximately 98% of the free world's vermiculite ore production comes from three locations. Two of these are owned by Zonolite at Libby, Montana and Enoree, South Carolina. The third is located in Transvaal, Union of South Africa, and operated by the Palabora Mining Co. (Palabora).

The latest statistics published by the United States Department of the Interior, Bureau of Mines, showed that in 1967 free world production of crude vermiculite (ore) totalled 368,000 tons, of which 255,000 tons (69%) were produced in the United States. Zonolite production totalled 248,000 tons in 1967 (97% of 1967 United States production), 267,000 tons in 1968, and is estimated at 286,000 tons in 1969.

The following table taken from the Bureau of Mines Mineral Yearbook, shows vermiculite production statistics for the period 1963 through 1967.

(See table on the following page)

FREE WORLD PRODUCTION OF VERMICULITE (1)

	U.S. PRODUCTION						WORLD PRODUCTION (EX U.S.)					
	Zonolite		Other (2)		U.S.		So. Africa, Republic of		Other (3)		Total	
	Tons (000)	%	Tons (000)	%	Tons (000)	%	Tons (000)	%	Tons (000)	%	Tons (000)	%
1963	110	97	6	3	226	100	99	96	4	4	103	1
1964	116	96	10	4	226	100	112	96	5	4	117	1
1965	118	100	1	-	249	100	127	98	3	2	130	1
1966	110	99	2	1	262	100	114	95	6	5	120	1
1967	118	97	7	3	255	100	112	99	1	1	113	1
1968	117	--	NA	-	NA	---	121	--	NA	-	---	-
1969 Est.	136	--	NA	-	NA	---	NA	--	NA	-	---	-

(1) Although production is reported to exist in Russia, no further information is available.

(2) Other listed U.S. producers are: Patterson Vermiculite Co. - South Carolina
American Vermiculite Co. - North Carolina - (The only one)
Rimledge Uranium and Mining - Colorado

(3) Other foreign producers are located in:

	TONS PRODUCED			
	1963	1964	1965	1966
ARGENTINA	3,064	4,071	1,857	2,200
BRAZIL	NA	NA	NA	4
INDIA	746	473	807	5
KENYA	101	37	24	
TRANZANIA	30	144	108	1
EGYPT	33	459	639	2,0

<u>Total World Production</u> Tons (000)	<u>% OF WORLD PRODUCTION</u>		
	<u>Zonolite</u>	<u>So. Africa, Republic of</u>	<u>Other</u>
	%	%	%
329	67	30	3
343	63	33	4
379	65	34	1
382	68	30	2
368	67	31	2
NA	--	--	-
---	--	--	-

. producer actively mining vermiculite during 1969)

1967

NA
240
409
277
100
NA

There are nine other sources of vermiculite production listed besides Zonolite and Palabora. All of these (three United States producers, of which one is still producing, and six in foreign countries) have had little or no significance on the total free world vermiculite ore production. There are no indications to date that suggest this situation will change in the foreseeable future.

Geological literature refers to vermiculite ore production in Russia from an area in the Ural mountains near Uralskiy and Karabash. We have no knowledge beyond this concerning the Russian production and have not considered it in this study.

Most of the ore produced by Zonolite is sold and used in the United States with a small quantity going to Canada and other foreign countries. In 1968 Zonolite exported 24,000 tons of vermiculite to Canada and 4,000 tons to other foreign countries.

The majority of the South African production is sold in Europe with Great Britain, Italy, France, and West Germany taking the greatest percentage. Approximately 20,000 tons per year are imported to the United States and Canada.

Zonolite purchases 5,000 to 8,000 tons of South African ore per year for special uses. The African ore is much lighter in color than Zonolite's ore and is advantageous only in a few special purpose end uses and is of little significance to the total United States market. The selling price of African vermiculite including

ocean freight averages \$26 per ton compared with Zonolite's selling price of \$22 per ton.

There is good reason to believe from contacts earlier this year that the Palabora mining operation is presently producing at capacity. An investment in the order of \$5,000,000 to \$10,000,000 would be required to significantly increase their present operation. Palabora has indicated that if they do in fact increase capacity, the cost of ore could increase as much as \$5 per ton. This would further limit their competitive position in the United States.

III. VERMICULITE ORE RESERVES

Zonolite maintains an active but small-scale prospecting program in the United States and keeps a surveillance of all vermiculite occurrences as they are reported both in the United States and the rest of the free world. The objective of this prospecting program is (1) to locate additional reserves for the eastern United States markets and (2) to protect Zonolite's control of the largest and most economically workable deposits of vermiculite ore in the United States.

(1) Overseas

Vermiculite deposits have been located in many countries throughout the world. The information available to us concerning these deposits has been obtained from published literature and correspondence with those seeking markets for vermiculite.

Attached as an appendix to this report is a world map on which most of the known occurrences of vermiculite have been plotted. Of these, the larger known deposits occur in Korea, Pakistan, and Uganda. However, from the geological viewpoint, certain areas in Southeast Africa, Kenya, Uganda, Tanganyika, Rhodesia, Nyasaland, and the Union of South Africa are good potential prospecting sites for vermiculite ore.

There is not enough information listed on most of the deposits described in the literature to make any commercial evaluation. One reason for this is that most geologists and engineers are not familiar with the techniques necessary to evaluate the quality of vermiculite for commercial use. However, most of the ore

samples received by Zonolite from foreign deposits have been of a poor quality except for Kenya and Yugoslavia.

(2) Canada and Mexico

Some of the Mexican deposits examined may be of sufficient size to warrant commercial development, but the ore tested was not good quality. The Canadian samples tested were of good quality and compare to the Libby ore. Although only a few small deposits have been reported in Canada, the geological formations in southern Quebec and Ontario indicate that it is a good prospecting area for vermiculite.

Zonolite plans to initiate prospecting in southern Quebec and Ontario by 1971.

(3) United States (ex South Carolina and Libby)

Vermiculite occurrences are widespread in the United States, but most are confined to two general areas. One area is the upper Piedmont and mountain range from Alabama to Charlottesville, Virginia. A few scattered deposits are found north of this area but nothing that even approaches a commercial deposit is known. The other area is in the Rocky Mountain chain that reaches from Texas to Montana and Idaho. The Mexican and Canadian areas are an extension of these areas. A few isolated deposits occur in Kansas, Arkansas, Oklahoma, California, Arizona, and southern Nevada.

Deposits of fair size and quality occur in Harvard, Idaho and Pony, Montana. Both of these appear to be large and of good quality which would justify further investigation. However, since

the location is no better than Libby, we have deferred doing any work on them. One deposit near Lake Mead in southern Nevada is large enough to mine, but is poorly located for commercial development. The deposits in Texas are small and of poor quality. The deposit in Kansas is low grade but fair in quality and might be large enough to support a small mining operation. We do not intend to conduct drilling programs in any of these areas until results of the Virginia program are known.

The deposits in Georgia, North Carolina and lower Virginia, as well as most of those in Colorado and Wyoming, are too small to mine economically.

The one area that looks promising and may contain deposits of large enough tonnage to support a small operation is located near Louisa, Virginia. Zonolite is currently conducting an exploratory drilling program on 5 deposits of 25 known occurrences of vermiculite in a 7-mile diameter area. Indications are that the ore will average "low grade" in the 20% to 30% vermiculite range, will consist of 3 smaller size grades (#3, #4, and #5), and will be variable in grade quality and size from one spot to another.

Land prices in the area are high, and dealing with land owners will be difficult. Three land owners have so far refused to let us put down drilling holes.

Depending on the results of the exploratory drilling (expected to be finished by late 1970), the area will either be abandoned or a more substantial and long range development program

will be instituted.

(4) South Carolina

Vermiculite occurs in three locations in the Piedmont area of South Carolina. These areas are Tigerville (north of Greenville), Enoree, and Ware Shoals. The Tigerville area has been worked by Zonolite and abandoned. Little or no tonnage is left at this location. The Ware Shoals area is located approximately 30 miles south of the Kearney Mill in lower Laurens County. The deposits are small and are of relatively low percent vermiculite but usable. The economics of hauling this ore to be processed at the Kearney Mill are marginal and will not be done pending completion of analysis of the Virginia drilling program.

The Enoree area is being mined by Zonolite and Patterson Vermiculite Company. Only Zonolite is actively acquiring ore deposits. Zonolite has been mining in the area since 1948 and built the Kearney Mill in 1956. The following chart shows the proven ore reserves as estimated at the end of 1963 through 1968.

SOUTH CAROLINA ORE RESERVES AT YEAR END
(000 tons)

<u>YEAR</u>	<u>QUALITY GROUPS</u>			<u>TOTAL</u>
	<u>GROUP I</u>	<u>GROUP II</u>	<u>GROUP III</u>	
1963	1218	1996	3655	6868
1964	1202	2306	3826	7334
1965	1019	2233	3805	7056
1966	901	2168	3805	6873
1967	875	2033	3716	6624
1968	866	2199	3672	6737

NOTE: Group I contains the highest quality of vermiculite, Group II next and Group III the lowest quality. All Quality Groups consist of the three smaller size grades (#3, #4, #5).

Only Groups I and II are currently being marketed. The Group III ore category represents a broad quality spectrum. Only a small percentage (5% to 15%) upon expansion would be of acceptable quality in present products. However, it is possible that a larger percentage (15% to 40%) could be blended with Group I and Group II ore and represent acceptable quality in selected uses. Research is currently working on this approach as well as new uses for Group III ore.

There has been little change in our forecast of the total tonnage remaining at the South Carolina Enoree Mine since 1963. This tonnage has been adjusted each year by the addition of new leases or purchased properties and also by the extension of the tonnage proven by actual mining. In no case have we mined less ore than was shown by drilling and in some cases the tonnage was doubled. A deposit is usually redrilled when several levels have been mined to re-establish a new reserve figure. We believe our reserve ore figures are on the conservative side when considering past experience and expect these figures could increase by as much as 20%.

At the end of 1969, the tonnage remaining in the Enoree area is estimated to be 6.3 million tons of which the Group I and II quality amount to 2.7 million tons. The present rate of usage at the Kearney Mill is approximately 425,000 tons of raw ore per year. Therefore, using only the Group I and II type ore, there are 6.5 years ore reserves remaining. Assuming a 20% increase in these ore reserves, the life would be 7.8 years.

In addition to Group I and II, Group III amounts to 3.5 million tons (8.2 years). Additional tonnage of Group III, which Zonolite has rejected, is still available for lease.

The Enorce area has been well prospected and very few new deposits are being discovered.

(5) Libby, Montana

In contrast to South Carolina, where small tonnage deposits occur over a three-county area, the Libby deposit is one large mass covering most of a mountain. The Libby deposit contains large flakes of ore which produces #1, #2, #3, #4, and #5 ore sizes.

Approximately 1,300 acres are under Zonolite's mining control. Vermiculite occurs in some form on most of the 1,300 acres. Drilling has never been conducted over the entire area, and the total ore reserve is unknown, but from the area drilled and mined, it is huge in relation to other known vermiculite deposits.

A drilling program was conducted between 1963 and 1966 which proved over 23 million tons of ore that would contain 20% vermiculite or better. Mining is still approximately 300 feet above the mill level which is built on vermiculite ore. There are many millions of tons of vermiculite ore in this deposit (75 to 100 years).

IV. BOTTLENECKS OR LIMITING FACTORS

Zonolite's major limitation is the geographic location of present ore reserves. The largest reserve (proven reserves in excess of 23 million tons of ore) is located in northern Montana (Libby) far removed from the major eastern U.S. markets resulting in high freight costs. The freight rates from Libby are \$5 to \$10 a ton more than from South Carolina to population centers east of the Mississippi. The Enoree Mine in South Carolina is in a good location to serve the eastern market, but has a limited ore reserve (6 to 10 years). Of the 290,000 tons ore usage projected for 1969, approximately 60% will be supplied by the Libby Mine and 40% from Enoree.

In comparison to South Carolina, the cost to produce a ton of ore concentrate is 60% higher at Libby than South Carolina (approximately \$16 per ton versus \$10 per ton). The primary reasons for this are:

- (1) The recovery of the vermiculite passed through the mill is much lower (50%) at Libby than in South Carolina (70%).
- (2) The feed to the Libby mill is lower grade averaging 27% vermiculite compared to 36% vermiculite at South Carolina.
- (3) A higher mine waste to ore ratio exists at Libby. At Libby, the mine moves approximately 22 tons of material for each ton of concentrate produced whereas at South Carolina the ratio is 10 to 1.
- (4) The long winter and cold temperatures at Libby also increase costs. Building, heating, repair and maintenance costs are high due to periods of

extreme cold weather. The freezing weather makes it impossible to stockpile ore in the open for blending purposes. Specially designed bins and feeders must be used to keep the raw feed flowing in cold weather.

Although it may be possible to reduce the cost per ton at Libby by as much as 20% to 25% via programs presently underway, it will not be possible to overcome the mining cost and freight advantages of having a mining operation on the eastern seaboard.

Another limitation is the present milling capacity. Both the Enoree and Libby mills are operating at full capacity. Some relief will be obtained by improved yield and milling throughput increases which are now in the process of being installed (principally an extractor and ore desliming and scrubbing equipment). However, as discussed later in this report, programs must be implemented to further increase milling capacity at Libby.

V. PROGRAMS FOR THE FUTURE

In addition to the drilling program at Virginia and the investigation into potential uses for Group III ore, there are two other major programs currently in the planning stage. The first of these programs is to cut costs and increase yields and production capacity at Libby. The second is to eliminate a serious health hazard caused by the presence of vermiculite and asbestos dust in the mill and expanding plants.

Libby

A Metallurgical Engineer was transferred from the Agricultural Products Division to Libby for the purpose of finding a more efficient method of processing vermiculite ore. It appears that he has found a new reagent to add to the wet mill circuits that will improve the recovery on the #3, #4 and #5 ore sizes. A stepped-up pilot plant testing program is underway to fully test the new reagent and to determine the type of equipment which will make the best use of it. We expect to complete the research by the end of 1969, along with a tentative rebuilding plan to accomplish the following by the end of 1971:

- (1) Raise the vermiculite recovery from the present 50% to 80%.
- (2) Lower the rock content from 10-15% to 5% or less in the concentrates.
- (3) Reduce total production cost by 20-25%.
- (4) Increase the production at Libby to take care of immediate and near future increased sales requirements.

Dust Collection

Zonolite is working on a dust collection and control system at the Libby mill and the expanding plants which use Libby ore. The dust problem is particularly serious since the vermiculite ore from Libby contains Tremolite asbestos. This material is difficult to separate from the vermiculite in the mill and is usually part of the rock remaining in the concentrate when shipped. Tremolite asbestos is a definite health hazard at both the Libby operation and at the expanding plants using the ore.

APPENDIX

22 x 17 WORLD MAP SHOWING VERMICULITE
OCCURRENCES ATTACHED TO ORIGINAL REPORT.
LARGER COPY ALSO ATTACHED TO H. A. BROWN'S
REPORT.