

THE U.S. VERMICULITE INDUSTRY

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INTRODUCTION

The purpose of this report is to present an analysis of the vermiculite industry in the United States with a secondary objective being to assess, in general terms, the prospects for success of a new vermiculite mine such as that proposed by the Stansbury Mining Corporation on the Bitterroot National Forest in Montana.

Vermiculite is a mineral very similar in appearance to biotite, a type of mica, and, in fact, vermiculite is formed by the alteration of biotite. This alteration takes place when alkali elements in biotite are leached out and water molecules are added to the crystal structure. With less than complete alteration, layers of vermiculite are interspersed among the biotite layers, but where the alteration has been complete, no biotite remains and the layers of vermiculite are separated only by water molecules. When heated (exfoliated), some of the water is converted to steam, forcing the vermiculite layers apart at right angles to the cleavage planes and causing the vermiculite to expand to 12 times or more its original volume.

Being fire resistant and having the properties of a very low bulk density and low conductivity, vermiculite is used principally in agriculture and the construction industry. In agriculture, vermiculite is employed in horticulture and as a fertilizer carrier and soil conditioner, while in construction, it is used in thermal insulation and as a lightweight aggregate in concrete, plaster, and premixes. Other applications of vermiculite include its use in plastics and rubber for either filler or texture purposes.

SUPPLY

Market Structure

Vermiculite is mined by just 4 firms in the United States and by virtually any measure, the domestic vermiculite mining industry would have to be considered highly concentrated. W.R. Grace & Co. is the largest producer with output coming from mines near Libby, Montana and Enoree, South Carolina. Other vermiculite mines are operated by Patterson Vermiculite Co. (Enoree, South Carolina), Carolina Vermiculite (Spartanburg and Laurens Counties, South Carolina), and Virginia Vermiculite Ltd. (Louisa County, Virginia). Although W.R. Grace's market share has been declining in recent years (Table 1), its proportion of total production was still 80% as of 1985.

With imports and exports of vermiculite rather small relative to domestic production (see p. 14), the market structure can probably, therefore, best be described as oligopolistic with one very large, dominant firm and several much smaller companies operating on the fringe. It must be recognized, however, that, since vermiculite faces one or more highly competitive substitutes in almost every application, this market structure description is not strictly applicable if viewed from the end use standpoint. Substitutes for vermiculite will be discussed in more detail in subsequent sections.

Table 1

VERMICULITE CONCENTRATE PRODUCTION IN THE U.S.

Year	Total Production Tons	W.R. Grace	
		Tons	% of Total
1980	337,000	324,000	96.1
1981	320,000	297,000	92.8
1982	316,000	268,000	84.8
1983	282,000	247,000	87.6
1984	315,000	254,000	80.6
1985	314,000	253,000	80.6

Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, various years, and W.R. Grace & Co., 10-K Reports, various years.

From a worldwide perspective, a very large percentage of the production of vermiculite concentrate occurs in only 2 countries, the United States and South Africa (data on production of vermiculite concentrate in centrally planned economies is not available and, therefore, not considered here). Figure 1 shows the distribution of world production in 1967 and 1986, and even though the absolute level of mine output in the U.S. has risen over the past 20 years and the U.S. continues to be the largest producer, it is clear that its share of world production has fallen. In 1986, the U.S. accounted for 56.5% of the world total compared to 68.7% in 1967. South Africa and the "other" category, comprised mainly of Brazil and Japan, have gained in relative importance since 1967. Together, the U.S. and South Africa still produce over 90% of the world's vermiculite concentrate.

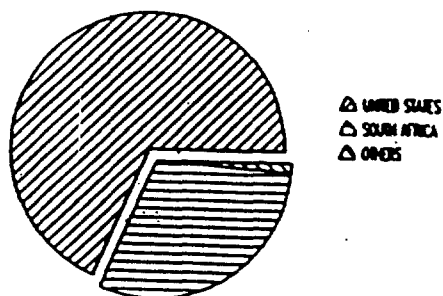
Mining and Beneficiation

In both the United States and South Africa, the open pit method is used to mine the vermiculite. At W.R. Grace's Montana operation, for example, the ore is

Figure 1

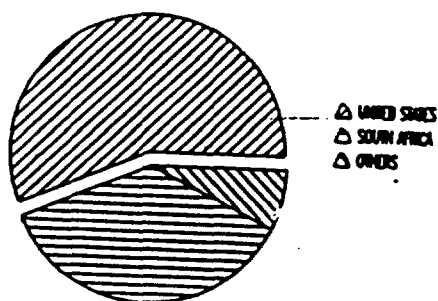
1967 MINE OUTPUT OF VERMICULITE-MARKET ECONOMY COUNTRIES

Total Production = 370.8 thousand tons



1986 MINE OUTPUT OF VERMICULITE-MARKET ECONOMY COUNTRIES

Total Production = 563 thousand tons



Source: U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, 1967 and 1985.

mined in 27-foot high benches which are connected by haulage ramps (White, 1985). After the ore has been drilled and blasted, it is loaded onto 85-ton dump trucks by front end loaders and then transported to a central transfer point. There, the plus 5/8 inch material is separated as waste, since the amount of recoverable vermiculite in it is so small, and the remainder is put on a conveyor belt to be transported through a storage and blending stage and then on to the mill.

In the mill, the ore goes through a wet screening process where the feed is separated into different size fractions prior to the froth flotation phase. After flotation, the concentrates are dewatered, dried, and sent to holding bins via a surface tramway. The concentrates are then trucked to the shipping point for further screening into the 5 commercial sizes (#1 to #5 with the coarsest being #1). The concentrates are transported in bulk to exfoliation plants by rail.

Exfoliation

Because of the high transportation costs associated with shipping low density, exfoliated vermiculite, the exfoliation plants are typically located close to end use markets. In 1986, there were 41 exfoliation plants operating in 27 different states, and W.R. Grace is again the dominant firm at this stage, either owning or having licensing agreements with 29 of the plants.

Exfoliation of the vermiculite is accomplished by dropping the concentrate into a vertical furnace which operates in a temperature range of 870⁰-1,100⁰C. Once exfoliation has occurred (4-8 seconds), the particles are drawn out of the

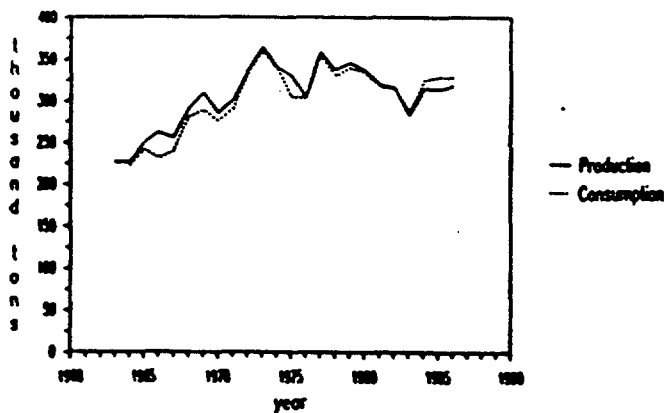
furnace by a suction fan, classified according to size, and bagged for shipment. The exfoliated vermiculite may also be mixed on site with other products, such as peat.

Historical Production

The historical U.S. production of vermiculite concentrate is shown in Figure 2. For comparison purposes, domestic consumption for the period 1964 to 1986 is displayed on the same graph (since information on inventories is not available, the difference between production and consumption is accounted for by imports and exports). Production was generally on an upward trend from 1963 to the 1973, peaking in 1973 at 365,000 tons. Since 1973, production has fluctuated.

Figure 2

U.S. MINE PRODUCTION AND CONSUMPTION OF VERMICULITE



Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, Mineral Facts and Problems, and Minerals Yearbook, various years.

between 282,000 and 359,000 tons, and, with the exception of occasional periods of recovery, mine output has been on a slightly downward path. The domestic mine production of vermiculite in 1986 was 318,000 tons, about 1% above the previous year's level.

In a previous, unpublished econometric analysis of the U.S. vermiculite industry (Marshall, 1986), supply was found to be insensitive to the current price of vermiculite concentrate or the price lagged by one period. This would be consistent with the expectation that, in the type of market structure found in the vermiculite industry, the major producers set prices based on what they believe to be a profitable, as well as sustainable, level and then adjust quantities to satisfy demand. From the data in Table 1, it is clear that W.R. Grace is doing more than its share of adjusting to decreases in demand, while not participating proportionately when demand rises. W.R. Grace's production has fallen by 71,000 tons between 1980 and 1986, while the output of firms on the competitive fringe has increased by 48,000 tons during that period. One explanation for the drop in W.R. Grace's market share might be that the transportation costs associated with shipping vermiculite concentrate from the company's Montana deposit are allowing imports and the other firms in the industry, which are located in South Carolina and Virginia, to capture some of the markets formerly held by Grace. Burlington Northern is the only railroad servicing the Libby, Montana area, so it can charge W.R. Grace much higher rates than would otherwise be expected in a more competitive environment.

DEMAND

Historical Consumption

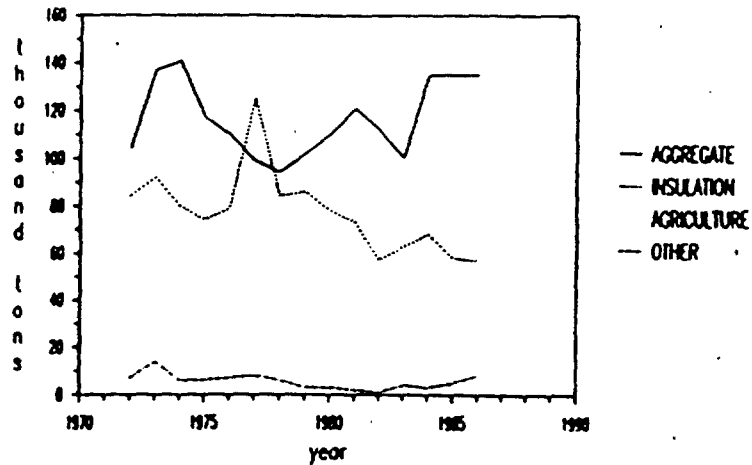
Total U.S. consumption of vermiculite concentrate amounted to 328,000 tons in 1986, essentially the same as in the previous 2 years (Figure 2). As with production, domestic consumption was generally rising between 1963 and 1973, topping out at 359,000 tons in 1973. From 1973 to 1976, total consumption fell by 15.6% before recovering sharply in 1977. Demand then began a slow descent until 1983 when it dipped significantly as a result of the recession. Consumption then jumped back up in 1984, and, since then, has been quite flat. Reasons for the fluctuations in total U.S. vermiculite demand are not always readily apparent, so the following sections present a more detailed discussion of the major end uses of exfoliated vermiculite.

Insulation

After rapid increases in energy prices, the demand for exfoliated vermiculite in insulation rose briefly in the 1970's and then continued on a downward trend to the present (Figure 3). With the exception of 1978 and 1979, the amount of exfoliated vermiculite used in insulation tracks fairly well with the value (in real terms) of new construction activity in the United States. During 1978 and 1979, however, the consumption of vermiculite in insulation was falling while the value of new construction was rising. The magnitude of the spike in insulation demand in 1977 may have been due to the rush to insulate existing buildings in response to the dramatic rise in energy prices, and once that was accomplished, consumption of vermiculite in insulation then settled back down to

Figure 3

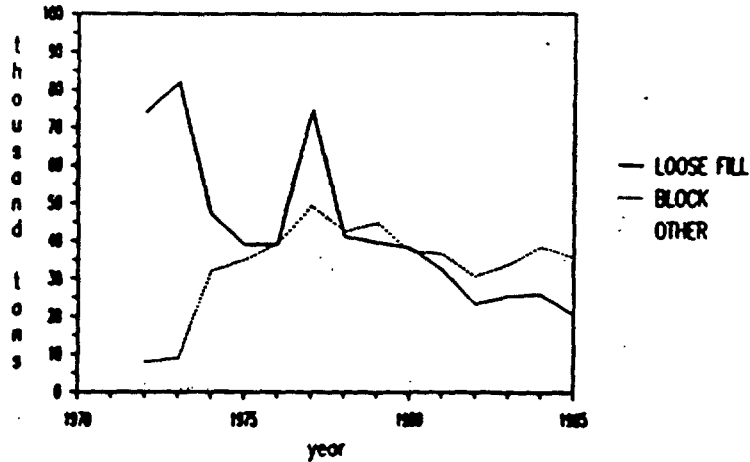
**U.S. DEMAND FOR EXFOLIATED VERMICULITE
BY END USE**



Source: U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, various years.

Figure 4

**U.S. DEMAND FOR EXFOLIATED VERMICULITE
INSULATION**



Source: U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, various years.

more normal levels, again following the pattern of new construction activity.

Thus, for the period 1977 to, say, 1979, a high correlation between the level of consumption of vermiculite in insulation and a measure which considers only new construction activity would not be expected.

Figure 4 shows the trends in consumption of exfoliated vermiculite for different types of insulation. Loose-fill insulation is applied in attics, floors, and wall cavities for purposes of heat and sound insulation, as well as fireproofing. In the building insulation market, one of the major substitutes for exfoliated vermiculite is perlite. Perlite, like vermiculite, expands when heated with the grains swelling into light, fluffy particles. Perlite is less expensive than vermiculite (e.g., \$165/ton for expanded perlite in 1983 vs. \$233/ton for exfoliated vermiculite, f.o.b. plant), the domestic sources of perlite are more widely distributed geographically, and the U.S. production of processed, but not expanded, perlite exceeds the production of vermiculite concentrate by approximately 65%. Other highly competitive substitutes for both vermiculite and perlite in building insulation are mineral wool and fiberglass.

Exfoliated vermiculite is used in refractory insulation either in back-up or hot face applications. With potassium or sodium silicate binders, the vermiculite is compressed into blocks, boards, or other shapes which are then dried in kilns. The resulting product is not affected by heat or flame up to a temperature of 1200°C and it can be used in direct contact with molten metal in lower temperature metal processing industries such as aluminum.

In cryogenic insulation applications (e.g., for liquefied natural gas), perlite is preferred, since it does not absorb moisture like vermiculite. The

absorption of moisture significantly reduces the effectiveness of the insulation.

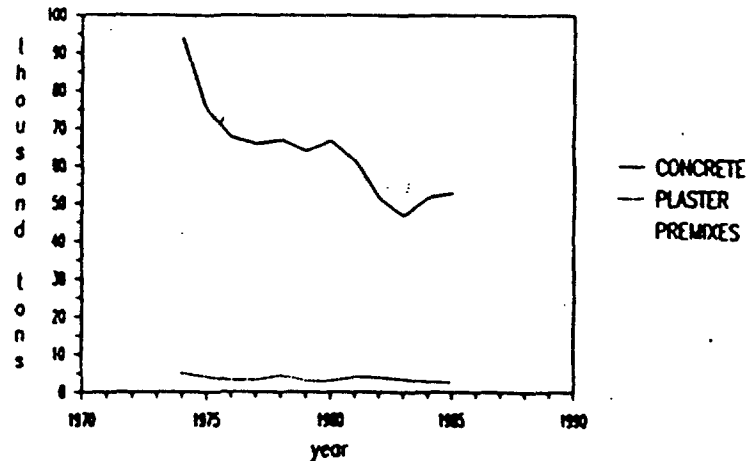
Aggregate

The largest single use of vermiculite is in aggregate where, after falling for several years in the mid-to-late 1970's, consumption began to increase and, since 1984, has been just short of the 1974 peak of 141,000 tons (Figures 3 and 5). Exfoliated vermiculite is used in aggregate where weight is an important consideration (e.g., in roof decks and flooring). In one application, vermiculite is mixed with Portland cement to provide an ultralightweight concrete.

In the above-mentioned econometric analysis, there was no statistically significant relationship between the consumption of vermiculite concentrate in aggregate and the value of new construction activity. There also does not appear to be a close relationship between vermiculite demand in aggregate uses and U.S. shipments of Portland cement, a measure which one might think would better represent the lightweight aggregate market. This suggests that substitutes may have a strong role in determining the level of demand for vermiculite in aggregate. Here, perlite is, again, the major substitute, and it has gained market share from vermiculite based on the advantages of being somewhat stronger and not degrading under wet conditions. If weight is not a critical issue, vermiculite may face competition from such other substitutes as expanded clay, shale or slate.

Figure 5

U.S. DEMAND FOR EXFOLIATED VERMICULITE
AGGREGATE



Source: U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, various years.

Vermiculite is also mixed with powdered gypsum or cement to form a lightweight plaster. This plaster spreads easily, is fire retardant, and provides thermal and noise insulation. Several different grades of plaster are produced and the grade depends on the aggregate to gypsum/cement ratio. The plaster market once belonged exclusively to vermiculite, but, because of being cheaper, perlite has made inroads here, as well. Nevertheless, if fire resistance is important, vermiculite is preferred over perlite. In South Africa, vermiculite plaster is sprayed onto the walls of mines to act as a sealant and fire retardant.

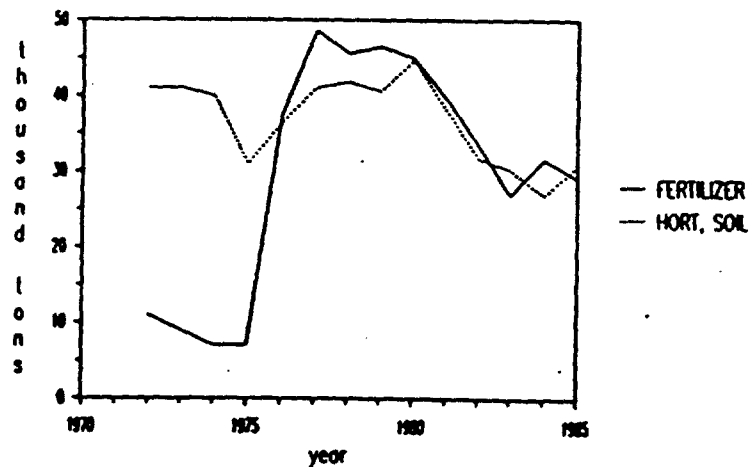
Agriculture

As Figure 3 indicates, exfoliated vermiculite consumption in agriculture has been hovering around 60,000 tons per year, about 1/3 less than in the 1977 to

1980 period. Figure 6 traces the consumption of exfoliated vermiculite in specific agricultural uses over the 1972 to 1985 period. The amount of vermiculite used as a fertilizer carrier increased sharply from 1975 to 1977 before dropping off considerably in subsequent years. The Federal Reserve Board index of agricultural chemicals use did not follow this same pattern (although there were some similarities), so it would appear that the post 1977 downturn may have been due to vermiculite losing market share to a substitute such as perlite.

Figure 6

U.S. DEMAND FOR EXFOLIATED VERMICULITE AGRICULTURE



Source: U.S. Department of Interior, Bureau of Mines, Minerals Yearbook, various years.

Exfoliated vermiculite used in horticultural and soil conditioning totalled 30,800 tons in 1985, up 4,000 tons from 1984, but still far below the 1980 level of 44,700 tons. With a low bulk density, both exfoliated vermiculite and

expanded perlite provide excellent insulation, protecting plants from large shifts in temperature. They also offer plant handling-related advantages in that their lightness reduces the probability of damaging the root ball during transplanting, for example.

Although both expanded perlite and exfoliated vermiculite are used in horticulture, each tends to have its own segment of the market based on its physical properties. Vermiculite is preferred over perlite for seed germination, as the high water-holding capacity and aeration properties of vermiculite promote a rapid rate of germination (Power, 1986). Because it retains water so well, vermiculite excels in any horticultural application where it is important to prevent the soil or other growing medium from drying out. With its high cation-exchange capacity, vermiculite can also hold nutrients in its molecular structure for slow release into the soil.

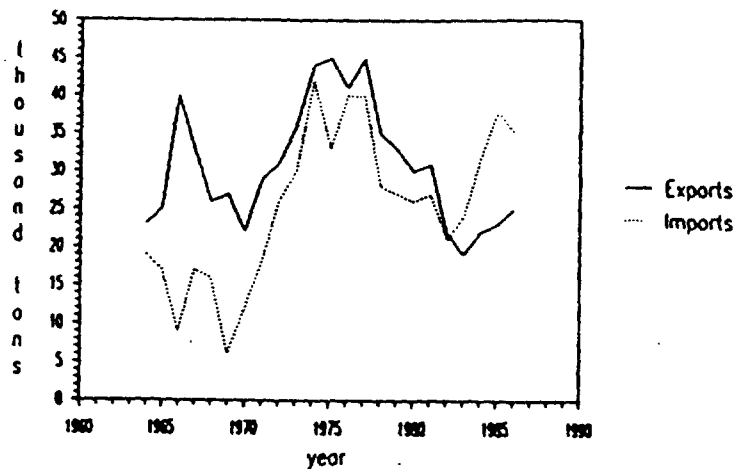
On the other hand, where good drainage is desirable, such as for hardwood cuttings, perlite is often chosen over vermiculite. Both perlite and vermiculite can be mixed with peat to be used in potting, but if prolonged wetness will be a concern, perlite is preferred.

U.S. EXPORTS AND IMPORTS

Figure 7 shows U.S. exports and imports of vermiculite concentrate from 1964 through 1986. In 1986, imports of vermiculite concentrate totalled 35,000 tons, while exports amounted to 25,000 tons. A small amount (5% or less) of concentrate is imported from Brazil with the balance coming from South Africa.

Figure 7

U.S. EXPORTS AND IMPORTS OF VERMICULITE



Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, Mineral Facts and Problems, and Minerals Yearbook, various years.

Vermiculite concentrates from South Africa are distributed to independent exfoliation plants in the U.S. through the American Vermiculite Corporation of Atlanta, Georgia, and a major reason why the independent exfoliators depend on imports rather than on domestic sources is the availability in South Africa of greater quantities of the coarser grades of vermiculite (personal communication with Arthur Meisinger, May 15, 1987). In some areas of the United States, it may also be cheaper to import vermiculite rather than incur the shipping costs from domestic deposits.

In the econometric analysis, the hypothesis for imports was that they are dependent upon the level of domestic activity in each of the major consuming sectors, as well as upon U.S. and South African vermiculite concentrate prices

(because information on transportation costs over the entire period was not readily available, f.o.b. mine prices were used). Imports were found to be responsive only to the production index for rubber and plastics, possibly indicating that the "other" category is the only sector which depends on imports as a source of supply. This would be consistent with the fact that coarser grades of vermiculite are often required for filler purposes (as in rubber and plastics, for example), and it is the coarser grades which tend to be imported. Neither the U.S. nor the South African price variables (current or lagged) turned out to be statistically significant.

Canada is the destination for almost all exports of vermiculite concentrate, but small quantities may also be shipped to Mexico. Both W.R. Grace and Virginia -- Vermiculite export vermiculite concentrate to Canada, and Grace has its own exfoliation plant in that country. In some Canadian markets, the location of the Grace and Virginia Vermiculite mines may confer cost advantages to those sources relative to imports from South Africa.

Exports, in the econometric analysis, were found to be sensitive to the U.S. vermiculite price lagged one period, as well as to the Canadian industrial production index. The South African price of vermiculite concentrate seemed to have no effect on U.S. exports to Canada.

PRICES

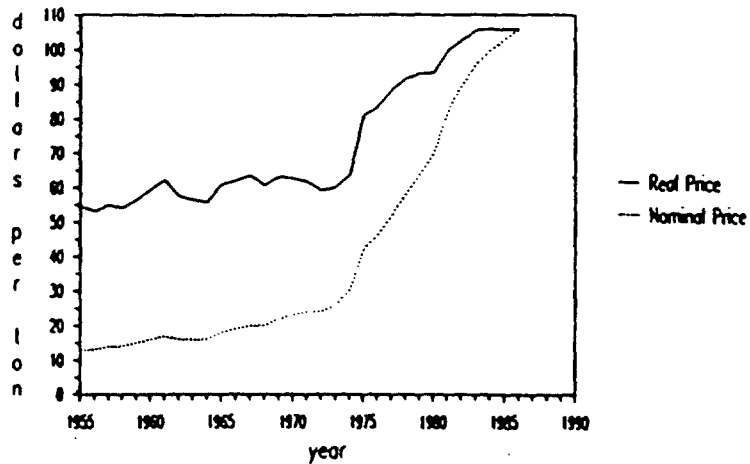
Historical prices of vermiculite concentrate and exfoliated vermiculite are shown in Figures 8 and 9, respectively. The nominal price of vermiculite

= concentrate has been rising continuously over at least the last 30 years and, like many mineral commodities, the most rapid increases occurred in the

Figure 8

U.S. VERMICULITE PRICE-F.O.B. MINE

(REAL PRICES ARE IN CONSTANT 1986 DOLLARS)

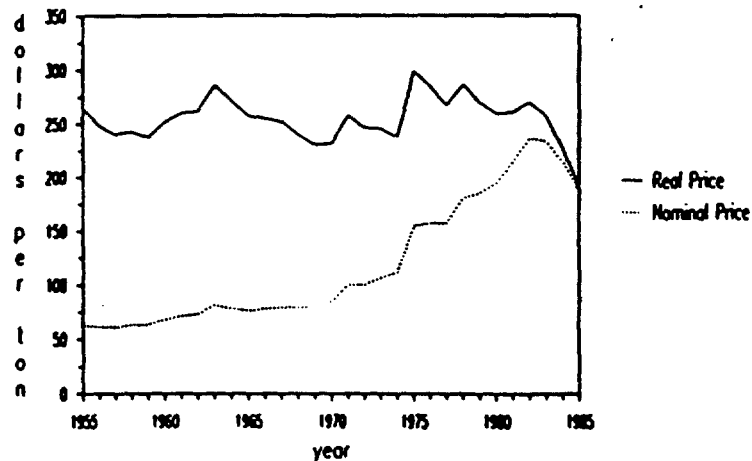


Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, Mineral Facts and Problems, and Minerals Yearbook, various years.

Figure 9

U.S. EXFOLIATED VERMICULITE PRICE-F.O.B. PLANT

(REAL PRICES ARE IN CONSTANT 1986 DOLLARS)



Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, Mineral Facts and Problems, and Minerals Yearbook, various years.

high-inflation years of the mid-to-late 1970's. More recently, however, the rate of increase has begun to taper off. In real terms (constant 1986 dollars), vermiculite concentrate prices have been on a plateau for the last 4 years at about \$106 per ton, after having risen in a series of steps since 1974.

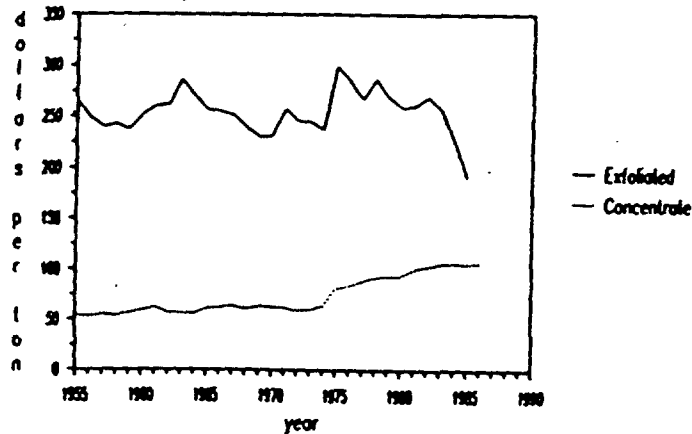
The nominal price of exfoliated vermiculite peaked in 1982 at \$236 per ton before dropping to the 1985 level of \$186 per ton. Real prices have also fallen since 1982, a departure from the rather trendless experience of the 1955 to 1982 period.

Vermiculite concentrate and exfoliated vermiculite prices are shown together in Figure 10. As this graph indicates, the gap between the 2 prices has narrowed considerably in recent years, and this could be an indication that monopoly rents are being relinquished by the industry, to the benefit of purchasers of exfoliated vermiculite. It also points out one of the major problems in attempting to analyze price movements in the vermiculite market. W.R. Grace is, by far, the largest firm in the industry and it happens to be vertically integrated, producing vermiculite concentrate, exfoliated vermiculite, and products made from vermiculite. Aside from what might be exported, actual market sales by W.R. Grace occur mainly (if not only) at the latter 2 stages. Even then, the exfoliated vermiculite which goes into W.R. Grace products is not really subject to a market transaction. Thus, because of the transfer pricing issue, the price data, especially for vermiculite concentrate, may be somewhat questionable. If, however, it can be assumed that the vermiculite concentrate prices truly reflect what the concentrate would have sold for in arms length

transactions (and this does not appear to be an unreasonable assumption considering the relatively small difference between the range of U.S. prices

Figure 10

U.S. VERMICULITE PRICE-CONCENTRATE AND EXFOLIATED
(CONSTANT 1986 DOLLARS)



Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, Mineral Facts and Problems, and Minerals Yearbook, various years.

versus the range in the landed costs of vermiculite concentrate imported from South Africa), then one explanation for the narrowing of the price gap might be that producers are reducing their profit margin on exfoliated vermiculite in order to stop or reduce further potential market share losses to substitutes, such as perlite.

OUTLOOK

In the 1985 edition of Mineral Facts and Problems, the U.S. Bureau of Mines estimated that vermiculite reserves in the United States totalled 25 million

tons with another 20 million tons of vermiculite reserves in South Africa. The reliability of these figures cannot be considered particularly high, however, since the reserve estimates are not typically revised to take into account changes in prices, new discoveries, or past production. Nevertheless, there is no evidence to indicate that world reserves are not sufficient to accomodate cumulative world demand for at least several decades. According to W.R. Grace's 10-K Report for 1985, the company has reserves adequate for a minimum of 40 years based on current production levels and prices.

From a 1983 base of 287,000 tons, the Bureau of Mines has also forecast that U.S. demand for vermiculite concentrate will increase at an average annual rate of 2.7% and total 450,000 tons by the year 2000. This forecast was developed by making statistical projections based on the correlation between consumption in the major end use categories and certain economic indicators, and then modifying the statistical projections to take into account other factors expected to affect demand. In the rest of the world, demand is projected to rise at a slightly lower rate of 2.4% per year.

These growth rates seem rather excessive and may very well turn out to be overly optimistic. Substitutes exist for vermiculite in every major end use and one of the biggest competitors in most end use markets is the lower-priced perlite. In some respects (e.g., fire resistance), vermiculite is superior to perlite, but in many applications the two can be substituted for each other with no loss in effectiveness. Under these conditions, price will be the determining factor with the advantage currently held by perlite. In some markets (e.g., insulation), both vermiculite and perlite face competition from other substitutes, as well. The availability of substitutes, coupled with the fact

that none of major end uses (i.e., aggregate, insulation, or agriculture) are expected to display vigorous growth over the coming years, should restrict the increase in domestic vermiculite concentrate consumption to no more than about 1% per year from a 1986 base of 328,000 tons. Cyclical factors will, of course, cause short run deviations from that growth rate.

With adequate vermiculite supplies, a small projected yearly increase in demand, and the potential of further losses in market share to substitutes, the real price of vermiculite concentrate should remain constant at \$106 per ton (1986\$) or even decline somewhat. Also, the nominal and real price of exfoliated vermiculite could continue to fall for a time, especially if exfoliators become more inclined to pass savings in fuel costs along to customers. ..

THE FEASIBILITY OF A VERMICULITE MINE ON THE BITTERROOT NATIONAL FOREST

As mentioned in the introduction, Stansbury Mining Corporation is proposing to develop a vermiculite mine on the Bitterroot National Forest in Montana. Since only a conceptual operating plan has been submitted, it is impossible to do a detailed feasibility analysis of this project. No cash flow projections or market studies have been provided, and further complicating the situation is the frequency of the changes in the proposal. For example, in their 1986 10-K Report, the company was estimating that approximately 100,000 tons of vermiculite concentrate would be produced each year beginning in 1988. The vermiculite concentrate was also initially to have been shipped elsewhere for exfoliation and the company indicated that it was negotiating to buy exfoliation plants in Phoenix and Pittsburg.

The most recent proposal is for mining 400,000 tons of ore annually from which 30,000 tons of vermiculite concentrate will be produced (personal communication with Marti White, May 12, 1987). Stansbury now also plans to construct its own exfoliation plant near the Hamilton, Montana city limits and the entire 30,000 tons of vermiculite concentrate will be exfoliated at that location. The exfoliated vermiculite would be mixed with perlite and peat to form a product which would be used in horticulture, and it would also be combined with gypsum into a plaster product. The exact sources of the gypsum, peat, and perlite have not yet been determined, but the perlite would be shipped to Hamilton in concentrate form and expanded by Stansbury at the same site.

Although a detailed feasibility is not possible at this point, some general comments about the proposal can be made. If it is assumed that, based on a weighted average of Bureau of Mines figures for 1981 to 1985, 0.81 tons of exfoliated vermiculite are produced from each ton of vermiculite concentrate, then approximately 24,300 tons of exfoliated vermiculite would be produced from Stansbury's annual output of 30,000 tons of vermiculite concentrate. A portion of the 24,300 tons of exfoliated vermiculite would be mixed with gypsum and the remainder with perlite and peat.

In the entire United States, the 1985 sales of exfoliated vermiculite for horticultural and soil conditioning applications amounted to 30,800 tons while sales of exfoliated vermiculite in plaster totalled 2,500 tons. In horticulture alone, exfoliated vermiculite sales in the U.S. were just 22,400 tons. Thus, in order for Stansbury to sell a total of 24,300 tons of exfoliated vermiculite in the domestic horticulture and plaster markets each year, it would be necessary

either for U.S. consumption to increase by the entire amount of their output, for Stansbury to displace 100% of sales of all other firms in the plaster market and 71% of sales in the horticultural and soil conditioning market (97% of sales to the horticultural market alone), or some combination of these. This would appear to be an impossible task, as the company apparently has yet to sign any sales contracts for their products, it would be competing in Western North America markets with W.R. Grace, the largest and presumably lowest-cost producer in the industry, and the costs of transporting products containing vermiculite in exfoliated form would impose significant constraints on the ability of the company to penetrate more distant markets, including those in Canada.

Furthermore, even if Stansbury could market all of its planned output, there are serious questions about whether it could do so profitably. To examine this issue, a cursory discounted cash flow analysis was performed using the personal computer version of the U.S. Bureau of Mines Mine Simulator (MINSIM) program. This program has the capability to determine the product price necessary to achieve a specified rate of return. Following are the assumptions used in the analysis:

1. Operating costs and cutoff grades are identical to those at W.R. Grace's Montana mine and mill (this information is proprietary and, therefore, cannot be disclosed). Given the much larger scale of W.R. Grace's operation and their decades of experience in mining and milling vermiculite from the Montana deposit, it would seem highly probable, however, that Stansbury's operating costs will exceed those of W.R. Grace.
2. Based on a conversation with Marti White (May 12, 1987), total capital costs for the mine and mill were assumed to be \$9.00 million (1987\$) which would be equivalent to \$8.73 million in constant 1986 dollars at a 3% rate of inflation. The working capital portion of this was assumed to be \$.73 million and the remaining \$8.00 million was arbitrarily distributed between equipment (75%) and plant (25%).

3. All the capital costs are incurred in the first year and it is not necessary to replace any equipment or make any other capital investments during the assumed 15-year production period.
4. Full production of 400,000 tons of ore is achieved in the first year.
5. The company pays federal income taxes, but there are no state income, property, or severance taxes.
6. The cost of capital to the firm is 12% which, given Stansbury's financial history (including filing for reorganization under Chapter 11 of the Bankruptcy Reform Act of 1978), would have to be considered an understatement of the true cost of capital.

Under these exceedingly favorable (and totally unrealistic) assumptions, a vermiculite concentrate price of \$148.29 per ton (constant 1986\$) would be required to earn the target rate of return over the life of the project. This is 40% above the 1986 average price of \$106 per ton, and, as previously discussed, the price of vermiculite concentrate, in real terms, is not expected to increase at all, let alone to the level necessary to make this an economically feasible operation. In fact, at a vermiculite concentrate price of \$106 per ton, the project could not even cover operating costs.

Stansbury intends to produce all 5 grades of vermiculite concentrate (personal communication with Ed Vukelich, May 15, 1987), and, thus, cannot claim that anywhere near 100% of its output will command the premium prices quoted for Grade #1. Even if it did make such a claim, the required price of \$148.29 per ton is, in constant dollar terms, still above the highest quotes currently being published (Engineering & Mining Journal, March 1987 and Industrial Minerals, February 1987).

Finally, although the company contended in their 10-K Report that asbestos is not present in their deposit, subsequent analysis of samples from the area has

indicated otherwise (ibid, 1987). At this point, it is difficult to tell to what extent this might be a problem, if it is a problem at all. It is possible that areas in the deposit containing asbestos could be avoided or that appropriate mitigation measures could be designed, but both would entail additional costs. Given the potential for asbestos-related litigation, however, the issue cannot be casually brushed aside as Stansbury appears to be doing.

In conclusion, based on the above analysis, the prospects do not appear particularly bright that an operation such as that proposed by Stansbury Mining Corporation could become and remain viable for any length of time.

REFERENCES

Council of Economic Advisors, Economic Report of the President, 1987.

Engineering & Mining Journal, March 1987.

W.R. Grace & Co., 10-K Report, various years.

Industrial Minerals, February 1987.

Richard C. Marshall, An Econometric Analysis of the U.S. Vermiculite Industry, unpublished paper prepared for a University of Arizona course, December 1986.

Personal communications with:

Arthur Meisinger, Industry Economist, U.S. Department of Interior, Bureau of Mines, May 15, 1987.

Marti White, Geologist, Stansbury Mining Corp., May 12, 1987.

Ed Vukelich, Geologist, U.S. Department of Agriculture, Forest Service, May 15, 1987.

Tim Power, "Perlite and Vermiculite, the Market Overlap," Industrial Minerals, No. 230, November 1986.

Stansbury Mining Corporation, 10-K Report, 1986.

U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries, various years.

_____, Mineral Facts and Problems, various years.

_____, Minerals Yearbook, various years.

Brian G. White, Report on Mining Claim, unpublished report prepared for the U.S. Department of Agriculture, Forest Service, January 1985.