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VERMICULITE IN WYOMING

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Introduction

Vermiculite is a group of hydrated ferromagnesian aluminosilicate minerals that are characterized by the capacity to expand when heated (Stewart, 1983). It is micaceous in form, and has a greasy, almost talc-like feel, especially when wet. It is a clay mineral, although it is usually described separately due to its special characteristics and habit. Its chemical formula is: $(Mg,Ca)_{0\cdot7}(Mg,Fe^{+3},Al)_{6\cdot0}[(Al,Si)_8)_{20}](OH)_{4\cdot8}H_20$ (Deer and others, 1966).

The expanded product, which is also called vermiculite or expanded vermiculite, has excellent thermal and acoustic insulation properties. It is used in construction as a lightweight aggregate, in agriculture and horticulture as a soil conditioner, and in other industrial uses.

The market for vermiculite is increasing and some of the domestic supplies are almost depleted. A large deposit of vermiculite in Wyoming would be economically viable and provide a real opportunity for industrial development, including a mining operation and an expansion plant.

This report describes the uses and value of vermiculite, its geologic occurrences, current production and demand, and known occurrences in Wyoming. Most of the Wyoming occurrences have not been tested for quantity and quality of vermiculite. Potentially large ocurrences of vermiculite that have never been tested by drilling are found in Carbon County, Platte and Albany Counties, Converse County, and elsewhere. Some of the occurrences were mined in the past, and were not depleted when the mines were closed.

Uses, production, and price of vermiculite

Uses

Vermiculite (the expanded product) is valuable for its light weight and moisture-retaining and insulating properties. It is used in plaster and cement premixes (33%); in agriculture as a soil conditioner and fertilizer carrier (24%); as insulation (23%), and as a light-weight aggregate (20%) (Meisinger, 1985; 1989).

Vermiculite has been proposed as an additive to livestock and poultry feed. It has also been proposed for use as poultry and barnyard litter (Lin, 1989). It may be substituted for such materials as expanded perlite, sawdust, and peat in agricultural uses, and for asbestos, rock wool, fiberglass, and other materials in insulation. Vermiculite may be used in place of expanded clay, shale, slag, or slate in lightweight aggregates (Meisinger, 1989). Brown (1948) proposed that vermiculite can be mixed with a thermoplastic resin to produce floor coverings, pressure rings, gaskets, crown-cap seals, and other similar items. He also noted that vermiculite has been used as a catalyst in hydrocarbon conversion processes, as a lubricant, a carrier for paint and ink, and was once used to produce an artificial sandstorm in a motion picture (Brown, 1948).

Vermiculite can be (but is not at present) used in drilling mud and can be pressed into fireproof wallboard (Meisinger, 1985).

Production

Countries with current vermiculite production include The United States, Argentina, Brazil, Egypt, India, Kenya, Mexico, the Republic of South Africa, and Tanzania (Meisinger, 1985).

In the past, vermiculite was mined in the U.S. in Georgia, North Carolina, Pennsylvania, Texas, and Wyoming. Vermiculite is currently mined at Rainy Creek, near Libby, northwestern Montana, and near Enoree, South Carolina, by the W. R. Grace Company. In 1988, the Stansbury Mining Company applied for a state mining permit to open a vermiculite mine in Ravalli County, Montana. This mine had produced vermiculite in the past (Rice, 1989). Vermiculite from the operating U.S. mines was shipped to 41 exfoliating (expanding) plants in the U. S. Vermiculite is also imported into the U.S. from the Palabora Mining Company deposit at Phalaborwa, Republic of South Africa (Meisinger, 1989). Vermiculite production statistics are given in **Table 1.**

Table 1. Production and imports of vermiculite (after Meisinger, 1989; Wolter, 1989).

Year	1984	1985	1986	1987	1988
Production[1]	315,000	314,000	317,000	303,000	300,000
Imports[2]	32,000	38,000	35,000	30,000	30,000

[1]Short tons

[2]Short tons, imports for consumption from the Republic of South Africa

Vermiculite production is forecast to increase. The U. S. Bureau of mines predicts a demand for 350,000 short tons in 1990 and 450,000 short tons in 2000 (Meisinger, 1985). A more recent forecast is for the production of 300,000 short tons in 1990 (Wolter, 1989).

Vermiculite consumption has declined slightly from 1986 to 1988, but this trend is expected to reverse as new construction increases the use of vermiculite in insulation, particularly as a substitute for the environmentally banned asbestos, and in agriculture.

Price

The price of vermiculite has been increasing in recent years. As demand increases and as domestic production decreases, the price should continue to increase. Recent prices for vermiculite are shown in **Table 2.**

Table 2. Recent vermiculite prices (after Meisinger, 1989).

Year	1984	1985	1986	1987	1988
Price[1]	100.00	103.18	108.52	109.24	109.00

[1]Dollars per short ton, year's end.

Geologic occurrences of vermiculite

Vermiculite forms in two ways, by weathering or hydrothermal alteration of biotite, or by hydrothermal alteration of basic igneous or metamorphic country rock, usually containing biotite mica, at or near the contact with acidic intrusive igneous rocks (Meisinger, 1985, Bothner, 1967, Deer and others, 1966, Hagner, 1944). The larger deposits of vermiculite formed by the latter method. At Rainy Creek, the Montana vermiculite deposit, the intrusive is a peralkaline rock with a core of biotite pyroxenite. Vermiculite forms a doughnut-shaped deposit around the core of unaltered biotite-rich rock The deposit at Phalaborwa, South Africa is similar to the Libby deposit (Meisinger, 1985).

Smaller occurrences of vermiculite are found in altered metamorphic rocks, usually biotite or hornblende schists, and in some cases serpentinite, which are intruded by granites or granite pegmatites. These deposits in metamorphic rocks are usually found in layers a few feet thick and do not approach the size of the Rainy Creek or Phalaborwa deposits. The producing deposits at Enoree, South Carolina are of this type, as are the past producing deposits in Texas and Wyoming (Meisinger. 1985). Vermiculite is also formed in these deposits as an alteration product of mafic minerals, particularly hornblende and biotite, produced by the action of acidic solutions from the intrusives on the mafic minerals (Meisinger, 1985, Bothner, 1967, Deer and others, 1966, Hagner, 1944).

Wyoming vermiculite occurrences

Vermiculite occurs in Wyoming in biotite schist, hornblende schist, diorite and metadiorite, hornblendite, and serpentinite; and near or adjacent to a contact with granite, granite gneiss, granite pegmatite, and aplite or vein quartz (Hagner, 1944). For a review of the associated rock types and their characters, mineralogies, optical properties, and modes of occurrence, the reader is referred to Hagner (1944). North and Chandler (1953) stated that vermiculite bodies in Wyoming are irregular, pinch and swell, and may end at depth. However, this is true of all known vermiculite deposits. This brief paragraph in North and Chandler (1953), may have discouraged exploration for vermiculite in Wyoming.

Vermiculite has been produced in Wyoming (Meisinger, 1985). Production began about 1935 (Hagner, 1944), and continued intermittently until the early 1960's (Osterwald and others, 1966). Wyoming vermiculite production statistics are given in **Table 3.**

Table 3. Wyoming vermiculte production [after Hagner (1944) U.S.Bureau of Mines Mineral Yearbooks,1947-1965].

Year	1935-1936	1947	1948	1957	1958-1965
Production[1]	5500	2452	65	10	minor

[1]Short tons

The following is a description of known vermiculite occurrences in Wyoming. The numbers preceding each occurrence refer to numbers on the location map (**Figure 1**). The list is alphabetical by county.

Albany County

1. Long Jack claim (sec. 6, T.24N, R.70W).

Vermiculite occurs in a contact-metamorphic zone between a granite pegmatite and an intensely altered rock of undetermined type. The vermiculite is found in a lens that varies in width from less than one foot to several feet. It is exposed in a pit 25 to 30 feet deep. (Hagner, 1944). Large portions of this pit are now caved in. According to Mr. Marlin Vaughn, who worked the pit prior to 1944, about 40 tons of vermiculite were mined from this deposit (Hagner, 1944).

2. May claim (sec. 1, T.24N, R.71W).

Hagner (1944), reported a vermiculite occurrence in this area. A pit 4 to 6 feet deep, 15 feet long, and 6 feet wide was developed in an anthophyllite body, portions of which are altered to vermiculite. A small granite pegmatite is found in the south face of the pit. The deposit is unique because of the geological relationships of vermiculite and anthophyllite present here About 5 tons of vermiculite were removed from this deposit. (Hagner, 1944).

3. Roff occurrence no. 1 (sec. 18, T.24N, R.70W).

Vermiculite is found exposed in a small pit associated with chlorite, kyanite, and corundum in a biotite schist. The schist is a partly assimilated xenolith in a gneissic granite (Hagner, 1944). [Rolf occurrence no. 2 is in Platte County, occurrence 20, this report.]

4. W 1/2 sec. 7, T.13N, R.78W

Currey (1965) reported that impure vermiculite occurs here in an altered amphibole-gneiss exposed in a small prospect pit. No other information is available on this occurrence.

Carbon County

Three relatively large occurrences of vermiculite are found in the Encampment region of southern Carbon County. Together, these deposits constitute what is probably the largest resource of vermiculite in Wyoming. In 1987, these deposits were investigated by a large industrial mineral producing company, but were not studied in detail at that time. These occurrences represent an investment potential for small-scale production. The shafts, pits, and tunnels have been covered recently by the Abandoned Mined Lands Reclamation Program.

5. "Mikolite" deposit (sec. 15, T.15N., R.83W).

Approximately 1,000 short tons of vermiculite were produced from an underground mine at this location between 1937 and 1941. The vermiculite was marketed at that time as "Mikolite" (Hagner, 1944).

Vermiculite occurs at the contact of hornblende and hornblende-biotite schist with granite pegmatite. Small amounts of chlorite and tremolite-

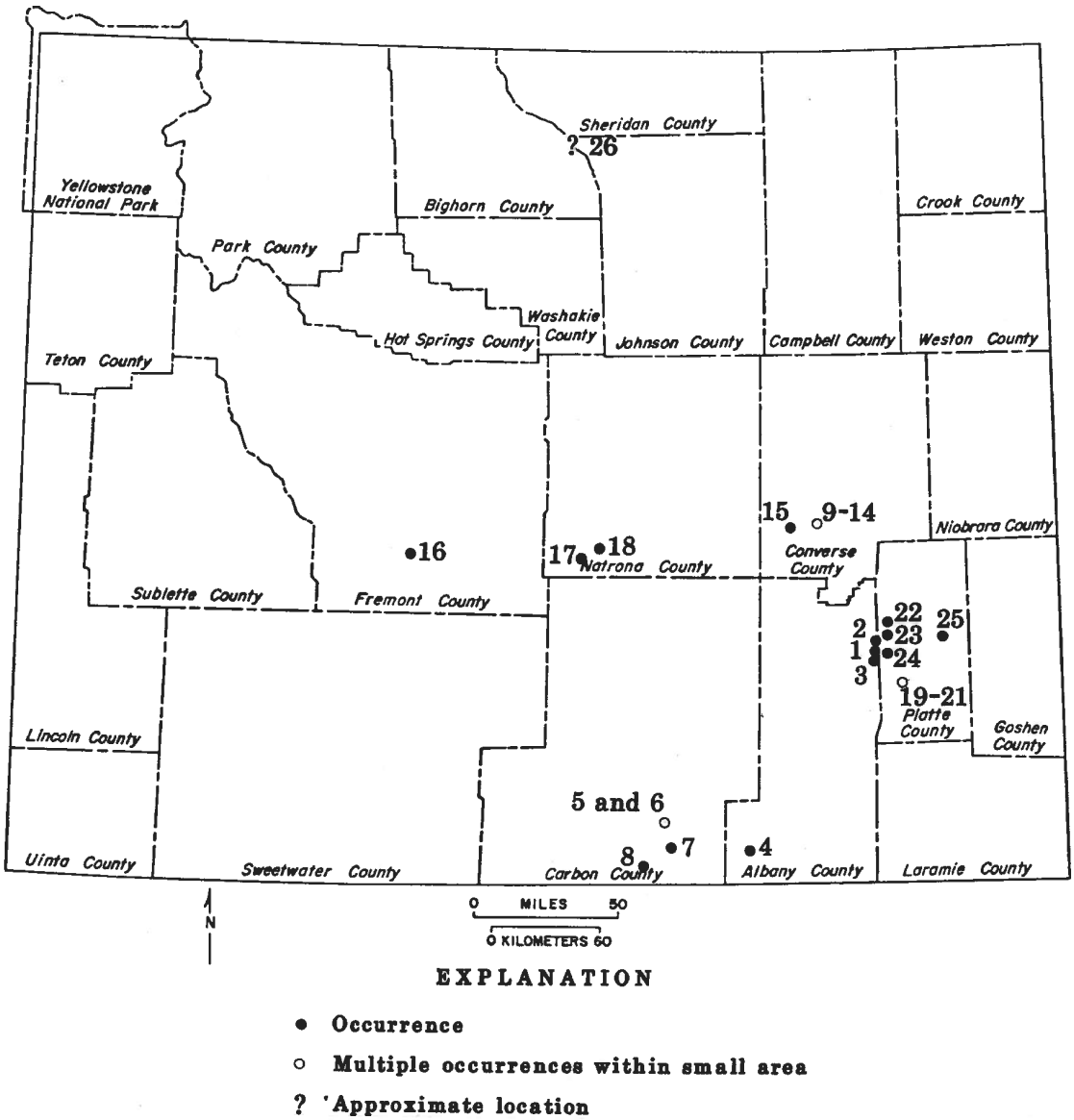

Figure 1. Vermiculite occurrences in Wyoming (numbers refer to numbers assigned to each occurrence in the text).

actinolite were also produced at this locality. The vermiculite is found in large flakes to thin scales and it is bronze, greenish brown, and light to dark brown in color. Admixed chlorite lowers the value of the vermiculite in some places (Hagner, 1944). Beneficiation may improve the quality of the ore.

The mine was developed by three shafts 65, 95, and 105 feet deep. Several drifts extend off the shafts. Several 40-foot-deep pits were developed at the surface (Hagner, 1944). There has been no drilling or serious testing on this deposit to explore its viability as a large open pit operation.

The deposit is near paved Wyoming Highway 230 and is about 20 miles from a railhead at Saratoga. It is located near the North Platte River at an elevation of 7,750 feet. The deposit may extend north under the North Platte River to the Paine occurrence (Houston, 1970, Hagner, 1944), described below.

6. Paine occurrence (sec. 9, T.15N, R.83W).

This occurrence may be a continuation of the "Mikolite" deposit above (Houston, 1970; Hagner, 1944). If so, this area could host a very large vermiculite resource (including the resources at depth between the occurrences).

Vermiculite occurs in this deposit at the contact between biotite-hornblende schist and granite pegmatite. The remains of a mill, numerous open cuts, and a caved-in adit indicate that this deposit was worked in past years, but no production figures from this early mining are available (Hagner, 1944).

7. Platt Ranch (sec. 3, T.13N. R.82W).

The greatest amount of vermiculite-production in Wyoming came from this section. Vermiculite was mined and exfoliated at this site from 1941 to 1944 (Hagner, 1944). After 1942, the Mikolite Company acquired the mining and processing rights to this area, conducted additional tests, and produced about 2,000 tons of vermiculite before 1951. In 1949, the Mikolite Co. began constructing an exfoliation plant in Encampment. The vermiculite was also shipped to exfoliation plants in Kansas (Young, 1952).

Vermiculite occurs in hornblende-quartz diorite adjacent to granite pegmatite that strikes northwest-southeast. The deposit was mined by underground methods. An adit leads to a main drift 133 feet long with numerous side drifts. In 1943, the drifts were still in vermiculite (Hagner, 1944). In 1948, drilling by the Mikolite Co.outlined another body of vermiculite that extended below a 50-foot drilling depth (Platt, 1949).

In 1949, the U. S. Bureau of Mines conducted a surface trenching and drilling analysis of the property, including an amenability test to determine the best means of beneficiating and expanding the vermiculite (Young, 1952). The results of this survey indicated that the ore can be beneficiated and processed for a high-quality product. However, this plant did not achieve full production. More recent improvements in beneficiation techniques may make an additional study of this property worthwhile.

8. SW 1/4 sec. 29, T.13N, R.83W.

Ferris (1964), reported an occurrence of vermiculite at this locality. Forty-four tons of vermiculite were removed in the years 1928 and 1929. The vermiculite occurrence grades east into a kyanite-bearing pegmatite dike. The vermiculite of economic importance was completely removed (Ferris, 1964).

Converse County

Vermiculite occurs in Converse County in the Glenrock mining area south of Glenrock in the Laramie Mountains. Small amounts of vermiculite were shipped from this area before 1943. Occurrences in this area differ from others in Wyoming in that the altered rock is serpentinite (Hagner, 1944). Asbestiform minerals and asbestos are often present in this type of deposit.

9. Smith Mine occurrence (sec. 20, T.32N, R.75W).

A number of large pits, and a 92-foot deep shaft connected to a 100-foot drift were developed on this vermiculite body. 1,539 tons of vermiculite were shipped from here between 1938 and 1943 (Hagner, 1944).

Vermiculite occurs at the folded contact of serpentine and granite. Vermiculite is also present at the contact of hornblende-bearing rocks and pegmatite. The vermiculite is light to dark brown, flexible, and varies in flake size (Hagner, 1944).

10. McCoun-Wells-Rhoads occurrence (Washakie Lode, secs 13 and 14, T.32N. R.76W).

Serpentinite and altered hornblendite or hornblende diorite have been altered locally to vermiculite adjacent to granite pegmatite. About 400 tons of vermiculite were produced from this area before 1944 (Hagner, 1944). According to Jenkins (1938), the vermiculite body exposed here was the largest discovered as of that date in the Converse County area.

11. Lucky Lode (sec.13, T.32N. R.76W, adjacent to the McCoun-Wells-Rhoads occurrence.

Serpentinite and hornblendite were altered to vermiculite in this area. A small amount of vermiculite was removed from this property (Hagner, 1944).

12. Beach prospect (sec. 33, T.32N, R.75W).

Several small pits on this property expose vermiculite in contact with a gray and a pink granite. No mafic rock is exposed (Hagner, 1944). However, Jenkins (1938) reported that the vermiculite was associated with a metadiabase rock containing biotite.

13. Badger prospect (sec. 29, T.32N. R.75W, near Serpentine Hill.

Vermiculite is found adjacent to a large pegmatite dike in this locality. It grades through talc schist into altered diabase. Serpentine is found with vermiculite in some areas (Page T. Jenkins, *in* Hagner, 1944). Jenkins (1938) reported that the locality was locally named Serpentine Hill and that some of the serpentine bodies had no vermiculite associated with them.

14. Stardust (sec. 20, T.32N, R.75W).

Jenkins (1938) reported that masses and lenses of vermiculite were found in altered serpentine at this locality. Gold colored vermiculite is found in bands and flakes in impure talc schist, clusters of vermiculite plates are found embedded in a granite pegmatite, and metadiabase grades into vermiculite (Jenkins, 1938).

15. Koch occurrence (sec. 15, T.31N. R.77W).

A tunnel 300 feet long was driven into a serpentinite body at this location (caved in 1942). The serpentinite is cut by several granite pegmatites.

Vermiculite is present in zones up to 8 inches wide bordering the pegmatites (Clabaugh, 1946, Hagner, 1944, Beckwith, 1935).

Fremont County

16. Abernathy prospect (Beaver Creek asbestos prospect, sec. 19, T.30N, R.96W).

A tunnel 70 feet long and several pits were developed on an asbestos and vermiculite body formed at the contact of granite with a serpentinite body. The vermiculite body is 25 feet wide, and its length and depth are unreported (Hagner, 1944; Beckwith, 1935).

Natrona County

17. Sec. 9, T.30N, R.87W (Vermiculite Sales Corporation, no. 1)

Fine-grained vermiculite occurs at the contact of biotite schist and granite and granite pegmatite. The biotite schist appears to be altered hornblende schist. Vermiculite is also present in bands and lenses enclosed by granite.and in pegmatite. A tunnel 40 feet long and several pits were developed on this property by the Vermiculite Sales Corporation in the early 1940s, and small amounts of vermiculite were mined and shipped from this property (Hagner, 1944). Clabaugh (1946) noted that 225 tons of vermiculite was the total production from this mine and all the production was recorded in 1941.

18. Sec. 6, T.31N. R.86W (Vermiculite Sales Corporation, no. 2).

Hagner (1944) reported that vermiculite occurs on this property in narrow zones and lenses in granite. The vermiculite was probably altered hornblende schist that was assimilated by the intrusive granite. Several pits were developed on the property by the Vermiculite Sales Corporation in the early 1940s, and small amounts of vermiculite were produced (Hagner, 1944).

Platte County

Cooney Hills area in T.23N. R.69W.

Bothner (1967) reported that numerous vermiculite bodies are present in the Cooney Hills. The parent rocks for the vermiculite are biotite schist or hornblende schist. In almost every occurrence, the vermiculite is in contact with granite gneiss or pegmatite. Locally, garnets up to 5 inches in diameter are present in the vermiculite bodies. Specific locations of vermiculite in the Cooney Hills were mapped by Bothner (1967). Three examples are given below (occurrences 19, 20, and 21).

19. J. B. C. occurrence (sec. 9, T.23N. R.69W).

Vermiculite occurs at this location at the contact between gray granite and hornblende or biotite schist. The vermiculite is dark brown and occurs in coarse flakes to thin scales. Several hundred tons of vermiculite were mined from this locality from several open pits (Hagner, 1944).

20. Roff occurrence no. 2 (sec. 9, T23N, R.69W).

This occurrence of vermiculite is near and geologically similar to the J. B. C. occurrence above. Less than one hundred tons of vermiculite were produced before 1943 from a 42-foot-deep shaft that connects to a short crooked drift (Hagner, 1944).

21. McDougal occurrence (sec.8, T.23N R.69W).

About one hundred tons of vermiculite were shipped from several pits on this property before 1943. The claims are near, and identical in geology, to the J. B. C. occurrence described above (Hagner, 1944).

22. Dixie Queen (sec. 17, T.25N R.70W).

Vermiculite is found at the contact of a granite pegmatite with a highly altered rock of undetermined type. Talc, anthophyllite, and chlorite are found in the area, indicating that the altered rock may be extremely altered serpentine. Small amounts of vermiculite were produced from small open pits on this claim (Hagner, 1944).

23. Palmer Canyon occurrence (sec. 8, T.24N, R.70W).

Hagner (1944) reported that vermiculite is present in a zone of altered hornblende schist adjacent to granite. The vermiculite zone is three feet wide, and increases to 6 feet wide at a depth of 12 feet as seen in an open pit. Several tons of vermiculite were shipped from this property.

24. Slate Creek area (NW 1/4 sec. 8, T.23N, R.70W).

Toogood (1967) reported that the open pit mapped at this location exposes a small pod of vermiculite. Toogood did not mention the grade or size of this occurrence.

25. Vaughn-Hyslop occurrence (sec. 28, T.25N, R.66W).

This occurrence is just south of the Grayrocks Road on the north side of a hill in which altered Precambrian rocks are exposed. Hagner (1944) reported that three pits are present in the area. In 1989, two of the pits were almost completely filled with windblown sediments. Brush and other vegetation and wall collapse obscures the geological relationships in the third pit. Hagner (1944) reported that vermiculite is present in altered hornblende schist near its contact with granite pegmatite. Some vermiculite was produced from this property in the early 1940s.

Sheridan County, Johnson County, or Big Horn County

26. Grub Stake Syndicate Prospect, located 29 miles southwest of Sheridan.

Vermiculite in "small quantities" occurs at the contact of hornblende schist with granite (Hagner, 1944). A number of small pits have been dug in the area, exposing the vermiculite. No more exact location is given for this occurrence (Hagner, 1944). A location 29 miles directly southwest of Sheridan is in Big Horn County. It is more likely that the 29 miles are road miles and the occurrence is on the east side of the Bighorn Mountains, near the Sheridan-Johnson County line.

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