FILE NAME: Orton (ORT)

DATE: 1940

DOC#: ORT017

DOCUMENT DESCRIPTION: Bulletin – American Ceramic Society

Experiments indicate that 950° to 1000°C. is the minimum safe operating temperature of the graphite resistor in the present silicon-carbide protection tube assembly.

(3) Self-Cooled Silicon-Carbide Resistors in a Continuous Tunnel Kiln

Provisions were made for operating the continuous kiln using silicon-carbide resistors (the only commercial nonmetallic heating element on the market at present) equipped with self-cooled terminals to give a comparison with behavior and operating characteristics of the graphite resistor.

A check at cone 13 down on a 60-hour schedule showed 11.2% less power input with the silicon-carbide than with the graphite resistors, a condition that probably was due to the smaller cross section of the graphite terminals, which allowed a relatively low heat transfer and radiation loss through the terminals.

At 1176 hours, the silicon-carbide resistors showed an average resistance increase of 46.9%. This study is being continued.

Electrotechnical Laboratory
Bureau of Mines
Norris, Tennessee

SUMMARY OF OCCURRENCE, PROPERTIES, AND USES OF VERMICULITE AT LIBBY, MONTANA*

By W. Wurth Kriegel

Abstract

Vermiculite is the name of a group of micaceous, hydrated silicates which are the alteration products of micas. The Libby mineral resembles jefferisite. Chemical analyses are given, and the history of the deposits is briefly reviewed. The mineral, which occurs in a stock intruding the Algonkian Belt series of the valley, is used principally in thermal insulation and also for acoustical and dehydration purposes. The coefficient of thermal conductivity varies between 0.26 and 0.35, the P.C.E. value is 11, and the coefficient of sound absorption varies from 0.34 to 0.58.

I. Introduction

Vermiculite is neither a rare nor a newly discovered mineral group, but until recent years it has remained a mineralogical curiosity without any particular value or use. With increasing public and industrial interest in thermal insulation in the last few years, vermiculite has become an important insulating material.

II. Mineralogy

Vermiculite is the group name of a number of micaceous minerals, all of them hydrated silicates. The chemical composition is indefinite, varying with the composition of the original mineral and the degree of alteration. When the dried material is heated to redness, it exhibits the characteristic property of all vermiculites, i. e., great expansion.

Dana[1] lists fourteen varieties from various sources. The Libby vermiculite appears to resemble most closely the physical properties of jefferisite which Dana describes as follows: "In broad crystals or crystalline plates. Surface of plates often triangularly marked by crossing lines 60 and 120 degrees. Cleavage: basal, eminent. Flexible, almost brittle. H = 1.5. G = 2.30. Luster pearly on cleavage surface. Color dark yellowish-brown and brownish-yellow; light yellow by transmitted light; also greenish-yellow."

Chemical analyses of the Libby vermiculite are shown in Table I.

Table I

Chemical Analyses

Column (1) analysis by J. C. Meyer, chief chemist, Great Northern Railway Co.; (2) analysis by National Bureau of Standards; and (3) analysis by Universal Insulation Co.

	(1)	(2)	(3)
Silica	42.8	41.0	42.6
Alumina		18.0	19.0
Iron oxide	26.2	7.0	7.2
Calcium oxide	1.9	1.0	1.9
Magnesium oxide	24.6	21.0	24.6
Sodium and potassium oxides	3.6	1.0	3.8
Moisture	0.7	11.0	
Total	99.8	100.0	99.1

III. History

Though many deposits of vermiculite have been found throughout the United States, including North Carolina, South Carolina, Colorado, New Mexico, California, Idaho, Wyoming, the New England States, and other parts of Montana, the history and development of the industry are closely allied with that of the Libby deposits and companies. The Libby deposits are reputed to have been discovered by the late E. N. Alley while he was prospecting for vanadium minerals during the World War. It is said that the heat of his candle caused the coarse, micalike mineral to swell and assume a golden color. He called the material "feather gold."

* Presented at the Golden Gate Meeting, American Ceramic Society, San Francisco, Calif., August 11, 1939. Received August 15, 1939.

Published by permission of the Director, Montana Bureau of Mines and Geology.

[1] E. S. Dana, System of Mineralogy, Descriptive Mineralogy, 6th ed., pp. 664–68. John Wiley & Sons, Inc., New York, N. Y., 1892.

Mr. Alley and a
Company to explo
began to market
The mine and plan
research laborator
and contracts, the
panding plants th
the Universal Insu
of the Vermiculit
Mont., and operat
Zonolite Company
had a similar distr
tory at Chicago. I
were combined in
Zonolite Insulation
trade names of "Z
being manufacture
cities; the mineral
and Australia; and
Africa and France.
in many other coun

(1) Topography

The deposits ar
east of Libby in t
Valley, two miles a
from the main high
valley widens near
of several small br
feet or more above

(2) General Ge

According to Pa
Valley "is underlai
that apparently are
along the Kootenai
are described in det
say further that th
in general exhibit m
that trend northw
belong to the Algon
A stock compose
and one-third syeni
trudes the Belt ser
miles of this area.
quent alteration has

(3) Occurrence a

Generally, vermic
altered igneous rock
rock. It occurs in
the Rainy Creek dis
The deposits exten
The east end (worke
contains a high con

[2] J. T. Pardee and
lite and Other Mine
Libby, Mont.," *U. S.*
29 (1928); see pp. 18
[3] F. C. Calkins, "G
Idaho and Northweste
(1909); p. 76.

Mr. Alley and a group of associates formed the Zonolite Company to exploit these deposits. In 1925, the Company began to market the expanded material in a small way. The mine and plant were operated at Libby and a plant and research laboratory at Detroit, Mich. Through licenses and contracts, the unheated material was supplied to expanding plants throughout the United States. In 1934, the Universal Insulation Company acquired the holdings of the Vermiculite and Asbestos Company of Libby, Mont., and operated properties adjacent to thdse of the Zonolite Company. The Universal Insulation Company had a similar distribution system with offices and laboratory at Chicago, Ill. In May, 1939, the two companies were combined in a new company called the Universal-Zonolite Insulation Company. The products, under the trade names of "Zonolite," "Unifil," and "Porosil," are being manufactured in nineteen American and Canadian cities; the mineral is being exported to England, Brazil, and Australia; and there are projected plants in South Africa and France. The expanded products are being sold in many other countries.

(1) Topography

The deposits are approximately seven miles northeast of Libby in the lower part of the Rainy Creek Valley, two miles above its mouth. A service road leads from the main highway along the Kootenai River. The valley widens near the deposits owing to the junction of several small branch valleys. Mountains rise 1000 feet or more above the drainage level.

(2) General Geology

According to Pardee and Larsen,[2] the Rainy Creek Valley "is underlain chiefly by argillite and quartzite that apparently are the equivalents of the rocks exposed along the Kootenai River west of Libby." These rocks are described in detail by Calkins.[3] Pardee and Larson say further that the rocks in the Rainy Creek Valley in general exhibit moderately steep dips and open folds that trend northwestward and that they "doubtless belong to the Algonkian Belt series."

A stock composed of about two-thirds pyroxenite and one-third syenite and their alteration products intrudes the Belt series and underlies about six square miles of this area. Pardee and Larsen say that subsequent alteration has taken place over wide areas.

(3) Occurrence and Development

Generally, vermiculite is an alteration product in altered igneous rocks and is distributed throughout the rock. It occurs in certain places in large bodies as in the Rainy Creek district.

The deposits extend in a generally east-west direction. The east end (worked by the former Zonolite Company) contains a high concentration of vermiculite. Large bodies run as high as 95% vermiculite. In these areas of high concentration, however, cores of partially altered biotite which expand poorly are encountered. This portion of the deposit has been developed by numerous pits, ranging from 25 to 40 feet deep and 100 to 250 feet long (Fig. 1). The property has been developed further by a 400-foot adit, which is 400 feet under the surface at the face and is reputed to be in good-quality material.

The west end of the deposits (operated by the former Universal Insulation Company) shows few accumulations of biotite. A series of syenite dikes, ten to fifty feet apart and roughly conformable in strike with the ore zone, block off the ore. The concentration of vermiculite varies from 30 to 60% with pockets of higher concentration. These dikes are thought to have been the source of solutions that altered the pyroxenite in whole or in part into vermiculite in this end of the zone.[4] A second series of dikes intersecting the ore body consists of material high in amphibole asbestos with less altered pyroxenite. Where the concentration of asbestos is sufficiently high, it is mined and marketed. The vermiculite is a minor constituent of this zone.

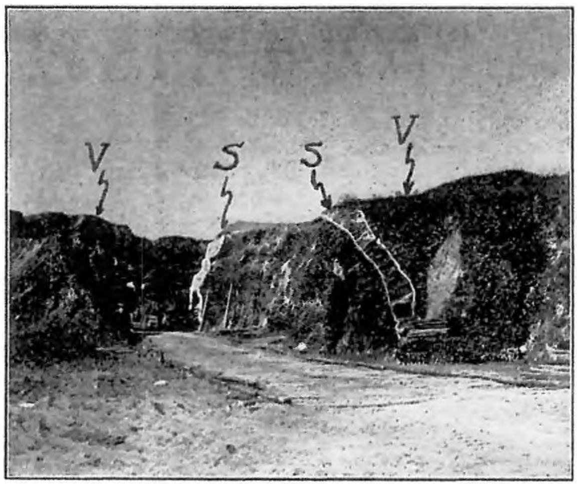

FIG. 1.—Portion of a pit in the Zonolite workings showing syenite dikes, *S*, cutting through the vermiculite, *V*.

IV. Mining and Concentrating

The Zonolite Company mined the ore by hand shoveling, selecting only the very high-grade rock; the Universal Company mined the deposits by power shovel on 30-foot benches between the syenite dikes. The dikes were toppled over periodically and trucked to a waste dump. The consolidation of the two companies, which has placed the entire deposit consisting of a mountain approximately 1000 feet high and a square mile in area under a single management, makes possible a more efficient plan of mining. At present, a $1^1/_4$-yard, Northwest gasoline shovel is leveling off the top of the

[2] J. T. Pardee and E. S. Larsen, "Deposits of Vermiculite and Other Minerals in Rainy Creek District, near Libby, Mont.," *U. S. Geol. Surv. Bull.*, No. 805-B, pp. 17–29 (1928); see pp. 18–24.

[3] F. C. Calkins, "Geological Reconnaissance in Northern Idaho and Northwestern Montana," *ibid.*, No. 384, 112 pp. (1909); p. 76.

[4] P. M. Tyler, "Minor Nonmetals: Graphite, Greensand, Kyanite, Mineral Wool, Monazite, Strontium Minerals, Vermiculite, and Wollastonite," U. S. Bur. Mines Minerals Yearbook, p. 1072 (1936).

mountain, preparatory to cutting the mountain down in 25-foot horizontal cuts; the ore is trucked down the mountain to the mill on the west slope; waste rock is discarded on barren ground. During the summer and fall months, approximately 250 tons of ore are being mined in an 8-hour day which supplies the mill for 24 hours.

The concentrator used was built by the former Universal Insulation Company. The ore from the mine is dumped on a grizzly, 28 by 3 feet in size with 4-inch openings. The oversize rolls out to the waste pile and the − 4-inch material falls into a 1000-ton steel bin. An apron feeder feeds to a 24-inch inclined belt conveyer, which carries the material to the top of the mill building, discharging into a trommel, 4 by 8 feet with $^3/_4$-inch openings. The oversize goes to waste and the undersize to a jigger screen with $^1/_2$-inch openings; the oversize of the screen passes through one of two hammer mills. The two products pass through a baffled, conical-shaped, oil-fired, flash drier, operating at 300°F., which removes the surface moisture of the vermiculite. The dried material is much easier to screen. From the drier, the material passes through a battery of two Hummer screens. The products are raised by two bucket elevators and are passed through a battery of four Hummer screens which size the material for the separators.

Thirty-two specially built air-separators, making a concentrates, a middlings, and a tailings product, remove the greater bulk of the waste rock. The middlings product, which consists mainly of small, thick books of vermiculite, is returned to the hammer mills for further grinding. The concentrates product passes directly into a 5- by 16-foot, oil-fired, Link-Belt rotary drier. All excess moisture that is not needed for the subsequent expansion of the vermiculite is removed. The moisture content of the vermiculite is periodically checked in the laboratory. The material passes from the drier through a triple-deck, jigger screen, which delivers the vermiculite into the four commercial sizes, designated as 1A, 1, 2, and 3, which are $-^1/_2$-inch to +3-mesh, −3 to +14, −10 to +20, and −16 to +24-mesh, respectively. The 1, 2, and 3 sizes pass through separate air-separators and then to storage bins. All waste rock is transported to a waste dump by a belt conveyer.

Two counter-balanced, $1^1/_2$-ton cars lower the sized concentrates along a 2800-foot incline to receiving bins at the foot of the mountain, and they are trucked about 8 miles to Libby where they are shipped in box cars or placed in storage. The present storage capacity is 2500 tons, but additional bins are being constructed.

The concentrator operates most economically on ore containing from 50 to 60% of vermiculite, produces 125 to 160 tons of concentrates per 24-hour day, and makes an 80% recovery. The principal loss is in the fine sizes for which at present no adequate market has been developed. The electric power for the mill is generated by two direct-connected, Superior, 215-h.p. Diesel engines. One of these engines also drives a Seroco fan, which delivers 8000 cu. ft. of air per minute to the air separators. Repairs on the equipment are made on Sundays when the mill is closed. The estimated production of the company for 1939 is 20,000 tons of concentrates.

Constant checks on the quality of feed and product are made in a small field laboratory. The expansibility of the ore, the percentage of waste rock, and the total water content of the vermiculite are determined.

V. Exfoliation

When vermiculite is heated to redness, it expands to corklike pieces of material, increasing up to sixteen times the original volume. Tyler[6] states that "experience seems to indicate that no vermiculite product after exfoliation, weighing more than 6 lb. per cu. ft., can be marketed successfully, and although there are many deposits of material that will show a considerable expansion on heating, few yield material that expands sufficiently to meet this requirement. Many vermiculites, moreover, decrepitate when expanded and fail to yield a blocky, corklike product, such as the trade demands for many purposes."

The reason for the phenomenal expansion of vermiculites has been assigned to the sudden expulsion by the application of heat of the chemically combined water and the water held between the folia of the mineral. The total water left in the mineral must not be reduced to less than 5 or 6% to obtain maximum expansibility.

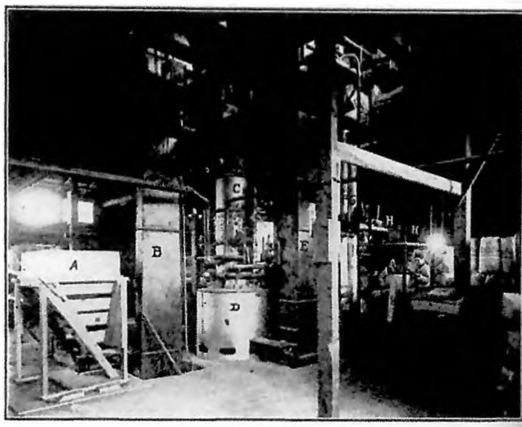

FIG. 2.—Expanding plant of the Unifil Division, Asbestos Supply Co., at Spokane, Wash.

A typical expanding unit is shown in Fig. 2. The vermiculite is loaded into the hopper, *A*, by wheelbarrow. An 8-inch, variable-speed, electric-vibrator feeder drops the vermiculite into the boot of elevator *B*, which discharges it by means of a 3-inch flight conveyer into the preheating chamber, *C*, of the expanding unit. The preheating chamber is a double-walled cylinder, and the inner cylinder contains conical baffles which impede the fall of the vermiculite. The products of combustion from the burners pass up through the falling vermiculite. The air for the gas burners is preheated as it passes through the annular space between

[6] P. M. Tyler, *loc. cit.*, pp. 1069–70.

the two walls of the preheating chamber. The six burners using preheated air and artificial gas discharge directly into primary expanding chamber, *D*, and maintain a temperature of approximately 2000°F. The expanded vermiculite is removed by a 6-inch flight conveyer and is delivered to the boot of elevator *E*, which discharges via a chute to two bagger bins, *H*. To remove any rock or unexpanded vermiculite, a small fan forces air upward through pipe *F* through a slot opening in the bottom of the chute to the bagger bins. Directly below the slot and closing off the lower half of the chute, there is a 12-mesh screen over which the expanded vermiculite is carried by the force of the air current. The rock, being heavier, falls against the air-stream down pipe, *G*.

The unit is capable of expanding 500 bags, 4 cubic feet in size and weighing approximately $5^1/_4$ lb. per cu. ft. The tops of the two elevators and the expanding unit are connected to an exhaust fan which removes the dust. The dust loss is approximately 2% and the rock loss 7% in the operation.

VI. Uses and Properties

As usual with new products, many uses have been suggested and are being tried with varying degrees of success. The principal use has been as "loose-fill" insulation for dwellings and buildings, refrigerators, and furnaces. Size No. 1 is used for these purposes. Table II gives the thermal-conductivity values of the material.

TABLE II

THERMAL CONDUCTIVITY OF LOOSE-FILL EXPANDED VERMICULITE

Test No. 1 is "Unifil," tested by P. C. Peebles, mechanical engineer, Armour Institute of Technology, Chicago, Ill.; Nos. (2) and (3) represent "Unifil," tested by W. T. Miller, professor of heating and ventilating, Purdue University, Lafayette, Ind.

	(1)	(2)	(3)
Density (lb./cu. ft.)	6.2	5.59	5.59
Mean temperature of test (°F.)	24	70	90
Thermal conductivity (B.t.u./hr./°F./sq. ft./in.)	0.317	0.245	0.263

Size No. 2 is being used for aggregate in insulating plasters, in insulating concrete for basement floors and furnaces, and in the tropics for homes. This size is also being used with suitable binders, generally cement, high-alumina cements, etc., for heavy-duty insulating brick on furnaces. The fusion temperature of vermiculite is cone 11. With gypsum and similar binders, it is being formed into steam-pipe coverings.

The total output of the smaller size, No. 3, is being used with a wood-fiber base in the manufacture of fire-resistant, insulating wall-boards and acoustical tile.

The large size, No. 1A, finds its chief use in acoustical plasters, wall finishes, and as acoustical tile. Coefficients of sound absorption of a $3^3/_4$-inch loosely compacted layer of Zonolite, for various frequencies of sound waves, are shown in Table III.

TABLE III

SOUND ABSORPTION*

Frequency of test tone	Coefficient of sound absorption
128 dv	0.34
256	.45
512	.58
1024	.57
2048	.56
4096	.56

* Tests by V. O. Knudsen, November 21, 1928.

Some of the less important uses are sound insulation for motor cars, grease lubricant, fillers for tires and rubber goods, and fireproofing.

Depending upon the conditions during the expansion of the material, colors ranging from near silver to gold can be produced. Very fine sizes are being used for extenders in gold and bronze paints and inks and in wall-paper printing.

"Lamisilite" (laminated silica) is produced by leaching unheated vermiculite with hot concentrated sulfuric acid, which leaves nearly pure SiO_2 in flake form. It is used as a dehydrating agent in air-conditioning units and industrial applications. Lamisilite will absorb about 20% by weight of water and may be renewed by heating.

Acknowledgment

The writer wishes to express his appreciation for the courtesies and assistance of R. R. Mount, plant superintendent, Unifil Division, Asbestos Supply Co., Spokane, Wash., and J. B. Meyers, Superintendent of Operations, Universal-Zonolite Insulation Co., Libby, Mont.

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA

THE BULLETIN
OF THE
AMERICAN CERAMIC SOCIETY

Volume 19 MARCH, 1940 Number 3

LEON J. HOUZE, SR., 1857–1940

For story, see pages 104–105

THE BULLETIN OF THE AMERICAN CERAMIC SOCIETY

Volume 19 | March, 1940 | Number 3

CONTENTS

[illegible] Office: 20th & Northampton Sts., Easton, Pa.
[illegible] and Advertising Office: 2525 N. High St., Columbus, Ohio.
[illegible] Office: 2525 N. High St., Columbus, Ohio.
[illegible] on Publications: J. D. Sullivan, *Chairman;* E. E. Marbaker, E. de F. Curtis, W. W. Winship, Ross C. Purdy.

Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription $1.50 a year. Single numbers twenty-five cents.
(Foreign and Canadian postage, 50¢ additional on subscriptions)