

A. Nature of Product

1. From company literature.

CHEMICAL COMPOSITION OF TYPICAL ZONOLITE VERMICULITE ORES

Vermiculite is a micaceous mineral that exfoliates when heated or subjected to certain chemical reactions. It is a hydrated magnesium-aluminum-iron silicate. Possessing a Mohs Scale hardness of 1.5, it is a monoclinic crystal with pseudo-hexagonal characteristics. The largest domestic deposits of vermiculite are located at Libby, Montana, and in the Greenville area of South Carolina, and are operated by the Zonolite Company. The chemical analyses given below show that the vermiculite from the two areas is essentially the same.

	Montana %	South Carolina %
SiO ₂ -----	38.64	38.66
MgO -----	22.68	20.04
Al ₂ O ₃ -----	14.94	17.36
Fe ₂ O ₃ -----	9.29	8.45
K ₂ O -----	7.84	5.24
CaO -----	1.23	0.75
Cr ₂ O ₃ -----	0.29	0.50
Mn ₂ O ₃ -----	0.11	0.12
P ₂ O ₅ -----	trace	trace
S -----	trace	trace
Cl -----	0.28	0.52
H ₂ O -----	5.29	8.71
Total -----	100.59	100.36

Analyses based on oven-dry weight (100°C or 212°F). The relative amounts of oxides were determined by the sodium carbonate fusion method and are listed without reference to actual crystalline arrangement. Free oxides, as such, do not exist in the vermiculite crystal.

The chemical composition of ore and expanded vermiculite are identical except for H₂O content.

2. From letter dated July 7, 1961, addressed to K. E. Dykosi from Benjamin F. Wake, Industrial Hygiene Engineer, Division of Disease Control, State Board of Health, State of Montana.

"Relative to the vermiculite question, several samples collected at the source of all vermiculite mined in the Western United States indicate a free-silica content of less than two percent. Although the dust concentrations might be extremely high, the free-silica content, as noted, is quite low.

In a letter received from Mr. Paul F. Woolrich of the U. S. Public Health Service a

few years back, he described vermiculite as, an essentially hydrous magnesium mica which was usually an alteration product of local phlogopite or biotite micas. Attempts to assign a definite mineralogical formula for vermiculite has been unsuccessful because of its highly variable composition. However, analysis of typical vermiculite from Libby, Montana is as follows:

SiO ₂	41%	Silicate	CaO	1%
Al ₂ O ₃	18%		Na ₂ O	1%
Fe ₂ O ₃	7%		K ₂ O	1%
MgO	21%		H ₂ O (at 105° C)	11%

Phlogopite mica is: $H_2KMg_3Al(SiO_4)_3$

Biotite mica is: $(H, K)_2(Mg, Fe)_2Al_2(SiO_4)_3$

3. Result of analysis of settled dust collected from the B. F. Nelson vermiculite plant in Minneapolis and analyzed by Terrance O'Dougherty in the Minneapolis Health Department laboratory for free silica content only.(February 1961)

Sample 1707 contained 1.12% free silica.

Sample 1708 contained 1.03% free silica.

4. Analysis of products collected at Western Mineral Products by the Aetna Casualty & Surety Company and done in their own laboratory in January 1953 by Miss Darby using their petrographic method.

<u>Product</u>	<u>Free Silica Content</u>
Panacolite	none
Alexite	none
Filter Fines	none
Second Cyclone Aggregate	none
Plaster Aggregates	none

5. Analyzed by Paul Lange, Industrial Hygiene Department, University of Wisconsin January 1950.

Raw Perlite Ore	1% Free Silica
Perlite Plaster Aggregate	1% Free Silica

6. Settled dust samples collected at Western Mineral Products and analyzed by Aetna Casualty & Surety Company in March 14, 1955, using the modified petrographic immersion method as outlined by Ross & Sehl in their "Determination of Free Silica", Analytical Edition, Industrial and Engineering Chemistry, Vol. 7, page 30, January 1935.

Sample No. 1 - Perlite Bagging Area	- no free silica
" No. 2 - " " "	- trace free silica
" No. 3 - " " "	- trace " "
" No. 4 - From box car	- trace " "
" No. 5 - Top of Screener	- no free silica

7. Dust counts made by Aetna Casualty & Surety Company at Western Mineral Products of vermiculite dust of 10 microns in size or less.

#1 - 4.4 Million particles per cubic foot of air
#2 - 4.8 " " " " " " "

#3 - 8.6 Million particles per cubic foot of air
 #4 - 21.4 " " " " " " "
 #5 - 5.1 " " " " " " "
 #6 - 14.6 " " " " " " "
 #7 - 10.5 " " " " " " "

8. Report of a study made by Industrial Hygiene Foundation of America, Inc. on Vermiculite at the Zonolite Company, 23rd Street & P.R.R., Sharpsburg, Pennsylvania in May 1948.

Free Silica content determined by x-ray diffraction analysis was found to be 2%.

The dust counts ranged from 3.2 million particles per cubic foot of air to 105.0 million particles per cubic foot of air.

The only dust counts over 50.0 million particles per cubic foot of air were found associated with unloading of fine ore from the boxcar. The particle size of dust found in the air in the Boxcar area was as follows:

COMMONWEALTH OF PENNSYLVANIA
 DEPARTMENT OF HEALTH
 BUREAU OF INDUSTRIAL HYGIENE

Table 2

Particle size of dust
 (Boxcar)

Zonolite Company
 23rd St. & P.R.R.
 Sharpsburg, Penna.

Size range in microns	Percentage distribution	Cumulated percentages
0.0 - 0.49	20.0	20.0
0.5 - 0.99	28.0	48.0
1.0 - 1.49	18.0	66.0
1.5 - 1.99	8.0	74.0
2.0 - 2.49	6.0	80.0
2.5 - 2.99	4.0	84.0
3.0 - 3.49	2.0	86.0
3.5 - 3.99	0.0	86.0
4.0 - 4.49	4.0	90.0
4.5 - 4.99	0.0	90.0
5.0 - and above	10.0	100.0

Median particle size - 1.1 microns.

9. From letter dated July 7, 1961, addressed to K. E. Dykoski from Benjamin F. Wake, Industrial Hygiene Engineer, State Board of Health, State of Montana. "It might be productive to look into the asbestosis angle, since a portion of the mined ore contains from five to twenty per cent short fibre asbestos. There is an attempt made in the milling process to remove the asbestos which I believe is essentially successful; however, there is no doubt that some of the material is not excluded and would show up in the final product."

B. References and excerpts from the literature on effects of vermiculite and related dusts

1. Copy of Dr. W. E. Park's letter dated March 9, 1961, addressed to Occupational Health Field Headquarters of U. S. Public Health Service, Cincinnati, Ohio.

Dear Sirs:

ATTENTION: MR. DOHRMAN H. BYERS

I am writing you at this time for further information on vermiculite. I have on my files a letter dated May the 27th, 1955, which was addressed to me and signed by Melvin M. Udel, Assistant Surgeon, Clinical Services. This was in reply to my letter inquiring about the clinical effects of vermiculite.

At that time we had a case of pneumoconiosis which was thought to be related to a heavy exposure to vermiculite dust. We have recently had another case of similar pneumoconiosis reported to us. This workman has also been exposed to vermiculite dust of a long period of time. The vermiculite is being produced for use as insulation.

Although the workman involved are in two separate companies, they use the same source of raw product which is the zonolite brand.

I wonder if you can supply me with more recent information in regard to the effects of vermiculite dust, ~~and~~ was outlined in Dr. Udel's letter of May the 27th, 1955.

Through his letter and further articles which I have at hand I have the following references relating to this subject.

- 1) Dreessen, W. C.; Dalla Valle, J. M.; Edwards, T. I.; Sayers, R. R.; Eason, H. F.; and Trice, M. F.; "Pneumoconiosis Among Mica and Pegmatite Workers", Public Health Bulletin, No. 250, D.S.P.H.S. 1940.
- 2) Vestal, T. F.; Winstead, J. A.; and Joliet, Paul V.; "Pneumoconiosis Among Mica and Pegmatite Workers", Industrial Medicine, Vol. 12, No. 1, page 11, January 1943.
- 3) Harihara, C. R.; Gupta, M. N.; and Maniker, N. S.; "Notes on Mica Dust Inhalation", A. M. A. Archives of Industrial Hygiene and Occupational Medicine, Vol. 8, No. 6, December 1953, page 531.
- 4) Parada, A.; "Silicosis Caused by Sepiolite", Med. Secur. Trab., 2: 11-14. January - March 1954, (abstracted in Industrial Hygiene Digest, Vol. 19,

No. 4, page 30, April 1955.)

- 5) Patty, Vol. 1 (Second Revised Edition) 1958, page 361, item 3 bottom of page.
- 6) Vorwald, Arthur J.; "Diffuse Fibrogenic Pneumoconiosis", Industrial Med. & Surg., Vol. 29, August 1960, pp. 353 - 358.

We are proceeding to make a much more detailed investigation of both of these cases of pneumoconiosis and hope to have additional information which we will be glad to share with you."

2. Copy of Dr. Roy L. Gibson's reply to above letter dated March 27, 1961, and enclosure.

"Dear Dr. Park:

Your letter of March 9, 1961, a request for recent literature on the biologic effects of vermiculite, has been referred to me for reply.

I am sorry to say that new information on this subject published during the past five years is quite limited. A need for further study of the relationships between the silicates and pulmonary disease certainly exists.

Enclosed are three abstracts copied from the Industrial Hygiene Digest that were not included in your list of references. Another article that is old but relative to the subject is also mentioned.

Johnstone and Miller in their new book "Occupational Diseases and Industrial Medicine," W. B. Saunders Company, Philadelphia, 1960, classify various pulmonary responses to industrial dusts. Mica is broken down in this manner:

<u>Mica</u>	<u>Physical Characteristics</u>	<u>Chemical Formula</u>	<u>Tissue Response</u>	<u>Possible Entity</u>
Muscovite (sericite)	Crystalline	$K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$	Foreign Body Reaction	Minor silicate pneumoconiosis
Biotite	Crystalline	$H_2K(Mg, Fe)_3 3Al(SiO_4)_3$	Foreign Body Reaction	Minor silicate pneumoconiosis
Vermiculite Plates		Varied hydrated silicates	Foreign Body Reaction	Minor silicate pneumoconiosis

Under their section on Minor Pneumoconioses they discuss the usual pulmonary response to these silicates as consisting of an elaboration of a fine reticulum of fibers forming a loose mesh throughout the packed masses of dust cells. These changes are apparently responsible for an accentuation of linear markings and reticulation that is evident on a chest x-ray examination.

We are very much interested in the results of your pending investigation of the two men exposed to vermiculite dust.

Please do not hesitate to write us again if we can be of further help to you."

1. Pelican, A.: The action of mica dust on pulmonary tissue. J. Ind. Hyg. 16:160, 1934.

2. Ramaswamy, A. S., Venkatish, D. S., and Rama Rao, R.: The nature of lesions caused by asbestos and mica in experimental pneumoconiosis in guinea pigs. J. Indian Inst. Sc. 35, Sect. A., 319, Oct., 1953. (Ind. Hyg. Dig. 18. No. 550, 1954).

Guinea pigs were subjected to intratracheal injections of mica and asbestos dusts. Stress is laid on the development, after long periods, of lesions in other organs besides the lungs, especially in the adrenal glands. Mica dust was found to lead to some degree of nodular formation in the lungs, but the asbestos dust set up diffuse fibrosis only. These differences are portrayed in a series of photomicrographs. Mica induced hypertrophy of the adrenal cortex with extensive foamy disintegration of the cortical cells; asbestos induced lesser changes, but small areas of necrosis were occasionally found in the zona fasciculata and zona reticulata. In a theoretical discussion the authors attempt to draw a relation between the atomic structure of mica and asbestos and the pathological lesions in the lungs and other organs. Their theory, however, leaves many points unexplained.- Cond. from Bull. Hyg.

3. Gupta, M. M.: Silicosis amongst supervisory staff in mica mining in Bihar. Report No. 8 Govern. of India, Ministry of Labor, Office of the Chief Advisor Factories, New Delhi, India. 6pp, 1955. Ind. Hyg. Digest 21: no. 1437, 1957.

The silicosis hazard among the supervisory staff in mica mining was studied. Nodular and conglomerate silicosis was found in 45.2% of the supervisory staff and was fairly well correlated to the number of years spent in underground work. Pulmonary tuberculosis was found in 19% of the supervisory staff.

4. Health Hazards in Mica Processing, India, Government of: Ministry of Labour. Report No. 4. Office of the Chief Advisor Factories, Ministry of Labour and Employment. New Delhi. 11pp, 1954. (Ind. Hyg. Dig. 23: No. 186, 1959).

The production of mica in India increased from 6,000 tons in 1939 to nearly 10,000 tons in 1951 and the industry now employs about 27,000 workers, 16,500 of whom work underground. A recent investigation revealed a high prevalence of silicosis in mica miners. The hazard in mica mining is mainly from free silica and the investigation described in this report was carried out to determine the importance of inhalation of mica dust. Dust measurements taken during the different processing operations were found to exceed the maximum allowable concentration (MAC) for mica of 20 million particles per cubic foot in screening and grinding mica. Chest x-rays of 61 workers, 53 men and eight women were taken; 58 of those studied worked in processing factories and three in mica grinding. Twenty (32.7%) of the x-rays were recorded as showing "linear exaggeration" and 41 (67.3%) "ground glass" appearances. No x-rays showed nodular silicosis and none were recorded as normal. The self-evident conclusion is drawn that it is desirable to keep "the dust concentration of mica within safe limits". As no nodular case was noted in the 61 workers whose average time intensity factor was 360, equivalent to 18 years exposure to 20 million particles per cubic foot, the suggested MAC is considered reasonable. - Cond. from Bull. Hyg.

C. Extracts from case histories

1. W. McM. An employee of Western Mineral Products. Patient of Dr. Thomas Lowry. A long time employee. As maintenance man he had massive exposures to settled vermiculite dust at night which he disturbed during his maintenance work.

From Dr. Lowry's report to the Aetna Casualty and Surety Company dated July 6, 1955. "There is no doubt in my mind that W. McM. suffers from a dust inhalation disease which can be classified as pneumoconiosis, probably due to inhalation of "Vermiculite" over a period of ten years."

"There is ample evidence from the x-ray films that this dust has caused an inhalation disease in the lungs which is finely nodular, fibrotic and almost certainly irreversible, if not actually progressive. In any case the disease has increased in extent between 1952 and the present time (1955)". "There is no evidence of tuberculosis or other significant infection in the lungs."

Mr. W. McM. has had no great vermiculite dust exposure since 1955. In a telephone conversation with Dr. Thomas Lowry in May 1961 it was learned that Mr. McM's chest x-ray picture is unchanged.

2. D. C. - An employee of the B. F. Nelson & Company. He has a history of over 15 years exposure to vermiculite dust. He is a patient of Dr. John T. Kelly. Referred to Dr. John E. Middlebrook in February 1961.

In a telephone conversation with Dr. Middlebrook in early March 1961, it was learned that a diagnosis of silicosis had been made and the patient removed from further exposure to dust. The patient is apparently on compensation.

3. H.E. - An employee of B. F. Nelson & Company exposed to vermiculite dust for 23 years.

He was examined by Dr. Lowell W. Weber in March 1961. Extract from Dr. Weber's report dated March 16, 1961. "Asymptomatic" "Chest x-ray, taken 3-1-61, by Drs. Naslund, Olson & MacDonald is reported as follows: There is a rather granular appearance throughout both lung fields, particularly at the bases, strongly suggesting the possibility of a Boeck's sarcoid or inhalation disease."

Dr. Weber's comment, "It is my opinion that this man unquestionably does have silicosis."

4. P.P.H. - An employee of B. F. Nelson & Company who has been exposed to vermiculite dust for over 15 years.

He was examined by Dr. Lowell W. Weber in March 1961. Extracts from Dr. Weber's report dated March 20, 1961. "Symptoms - cold in chest one year, wheezing, coughs frequently, progressively short of breath during the past year."

"Chest x-ray taken in the offices of Drs. Naslund, Olson and MacDonald, on March 3, 1961, is read as follows: "Negative diagnosis of pulmonary tuberculosis or other infiltration or consolidation involving the parenchyma of the lungs. The markings throughout both lungs show increase in size and density and there is some relative enlargement of both hilum areas over average."

Dr. Weber's comment - "Opinion: This man has a significant impairment of his functional pulmonary reserve. At present, his total lung vital capacity is 65% of the predicted normal. - chronic bronchitis due to smoking, - pulmonary silicosis, secondary to dust exposure at work."

5. J.A.B. - An employee of J. B. Nelson Company who has been exposed to vermiculite dust for 17 years.

He was examined by Dr. Lowell W. Weber in March 1961. Extracts from Dr. Weber's report dated March 16, 1961.

"Progressive diminution of lung reserve, and increase in shortness of breath with exertion, during two year period." "Lung vital capacity 2.6 liters total."

"Chest x-ray, taken 3-1-61, by Drs. Naslund, Olson and MacDonald is reported as follows: Several small pulmonary calcifications are identified and multiple large calcified densities are seen in both hilum areas. Both lower lung fields have a rather diffuse and dense granular appearance. The upper lung fields are much less remarkable. The possibility of a Boeck's sarcoid or an inhalation disease must be considered."

Dr. Weber's comment - "This man has serious impairment of his functional pulmonary reserve, as a result of a combination of silicosis and chronic bronchitis."

6. D.E.Z. - An employee of Western Mineral Products and exposed to vermiculite dust for 14 years.

Seen by Dr. Yue at Glen Lake Outpatient Department. Extract from Dr. Yue's notes "Some cough, dyspnoea on exertion, clubbing of fingers," Film #167301 taken on 1-12-60 "Some diffuse bilateral, finely granular and linear infiltration, most marked at the bases. The hilar shadows appear rather prominent. The possibility of Boeck's sarcoid, pneumoconiosis, or other chronic inflammatory process would have to be considered" "Positive Kveim test". "Biopsy of cervical gland - normal lymph gland".

7. H.I. - An employee of Western Mineral Products and exposed to vermiculite dust for 15 years. Seen by Dr. J. J. Hopperstad in Glen Lake Outpatient Department. Film #182026 taken 5-23-61. Extract from Dr. Hopperstad's notes. "There is bilateral apical pleural thickening with fibroid infiltrate in the right apex. There are pleural thickening and adhesions at both bases with thickened and calcified pleura over the left chest laterally. Numerous small strands of interstitial fibrosis scattered throughout both lung fields, but most marked in the right mid and lower lung field where there appear to be rather large emphysematous blebs."

8. Negative x-ray findings on other workmen who have been exposed to vermiculite dust.

L.W. (film 182687 Glen Lake Outpatient) an employee of Western Mineral Products for 14 years.

R.B. (037382 Mobile Unit, 24th & Central 5-12-61) an employee of Western Mineral Products for 8 years.

T.G. (film 037311 Mobile Unit, 24th & Central 5-12-61) an employee of Western Mineral Products for 15 years.

L.E.H. (film 037314, 24th & Central 5-12-61) an employee of Western Mineral Products for 8 years.