FIBROUS SEPIOLITE FROM YAVAPAI COUNTY, ARIZONA

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Abstract

Data yielded by chemical, optical, and *x*-ray methods of analysis identifies a hydrous magnesium silicate from Yavapai County, Arizona, as fibrous sepiolite. The study of this specimen is of interest because of the further information it yields concerning the nature of sepiolite. The literature may profit from more coordinated chemical, optical, and *x*-ray data on this mineral. The term 'parasepiolite' is justified rather than sepiolite when referring to the fibrous, highly crystalline variety of this material. A rather complete bibliography of sepiolite is included, in addition to the references cited.

Occurrence

The hydrous magnesium silicate described herein occurs in a contact zone situated about a half mile south of the Santa Maria River near the western boundary of Yavapai County and about 40 miles, by road, in a westerly direction from Congress Junction, Arizona.

This locality, in southwestern Yavapai County, is in the ruggedly dissected basin of the Santa Maria River west of the McCloud Mountains, a granite range that attains a height of 4900 feet. The region is composed mainly of granite, gneiss, and schist intruded by various dikes and stocks and overlain in places by mesa-forming lavas.

This deposit was prospected thoroughly by the R. T. Vanderbilt Co., New York, but was found to be too limited in extent for commercial development.

Physical Properties

In a hand specimen this material is white, massive, and compact with a foliated structure. The surface is smooth with a dull luster that assumes a polish with slight rubbing.

The material was studied optically by the immersion method and in thin section, being found homogeneous and free from noticeable impurities. It is completely crystalline without any indication of an 'amorphous' constituent.

In thin section, with plain light, little detail can be seen because of the low relief in balsam and lack of color. Under crossed nicols, however, the truly fibrous structure, similar to serpentine, is made evident. The fibers show a wavy extinction which is essentially parallel to the length, with positive elongation. The birefringence is low and the interference figure is negative, $2V=$ about $40°–60°$.

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The fragments are irregular in outline but have a fibrous structure. The refractive indices are: $\alpha=1.490$, $\gamma=1.505$ ($\pm.003$). These values agree with those given by Larsen and Berman (1934) for parasepiolite (fibrous), namely: $\alpha=1.498$, $\gamma=1.506$. The indices reported by Daly (1935) for fibrous sepiolite are given as $\alpha=1.506$, $\gamma=1.526$, and the type material from Madagascar (Caillere 1933) has a mean index of 1.499.

A comparison of the optical properties of several sepiolites is given in Table 1.

TABLE 1. OPTICAL PROPERTIES OF SEPIOLITE

Specimen	Color	Extinction	Elongation	Indices α	Indices γ	Optic Sign	Axial Angle
(1)	white	parallel	positive	1.490	1.505	neg.	2V=40°–60°
(2*a*)	white	parallel	positive	1.498	1.506	neg.	2V=50°
(2*b*)	white	parallel	positive	1.519	1.526	neg.	—
(3)	white	parallel	positive	1.506	1.526	neg.	—
(4)	white	parallel	positive	1.499		—	—
(5)	gray	parallel	positive	1.531		—	—

(1) Hydrous magnesium silicate, Yavapai Co., Arizona.
(2*a*) Fibrous sepiolite, Larsen and Berman (1934).
(2*b*) Sepiolite, Larsen and Berman (1934).
(3) Fibrous sepiolite, Daly (1935).
(4) Fibrous sepiolite, Mlle. Caillere (1933).
(5) Fibrous sepiolite, W. H. Bradley (1930).

GENERAL DESCRIPTION OF SEPIOLITE

Physically sepiolite is usually described as a white or grayish-white material, compact, with a smooth feel and a fine clay-like texture. Microscopically it seems to be a mixture of a fine fibrous material and an 'amorphous' substance of apparently the same composition. The fibrous material is called alpha or parasepiolite and the 'amorphous' component beta sepiolite.

Daly (1935) describes sepiolite from Crestmore, California, as a white fibrous material. Optically it is composed of finely interlocking fibers that have extinction parallel to the length and refractive indices of $\alpha=1.506$ and $\gamma=1.526$. The chemical formula is given as $2MgO\cdot 3SiO_2\cdot 3H_2O$, with variable water content.

Mlle. Caillere (1933) in describing a fibrous sepiolite from Madagascar indicates that the material is white with a fibrous texture. It has low birefringence, extinction parallel to the length of the fibers, positive elongation, and a mean refractive index of 1.499. Its chemical formula is $2MgO \cdot 3SiO_2 \cdot 4H_2O$.

Sepiolite or meerschaum, as it is known commercially, was first discovered in this country in Grant County, New Mexico (Bush 1915) early in 1875. However, no meerschaum has been produced in the United States since about 1914. The deposits of Eskishehir, in Anatolia, Asia Minor, were the principal source for over a century before this discovery and to this date still supply most of the world's demands (*Minerals Yearbook* 1940). Other commercial deposits are reported in Greece, on the Island of Euboea; in Moravia, Austria; in Spain near Vallecas, Madrid and Toledo; and in Morocco (Sterrett 1907).

Meerschaum was formerly used almost exclusively in the manufacture of smokers' articles. It is now, however, being used as a light weight building material in Spain, elsewhere as a soap substitute, and as a constituent of porcelain ware. According to Dr. Manfred Kraemer (1939) of Newark, New Jersey, magnesium trisilicate (sepiolite) has recently found use, in England and in this country, as a medicament.

Chemical Considerations

Published chemical analyses of sepiolite occur infrequently throughout the literature. In France Mlle. Caillere (1933, 1934), M. Migeon (1936), and M. Longchambon (1937) have recorded a few analyses but most of their efforts have been devoted to hydrothermal studies. In this country W. T. Schaller (1936), Wm. F. Foshag (1928), Douglas Sterrett (1907), and W. H. Bradley (1930) have listed analyses of this mineral.

The relationship between the chemical composition of the hydrous magnesium silicate from Yavapai County and those described by the above authorities is given in Table 2.

Table 2. Chemical Analyses of Sepiolite

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	$H_2O(-)$	$H_2O(+)$	Total
(1)	54.83	0.28	0.45	0.55	24.51	0.35	0.03	8.18	10.74	99.92
(2)	53.10	0.32	1.56	1.27	24.87	—	—	8.42	10.11	99.65
(3)	54.76	0.33	—	—	25.15	—	—	20.17		100.41
(4)	54.37	—	0.98	0.59	24.13	—	—	9.41	10.19	99.67
(5)	54.4	—	—	—	24.4	—	—	8.9	12.3	100.00
(6)	55.34	1.81	0.43	0.24	22.95	—	—	8.60	10.20	99.57
(7)	50.4	—	0.5	1.4	22.5	—	—	24.95		99.75
(8)	57.10	0.58	—	0.17	27.16	—	—	14.78		99.79
(9)	58.40	1.86	—	0.42	26.58	—	—	11.86		99.31*

* Included in this total are TiO_2 0.10% and CO_2 0.69%.
(1) Hydrous magnesium silicate, Yavapai County, Arizona.
(2) Fibrous sepiolite, Madagascar; Mlle. Caillere (1933).
(3) Sepiolite, Dorsey Mine; M. Migeon (1936).
(4) Sepiolite, Coulommiers; Mlle. Caillere (1933).
(5) Magnesium trisilicate (sepiolite) (Macksoud 1939).
(6) Sepiolite, Durango, Mexico; Wm. F. Foshag (1928).
(7) Magnesium trisilicate (sepiolite); Surfleet and Porter (1940).
(8) Sepiolite, New Mexico; Douglas Sterrett (1907).
(9) Sepiolite, Utah; W. H. Bradley (1930).

The silica, magnesia and water content of the analyses demonstrate an apparent similarity. In a consideration of the chemical composition of sepiolite interest is usually focussed on the magnesia–silica ratio. According to Surfleet and Porter (1940) a true magnesium trisilicate (sepiolite) should have a gravimetric ratio of magnesia to silica equivalent to 1:2.24, the allowable limits being between 2.21–2.28. A value of 2.24, identical with the theoretical, was calculated for the Yavapai County mineral. The ratio for sepiolite, free of impurities, is diagnostic of the correct constitutional formula.

The similarity of the water content is also significant. There seems to be a divergence of opinion throughout the literature on the number of water molecules contained in the sepiolite structure. The fibrous variety, known as alpha or parasepiolite, is thought to contain four molecules of water and the so-called 'amorphous' or beta form is thought to contain two molecules of water. Schaller (1936) made a careful study of this particular question and has offered the following explanation: out of 56 chemical analyses of sepiolite, 34 had the water content of alpha sepiolite (four molecules), 15 had the water content of beta sepiolite (two molecules), and 7 were intermediate. It was, however, subsequently found that the specimens with the low water content had been heated in varying degrees, some as high as 200°C., before analysis. These analyses were recalculated and all but four agreed with the alpha form of four molecules of water. This seems to indicate that there is actually only one type of sepiolite and it contains four molecules of water.

The formula of the Yavapai County specimen, as calculated from the chemical analysis, is $2MgO \cdot 3SiO_2 \cdot 4H_2O$ corresponding to the formula assigned to sepiolite and substantiated by Schaller (1936), Mlle. Caillere (1933), M. Longchambon (1935), and others.

X-ray Examination

No adequate summary of the *x*-ray data concerning sepiolite exists in the literature. Therefore it was necessary to compare the powder pattern of the Yavapai County material with a number of known sepiolite patterns. Most of these patterns were secured from the United States National Museum through the courtesy of Dr. Wm. F. Foshag. A partial list of the patterns used in the comparison follows:

Sepiolite—Chester County, Pennsylvania.
Sepiolite—Inyo County, California.
Sepiolite—Durango, Mexico.
Sepiolite—Dorsey Mine, Bears Creek Canyon, New Mexico.
Sepiolite—Bears Mountain, New Mexico.
Sepiolite—Little Cottonwood, Utah.
Sepiolite—Madagascar.

A routine comparison of these patterns with the pattern of the Yavapai mineral indicated their similarity. The position and intensity of each line was in close agreement. It was, however, necessary to calculate the interplanar spacings of each pattern so that an accurate comparison could be made.

The *x*-ray pattern of the Yavapai mineral was obtained by the powder method first using Mo K_α radiation but, subsequently, Cu K_α radiation was employed to obtain the high interplanar spacing values peculiar to sepiolite. The interplanar spacing values using Cu K_α radiation are given in Table 3.

Table 3. Interplanar Spacings of the Hydrous Magnesium Silicate, Yavapai County, Arizona

I	A.U.	I	A.U.	I	A.U.	I	A.U.	I	A.U.	I	A.U.
					Cu K_α						
S	12.3	M	3.75	M	2.61	W	2.05	W	1.55	W	1.31
W	7.52	W	3.53	S	2.55	W	1.95	W	1.51	W	1.29
W	6.75	M	3.35	M	2.44	W	1.86	W	1.49	W	1.27
W	5.02	M	3.18	W	2.38	W	1.72	W	1.46	W	1.25
W	4.51	W	3.04	M	2.25	W	1.69	W	1.43	W	1.00
S	4.29	W	2.82	W	2.18	W	1.66	W	1.40		
M	3.97	W	2.67	W	2.11	W	1.58	W	1.34		

Intensity: S, strong; M, medium; W, weak.

According to M. Urbain (1939) the line at 12.5 Å distinguishes sepiolite because it is definitely fibrous and not a phyllite. Kerr (1937, 1938) has shown that sepiolite is not related to the clay mineral montmorillonite as suggested by De Lapparent (1935, 1936). *X*-ray studies indicate a fibrous structure for sepiolite while montmorillonite and the high magnesia end member saponite have a fine micaceous habit suggesting a sheeted structure. It is thought by Longchambon (1936, 1937) that sepiolite is the main magnesium-bearing mineral of a group known as palygorskites. Other members of this group are altered amphiboles and the finely fibrous minerals asbestos, mountain leather and mountain cork.

M. Longchambon (1937) in describing fibrous sepiolite supports the distinguishing character of this high value by listing the first three lines of the pattern as 12.2 (±0.15) Å, 7.5 (±0.10) Å, and 6.7 (±0.05) Å.

The nature of the pattern of the Yavapai mineral indicates a high degree of crystallinity which is probably characteristic of the fibrous variety of this mineral.

TABLE 4. INTERPLANAR SPACINGS OF SEPIOLITE IN A.U.

(1) Mo K_α	(2) Cu K_α	(3) Mo K_α	(4) Mo K_α	(5) Mo K_α	(6 Mo K_α
—	12.20	—	—	—	—
—	7.6	—	—	—	—
6.77	6.7	6.80	6.75	—	—
5.01	5.05	—	—	—	—
4.50	4.50	4.54	4.52	4.49	4.51
4.29	4.30	4.32	4.29	—	—
3.96	3.83	3.93	3.95	4.05	4.06
3.75	3.60	3.73	3.73	—	—
3.35	3.40	3.34	3.36	—	—
3.17	3.22	—	—	—	3.01
2.76	—	2.68	2.65	—	—
2.60	2.61	2.60	2.58	—	—
2.55	—	2.53	2.54	—	2.54
2.43	2.45	2.46	2.45	2.48	2.45
2.25	2.28	2.27	2.27	—	—
2.11	2.09	2.10	2.09	—	—
1.95	1.97	1.93	1.94	—	—
1.86	1.88	—	—	—	—
1.73	1.71	1.73	1.73	—	1.74
1.66	1.60	1.64	1.66	1.67	—
1.55	1.56	1.54	1.54	—	1.52
—	1.52	—	—	—	—
1.43	1.38	1.43	1.42	1.47	—
—	1.36	—	—	—	—
1.32	1.31	1.32	1.32	1.29	1.32
—	—	—	—	1.25	1.29
—	—	—	—	1.12	1.16
—	—	—	—	1.02	1.05

(1) Hydrous magnesium silicate from Yavapai Co., Arizona.
(2) Sepiolite, D'Ampandrandava; H. Longchambon (1937).
(3) Fibrous sepiolite, Madagascar; Mlle. Caillere (1933).
(4) Average of the United States National Museum specimens.
(5) Montmorillonite; P. F. Kerr (1937).
(6) Saponite; P. F. Kerr (1937).

Table 4 lists the interplanar spacings of the Yavapai mineral in comparison with those of Mlle. Caillere (1933), M. Longchambon (1937) and the average of the Un ted States National Museum samples. The spacings for montmorillonite and saponite (Kerr 1937) are included to show the lack of agreement between the patterns of sepiolite and these two clay minerals.

Summary

It has been the purpose of this paper to present chemical, optical, and *x*-ray data on a hydrous magnesium silicate from Yavapai County, Arizona, which is identified as fibrous sepiolite. The chemical composition as determined by a complete chemical analysis agrees satisfactorily with earlier published analyses for this mineral. The optical properties are in agreement, and the *x*-ray pattern compares favorably with those on record for sepiolite.

In addition to the original purpose, the evidence presented herein justifies the continued use of the term 'parasepiolite' rather than sepiolite when referring to the fibrous, highly crystalline variety of this mineral.

Schaller (1936) offers evidence that indicates there is only one type of sepiolite and its chemical formula is $2MgO \cdot 3SiO_2 \cdot 4H_2O$. There is, however, a variation in the refractive indices of sepiolite and in the number and development of the lines of the *x*-ray pattern. It seems logical to assume that these differences are due to physical rather than chemical conditions. The pattern of the Yavapai mineral consists of many well defined lines which indicate a high degree of crystallinity. This is supported by the lack of any 'amorphous' material as shown by studying fragments and thin sections. Sepiolite has been described, optically, by Michel (1913, 1914) and others as a mixture of a finely fibrous material and an 'amorphous' substance, probably of the same chemical composition. A specimen of sepiolite from Spain with a mean refractive index of 1.531 exhibits a poorly crystallized structure both under the microscope and in its *x*-ray pattern.

The refractive indices and the *x*-ray patterns are influenced by the degree of crystallinity. It seems that well crystallized specimens of sepiolite, free from impurities, have lower indices of refraction and well defined *x*-ray patterns, while an increase in the amount of the 'amorphous' material causes the refractive indices to be higher and the *x*-ray patterns less defined. The continued use of the term 'parasepiolite' for the well crystallized form of this hydrous magnesium silicate is therefore suggested.

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