

SEPIOLITE FROM PLUVIAL MOUND LAKE, LYNN
AND TERRY COUNTIES, TEXAS

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ABSTRACT

Long needles and fibrous bundles of authigenic sepiolite occur in lacustrine sediments of Mound Lake, Lynn and Terry Counties, Texas. Presence of sepiolite in the fine-grained clay sediments is indicated by 12 Å X-ray diffraction, differential thermal analysis, and infrared absorption spectra.

The sepiolite is disseminated in illitic lacustrine clay immediately above a thin dolomite layer dated at $20,500 \pm 650$ years B. P., disseminated in soft sediment dolomite some of which is apparently of Recent age, and disseminated throughout seven to eight feet of Recent playa fill.

Sepiolite probably formed from montmorillonite in the lacustrine sediments when salinity of lake brines became extreme in response to an arid climatic cycle.

INTRODUCTION

Grim (1953, p. 356) considers saline lakes a particularly favorable chemical environment for formation of sepiolite. Bradley (1930), Rogers and others (1956), Sampson (1966), and Millot (1960) report sepiolite in lacustrine sediments. Sepiolite also occurs in post-Pliocene sediment of the Caspian Sea (Rateev and others, 1963), on the Mid-Atlantic Ridge (Hathaway and Sachs, 1965), and in soil developed on lacustrine sediments (Vanden Heuvel, 1966). However, thorough studies of desert lakes in the Western United States failed to find sepiolite. Güven and Kerr (1966) find no sepiolite in Deep Springs Playa, California, Mud Lake and Humboldt Playa, Nevada, Sevier Playa, Utah, or Animas Playa, New Mexico, and extensive studies of Great Salt Lake sediments (Grim and others, 1960; Eardley and Gvosdetsky, 1960) failed to discover any sepiolite. Droste (1961) examined clays from 45 playas in the Mojave Desert, California, and found no sepiolite; therefore, it appears that sepiolite is not as common in saline desert lakes as Grim (1953) indicates.

We have determined the clay mineralogy of sediments from six pluvial lake basins on the southern High Plains, Texas. Sepiolite is positively identified in the Mound Lake basin and tentatively identified in the Tahoka Lake basin. This report is a discussion of the nature and occurrence of the Mound Lake sepiolite.

Pluvial lake basins are widely distributed on the southern High Plains of West Texas (Fig. 1). Reeves (1966) describes major features and general geologic history of the basins. The physiographic province known as the southern High Plains was originally an alluvial apron formed during

Pliocene time by streams flowing eastward from the southern Rocky Mountains of New Mexico. These alluvial Pliocene deposits comprise the Ogallala Group consisting of the Bridwell and underlying Couch Formation. Secondary deposition of carbonates in the upper Bridwell forms a resistant caliche. Mound Lake basin was apparently formed by breaching of the caliche by Pleistocene pluvial streams, enlarged by solution and wind deflation, and then filled with black organic rich muds, black argillaceous silt, black clay with lenses of gypsum, sand, gravel, dolomite,

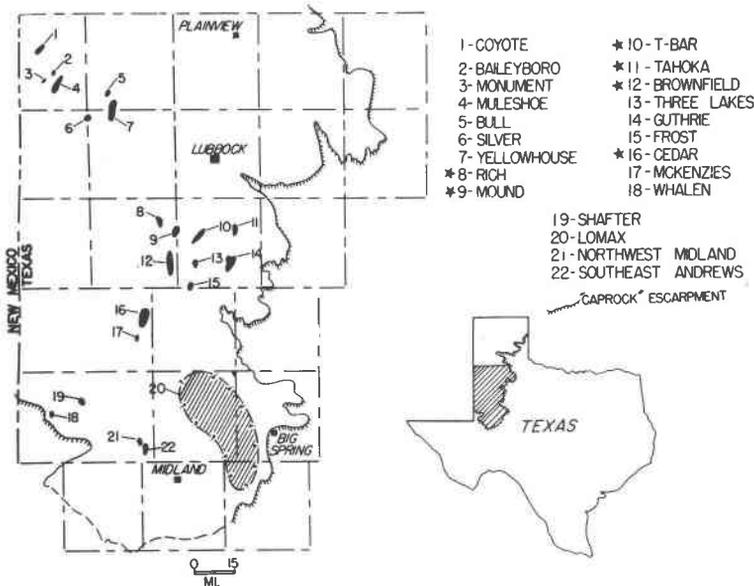


FIG. 1. Index map of pluvial lakes on the southern High Plains.
 Stars indicate lake basins searched for sepiolite.

and volcanic ash. Wind deflation removed up to 39 feet of sediment from Mound Lake during the Altithermal, beginning 6,500 years B. P., so that most of the present playa surface exhibits only a veneer of Recent debris 7 to 8 feet thick. Lowermost lacustrine strata are probably of pre-Wisconsin age.

The most abundant clay minerals in Mound Lake are mica, montmorillonite, interstratified mica-montmorillonite, kaolinite, and sepiolite. Glauconitic mica has also been observed in some auger samples (Parry and Reeves, 1966). Sepiolite occurs throughout the 7 to 8-foot veneer of Recent debris, with soft sediment dolomite on the northeast shore, and above a thin indurated dolomite on the west shore with a radiocarbon

age of 20,500 years B. P. Sepiolite is intimately mixed with mica and interstratified mica-montmorillonite in each occurrence.

SEPIOLITE ANALYSES

Mound Lake clays containing sepiolite were obtained by hand auger, core, and from surface outcrop of lacustrine strata. These samples were disaggregated using a high speed mixer and washed in distilled water until all soluble salts were removed. The clays were calcium saturated by repeated washing in 0.3 molar CaCl_2 solution followed by 20 percent glycerol solution for glyceration. Clays were potassium saturated by repeated exposure to 0.3 molar KCl solution. After removal of excess soluble salt, each sample was dispersed with calgon, and size separation at 5μ , 2μ and 0.2μ was accomplished by sedimentation. X-ray mounts were prepared by sedimentation on glass slides or packed as randomly oriented powders.

X-ray diffractometer traces of oriented Mound Lake clay are shown in Figure 2. The presence of sepiolite is indicated by a 12 \AA X-ray diffrac-

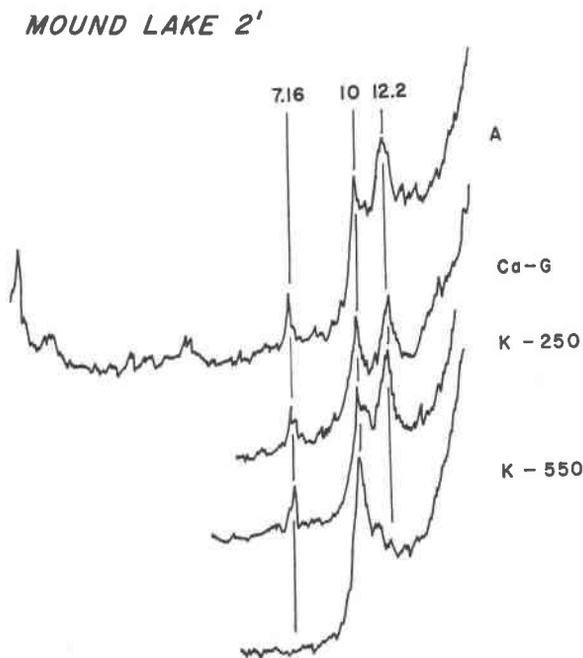


FIG. 2. X-ray diffraction patterns of Mound Lake sepiolite. A, air dried; Ca-G, calcium saturated and glycerated; K-250, potassium saturated and heated to 250°C ; K-550, potassium saturated and heated to 550°C . Ni filtered Cu radiation, 1° per minute scanning speed, scale factor 4, multiplier 0.8, time constant 4.

TABLE 1. X-RAY POWDER DATA FOR SEPIOLITE

(hkl)	Little Cottonwood, Utah (Brindley, 1959)		Mound Lake, Texas		
	d(A)	I	d(A)	I	
110	12.05	100	12.20	65	S
130	7.47	10			
200, 040	6.73	5			
150	5.01	7			
060	4.498	25	4.485	80B	S, M
131	4.306	40	4.320	19	S, M
330	4.022	7	4.020	13	S
260	3.750	30	3.770	14	S
241	3.533	12	3.530	12	S
080	3.366	30	3.343	44	S, M, Q
331	3.196	35	3.219	51B	S
261	3.050	12	3.042	3	S
370	2.932	4			
081	2.825	7			
421	2.771	4			
0.10.0, 510	2.691	20			
441, 281	2.617	30			
530	2.586	NR			
112, 371, 191	2.560	55	2.575	100B	S, M
2.10.0	—				
132	2.479	5			
202, 042	2.449	25	2.458	7	S
1.11.0, 222, 461	2.406	15	2.404	16	S, D
062, 312, 2.10.1	2.263	30			
620, 570, 332	2.206	3	2.194	29	S, D

B-Broad, S-Sepiolite, M-Mica, Q-Quartz, D-Dolomite, NR-Not Resolved. Other lines for dolomite, mica and quartz that were on the diffractometer trace are not listed.

tion peak which is unaffected by glyceration, saturation with different cations, heating to 250°C or treatment with strong alkali, but is destroyed at 550°C. The intensity of the 10 Å mica peak is decreased with glyceration and increased on heating, indicating presence of expandable layers. Powder X-ray data for random mounts are shown in Table 1.

Transmission electron micrographs were prepared by John Brown, Consulting Physicist, Atlanta, Georgia, by dispersing the -2μ clay fraction in 0.05 percent TSP solution in a weak ultrasonic field and depositing the material on a carbon substrate. The electron micrographs in Figures 3 and 4 show the characteristic needle-like morphology of sepiolite. Striations on the needles in Figure 4 are characteristic of alpha-sepiolite.

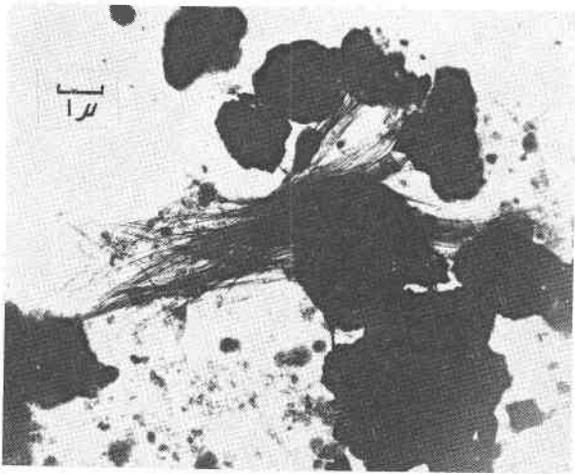


FIG. 3. Transmission electron micrograph of fibrous bundle of Mound Lake sepiolite.

Chemical analysis of the -2μ fraction yielded: SiO_2 36.80, Al_2O_3 20.23, Fe_2O_3 3.29, CaO 4.52, MgO 7.73, Na_2O trace, K_2O trace, ignition loss (600°C) 24.56, total 98.93%. Semiquantitative spectrographic analysis showed B 90 ppm, Pb 70, As 20, Ga 20, Ba 100, Mo 5, Sn 3, V 150, Cu 40, Zn 150, Ti 1500, Ag 2, Zr 50, Ni 25, Co 20, Mn 200, Sr 1500, Cr 30. The -2μ fraction is not pure sepiolite, but contains impurities of 2:1 type clays, kaolinite, and dolomite. Because of these impurities, no attempt was made to compute a structural formula. The sepiolite appears to be high in CaO and Al_2O_3 , but this may be due to impurities.

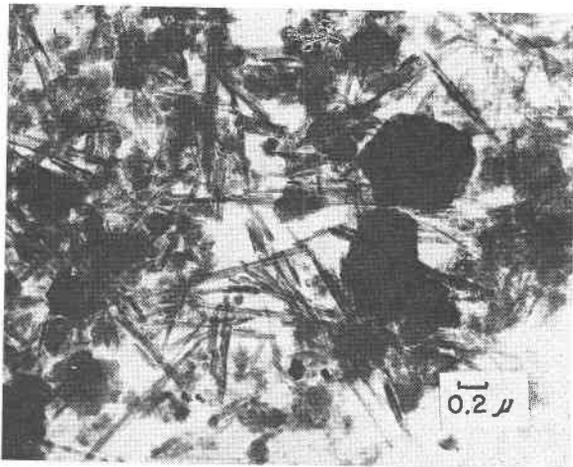


FIG. 4. Transmission electron micrograph of sepiolite needles.

Differential thermal analysis of the -2μ fraction is shown in Figure 5. Positive identification of sepiolite in a mixture by differential thermal analysis is difficult. Sepiolite exhibits a strong double endothermic reaction at 100–150°C, a very small endotherm at 300–340°C, a broad endotherm at 450°C, and an endotherm-exotherm inversion at 740–850°C (Mackenzie, 1957, p. 236). The strong endotherm at 125°C (Fig. 5) does not show the double character reported for sepiolite by Mackenzie (1957) and the very small endotherm at 300–340°C is not present in the Mound

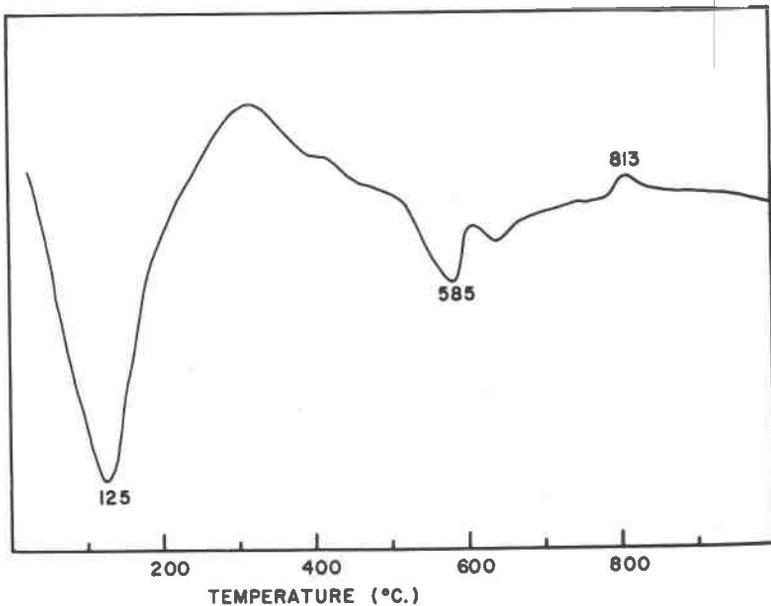


FIG. 5. Differential thermal analysis pattern of Mound Lake sepiolite. Equilibrated over saturated CaCl_2 solution, relative humidity 30%. Heating rate 12°C per minute.

Lake material. The broad endotherm reported by Mackenzie (1957) at 450°C might be apparent in the Mound Lake material as a change in slope at 410°C and 505°C. The endotherm-exotherm inversion occurs in the Mound Lake clay at 780°C and 813°C respectively although poorly developed. The endotherm in Figure 5 at 585°C is due to 2:1 type clays which also contribute to the 125°C endotherm.

Infrared absorption spectra of the Mound Lake sepiolite are shown in Figure 6. Keller and Pickett (1950) report OH and water absorption bands in attapulgite at 2.75 to 3.1 μ and 6.0 μ . Additional weak absorption bands are at 8.2, 8.7–8.9, 9.75, 10.2, 11.0, 12.6, 12.95 and 14.5 μ . Launer (1952) shows infrared absorption spectra of sepiolite and attapulgite.

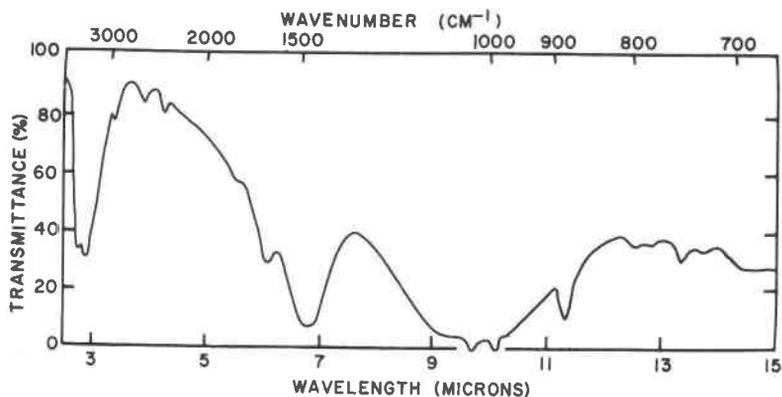


Fig. 6. Infrared absorption pattern of Mound Lake sepiolite. Perkin-Elmer Model 137 Infrared Spectrometer. KBr disc.

These two minerals have two strong absorption bands, one at 9.6μ and the other at 10.2μ and two weak bands at 8.4 and 8.9μ . Infrared spectra of the Mound Lake clay (Fig. 6) show bonded OH at 2.7μ , free H_2O at 2.9μ , OH at 4.25μ , H_2O at 6.1μ . Sepiolite absorption bands at 9.6 and 10.1μ are weak. The band at 6.8μ is due to carbonate and the bands at 11.3 and 13.3μ are due to 2:1 type clays.

Cation exchange capacities of various size fractions of sepiolite bearing clay are tabulated in Table 2. The high exchange capacities of the fine fractions reflect the presence of 2:1 type clays which are also visible on electron micrographs. The lower cation exchange capacity of the coarser clays shows that sepiolite is more abundant and 2:1 type clays are less abundant in these size fractions.

SEPIOLITE ORIGIN

Sepiolite is often associated with deposits formed in highly alkaline or saline environments, for example Lake Aboseli, Africa (Sampson, 1966),

TABLE 2. CATION EXCHANGE CAPACITIES OF SEPIOLITE BEARING CLAYS FROM MOUND LAKE

Size fraction	Cation exchange capacity MEQ/100 grams
$5\mu-10\mu$	2.9
$2\mu-5\mu$	5.6
minus 2μ	59.1
$0.2\mu-2.0\mu$	27.9
minus 0.2μ	65.0
Sepiolite, Pinos Altos, N. Mex.	20.0

the Caspian Sea (Rateev and others, 1963), and the Green River Formation (Bradley, 1930). Sepiolite also occurs on the Mid-Atlantic Ridge in a deep-sea environment where it forms from volcanic ash-derived silica which reacts with magnesium in solution (Hathaway and Sachs, 1965). The high pH necessary for the formation of sepiolite at lower temperatures (Siffert and Wey, 1962) may have been produced in the Mid-Atlantic Ridge sediment by the clinoptilolite-bearing brown clay (Hathaway and Sachs, 1965.)

Sepiolite has been reported from the calcareous zone of a soil located on a relict basin-fill plain near Las Cruces, New Mexico (Vanden Heuvel, 1966). Vanden Heuvel (1966) believes the sepiolite crystallized during caliche formation; however, the writers suggest the possibility of inheritance from parent lacustrine material. The discovery of lacustrine sepiolite associated with dolomite in pluvial Lake Mound, the common occur-

TABLE 3. MOUND LAKE WATER ANALYSES

Sample ^a	Density gm/cc	Salinity gm/l	pH	Cl eq/l	Na eq/l	K eq/l	Ca eq/l	Mg eq/l	SO ₄ eq/l	HCO ₃ eq/l	Mg/Ca
4	1.007	7.3	8.0	0.041	0.084	0.004	0.001	0.025	0.073	0.008	25
8	1.100			1.130	1.670	.086	.012	.194	.675		16
20	1.058	76.5	7.1	1.180	0.993	.188	.001	.152	.178	.006	152

^a Sample 4—Spring near north shoreline; Sample 8—Playa surface; Sample 20—Seepage water from 6 foot pit.

rence of sepiolite in the lacustrine environment, the presence of Pleistocene pluvial lakes in the Las Cruces area (Reeves, 1965), and the occurrence of residual soil sepiolite from lacustrine dolomite reported by Rogers, Quirk, and Norrish (1956) support this conclusion.

Most lacustrine sediment of Pleistocene age on the southern High Plains was derived from local soils because of isolation by the Pecos River Valley early in Pleistocene time. Clay minerals in the parent Ogallala Group are predominantly mica, montmorillonite, and mica-montmorillonite. Soils formed on the Ogallala Group during Pleistocene time commonly contain kaolinite as well.

The Mound Lake section which contains abundant sepiolite, also contains mica, montmorillonite, and kaolinite, but the quantity of montmorillonite is diminished considerably from the abundance of montmorillonite in the source Ogallala group, soils formed on the Ogallala, and lacustrine sediments derived from these soils. It seems likely that the sepiolite formed from montmorillonite as the result of exposure to alkaline lake brine rich in magnesium. Chemical analyses of Mound Lake brines is shown in Table 3. The high pH necessary for formation of sepio-

lite (Siffert and Wey, 1962) is not realized in Mound Lake. The maximum pH measured in the lake is 8.4 at the locality of sample 4 in Table 3; the usual pH at this locality is 8.0. The abundance of magnesium is shown by the analysis and by the presence of dolomite near the lake shoreline. Some volcanic ash was undoubtedly present in the lacustrine section and cannot be ruled out as a possible source of silica for the sepiolite, but the relative scarcity of montmorillonite in the sepiolite-bearing strata suggest that montmorillonite was the source material.

CONCLUSIONS

Sepiolite is positively identified in Recent sediments of pluvial Mound Lake, Texas. Mineralogical associations and brine chemistry indicate formation in a saline lacustrine environment by alteration of pre-existing montmorillonite to a sepiolite lattice.

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