

SEPIOLITE DEPOSITS OF THE LAS VEGAS, NEVADA AREA

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(Received 2 September 1977)

Abstract—Four sepiolite deposits of different origin, which occur near Las Vegas, Nevada, are compared and described. They include a playa deposit, a valley terrace deposit, and two types of vein deposits. The physical and chemical characteristics of the four materials are described, the engineering and commercial features are considered, and the varied origins of the sepiolite are discussed. X-ray powder diffraction data, infrared spectra, thermal characteristics, and chemical analyses are given for the Two Crows sepiolite. The vein deposit is proposed for use as a clay mineral reference standard because of its purity and availability. The apparent diverse morphology of the sepiolite deposits is shown with its common, lathlike basic structure.

Key Words—Fibrous, Magnesium, Palygorskite, Sepiolite.

INTRODUCTION

During a foundation investigation for the construction of low-cost housing in North Las Vegas in 1969 some very unusual soil horizons were sampled. Portions of the material were obtained from H. D. Blaser of the Federal Housing Administration, and subsequently identified as sedimentary sepiolite by Prof. R. L. Sloane, of the University of Arizona. A comprehensive description of this sepiolite deposit was presented at the 19th Annual Clay Minerals Conference in Miami Beach, October 1970, by Sloane, Post, and McKyes. The principal author died before the results of the investigation were prepared for publication.

The initial investigation was limited to the physical characteristics and engineering features of the North Las Vegas sepiolite and was restricted by the amount of material on hand before housing construction was completed, covering the site. Subsequently, three additional sepiolite deposits in the Las Vegas area were investigated. A comparison of these deposits of sepiolite, with different modes of formation, is given here.

SOURCE OF MATERIALS

The North Las Vegas sepiolite was found under the Windsor Park subdivision, unit No. 3, in the alluvial terraces at a depth of about 8 ft, along the north-central part of Las Vegas Valley, Sec. 17, T20S, R61E. The alluvial material is derived mainly from outwash from the Spring Mountains to the northwest. Dolomite comprises a dominant portion of these mountains.

The alluvial terraces of sand and gravel along the sides of the valley contain lenticular horizons of caliche. The caliche (calcareous duripan) near the surface is cemented by calcite whereas the caliche at greater depth is cemented by dolomite. The sepiolite appears in conjunction with the dolomitic duripan. The evaporation salts at the surface also include gypsum, and some montmorillonite occurs at depth.

The Two Crows sepiolite deposit occurs along the extreme southeastern edge of the Las Vegas Valley in Sec. 33, T21S, R63E, about 3 mi northeast of Hender-

son. A vein, up to 2 ft wide, can be traced over 1500 ft on both sides of the Las Vegas Wash Road. The vein dips about 45° westward and crosscuts sediments of the Muddy Creek formation. The vein occurs along a fault in strata of volcanic ash and consists of nearly pure sepiolite with fine calcite crystals coating the sides of the vein.

The Chambers Mine sepiolite deposit has been described by Hewett (1956). The mine is about 50 mi southwest of the center of Las Vegas, at the southwest corner of T20N, R10E, just into California. The material occurs in a cross fracture in Noonday (Lower Cambrian) dolomite. Minute crystals of calcite are dispersed throughout the sepiolite seam. The material is believed to represent a hydrothermal alteration of the dolomite.

The Amargosa Playa sepiolite deposit has been described by Papke (1972). The playa deposit described is about 60 mi west-northwest of the Center of Las Vegas, near the southwestern edge of the playa in Sec. 21, T17S, R51E. The sepiolite-rich bed is up to 4 ft thick and occurs in lenticular zones from about 2 ft to 8 ft depth. The playa bed occupies an area of about 6 sq mi and little is known of the persistence or thickness of the sepiolite bed beyond the explored area. The adjacent beds are described by Papke. As with the North Las Vegas sepiolite deposit calcite occurs near the surface and dolomite occurs in the sepiolite beds. The Spring Mountains are the main source of material on this side of the playa, including large amounts of dolomite.

Sepiolite formation

Each of the sepiolite deposits appears to be formed in a somewhat different manner, although they all appear to be brought about by groundwater movement in areas of high Mg concentration with high pH conditions. The sepiolite formation in terraces includes differential leaching in partially saturated soil horizons whereas the playa sepiolite deposits are saturated part of the time. The soil surface temperatures at both sites often exceed 165°F leading to high moisture mobility at the surface interface.

The sepiolite formation in both seam deposits appears comparable except that the Two Crows sepiolite occurs in stratified volcanic ash whereas the Chambers sepiolite occurs in dolomitic sediments. The mineral source in each case must have been derived from some depth in circulating groundwater.

PHYSICAL CHARACTERISTICS

The physical characteristics of the North Las Vegas sepiolite were of primary importance during the preliminary investigation. The question was, were the building foundations stable? The engineering test data, given in Table 1, indicated that they were. Although the plasticity index (PI) is high, the sepiolite samples are non-expansive in water or with ethylene glycol or glycerol. Some pure sepiolite from the Two Crows deposit was pulverized and mixed in varying proportions with quartz sand to compare with the terrace sepiolite material, which contains about 16% quartz and 4% microcline. The Two Crows sepiolite contains about 1% quartz sand.

The sepiolite-sand mixtures, when compacted, gave maximum oven-dry densities, at optimum moisture content, of 67.2 pcf at 52.2% W for 50% sepiolite, 85.8 pcf at 32.0% W for 25% sepiolite, and 95.6 pcf at 22.6% W for 10% sepiolite. The artificial sand-sepiolite compacted mixture comparable to the terrace sepiolite mixture has a comparable density of about 53.5 pcf.

ANALYTIC METHODS

Sepiolite samples from the four different sites were investigated using X-ray powder diffraction procedures, infrared spectrophotometry, and differential thermal analysis. Dehydration characteristics of the terrace sepiolite and Two Crows sepiolite were determined along with the elemental analyses of the latter

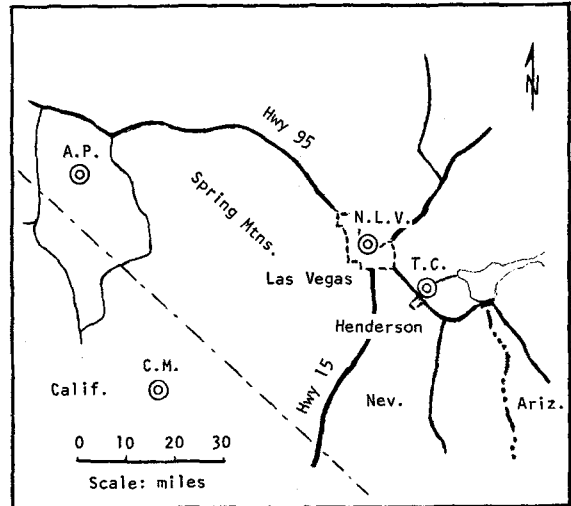


Fig. 1. The four sepiolite deposits of the Las Vegas, Nevada, area including Amargosa Playa (A.P.), North Las Vegas (N.L.V.), Chambers Mine (C.M.), and Two Crows (T.C.).

sepiolite. All samples for analysis were prepared by reducing air-dried material to minus 200 mesh.

X-ray powder diffraction

Loosely packed samples of powder were used for identification; densely packed for quantitative analyses. A Picker X-ray diffractometer with a scan rate of $1^\circ 2\theta/\text{min}$ in conjunction with a 1° divergence slit, 1° scatter slit, 0.002 receiving aperture, and nickel-filtered copper radiation was used.

The results from typical diffraction patterns for the four different sepiolites are given in Table 2. The Two Crows sepiolite is sufficiently pure and well crystallized to give additional diffraction peaks through $64^\circ 2\theta$. Do-

Table 1. Physical data results for pulverized sepiolite from the North Las Vegas terrace and from the Two Crows seam.

	North Las Vegas	Two Crows
Atterberg limits		
LL	236 (max)	290
PI	192 (max)	-
In-place density	53.1 pcf	-
Remolded density	59.6 pcf @53%W	47.1 pcf @84.5%W
pH	8.9	-
Unified Soil Classif.	CH	-
Unconf. Compr. Str.	-	41 psi (max)
Specific Gravity	-	2.16

Table 2. Observed sepiolite X-ray powder diffraction patterns for material representative of the four sepiolite deposits of the Las Vegas, Nevada, area. The peak intensities are not adjusted for scanning angle.

hKl	Two Crows		Chambers		Amargosa		N. Las Vegas	
	dÅ	I	dÅ	I	dÅ	I	dÅ	I
110	12.10	210	12.30	75	12.15	70	12.25	85
130	7.59	13	7.59	5	7.46	4	7.48	2
200	6.63	6	6.62	4	6.58	3	6.60	3
220	6.00	2						
001	5.19	2						
150	5.007	4	5.03	2	5.01	3	4.98	2
060	4.491	15	4.503	12	4.495	9	4.498	9
131	4.297	27	4.297	13	4.297	15	4.305	10
330	4.004	1						
221	3.960	2						
260	3.735	15	3.728	9	3.767	5	3.751	5
170	3.688	5			3.713	10	3.705	7
241	3.528	5	3.528	2				
080;420	3.353	12	3.330	11	3.293	6	qtz 101	
331	3.189	14	3.195	11	3.195	8	3.184	5
261	3.061	6						
351	2.877	3						
081	2.838	2						
421	2.786	2						
510	2.684	6	2.698	2	2.680	5	2.694	2
002	2.625	5			2.630	2		
441;281	2.608	10	2.611	5	2.616	3	2.590	5
371;191	2.558	19	2.577	19	2.554	13	2.563	14
202;042	2.440	9	2.442	7	2.443	5	qtz 110	
1,11,0;222	2.412	3			2.412	8	2.405	2
461	2.399	5	2.389	3				
312;2,10,1	2.256	10	2.253	6	2.252	5	2.260	5
570	2.211	2					2.214	1
082	2.075	4					2.073	2
601	2.065	5	2.057	3	2.064	4	2.058	2
641	1.962	1						
462	1.883	2						
591	1.865	2						
691	1.696	2						
2,1,12	1.688	3						
233	1.674	2						
662	1.598	2						
781	1.589	3						
3,15,1	1.580	4						
183;712	1.546	3						
093	1.515	4						
193;7,10,1	1.500	2						
1,10,3	1.463	1						

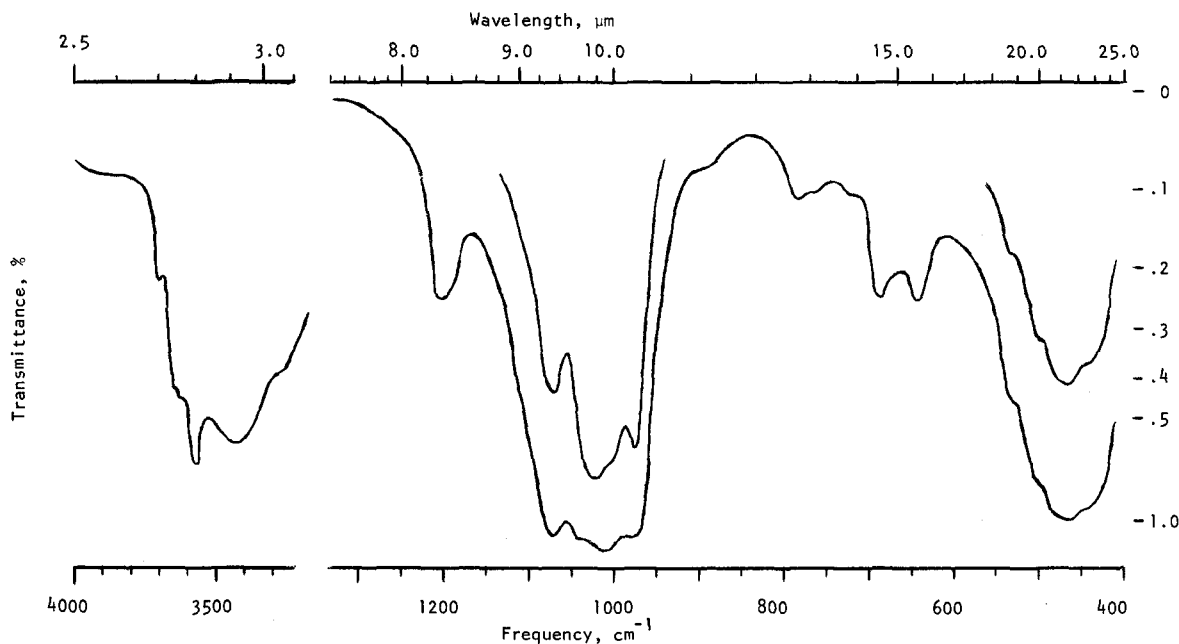


Fig. 2. The infrared spectrum of Two Crows sepiolite in the region of 4000 to 3300 cm^{-1} and 1300 to 400 cm^{-1} frequency.

lomite in the playa sample and quartz in the terrace sample interfere with those diffraction patterns. The Chambers sample appears rather poorly crystalline. The diffraction peak indices were taken from data compiled by Grim (1968), and the additional indices from data compiled by Borg and Smith (1969).

Infrared spectra

Infrared absorption spectra were obtained using K Br discs. A Perkin-Elmer 337 grating i.r. spectrophotometer having a light frequency response varying from 4000 to 400 cm^{-1} was used. Machine settings combined fast scan rate and normal slits with an air reference beam attenuator. The slow-scan rate was used to secure detail from 3800 to 3200 cm^{-1} and precise peak positions were determined with the aid of a standard polystyrene sample spectrum.

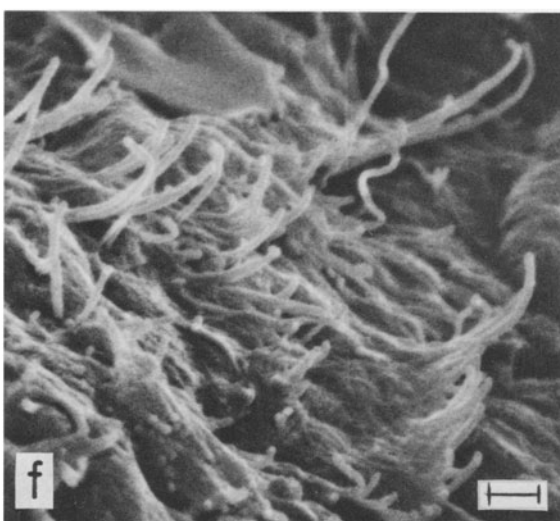
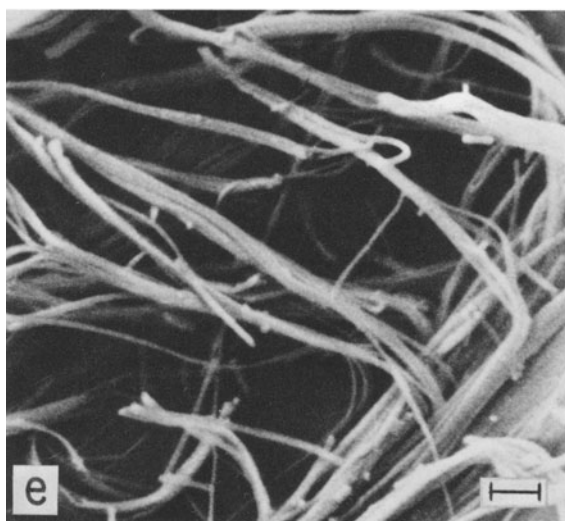
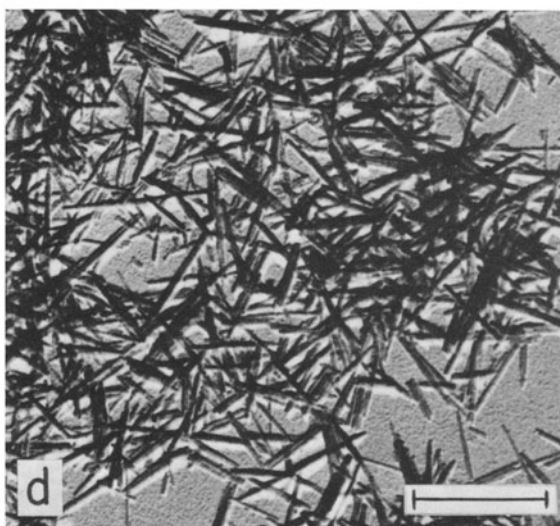
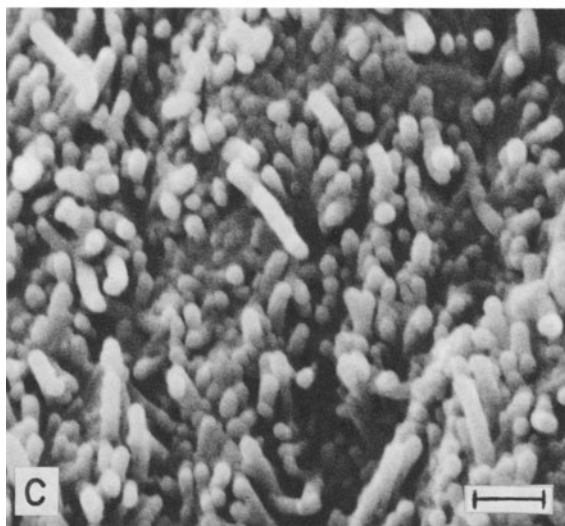
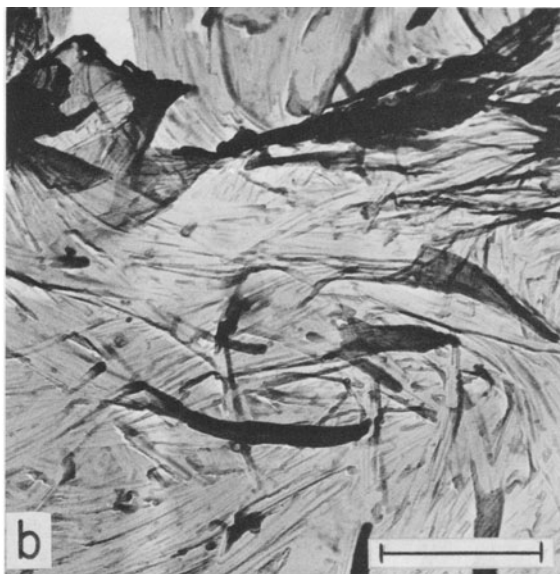
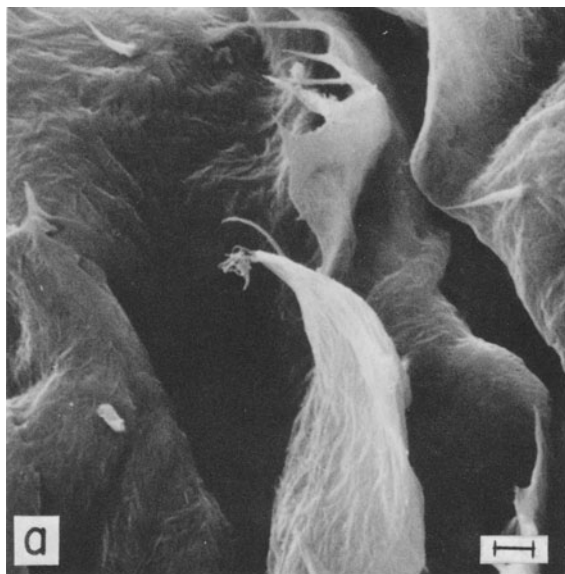
The i.r. spectrum for Two Crows sepiolite, shown in Figure 2, is comparable to those described by Farmer (1974), and Nagata et al. (1974). The spectra for the other sepiolite samples are nearly identical when accounting for the mineral impurities present. The nature of the absorption bands arising from hydroxyl stretching are discussed by Cannings (1968). These include the four distinct bands at 3700, 3650, 3630, and 3570 cm^{-1} , with a broad water adsorption band at 3435 cm^{-1} , and an unidentified band at 3265 cm^{-1} . The absorption band given by Nagata et al. at 1017 cm^{-1} appears as two bands at 1024 and 1002 cm^{-1} , and additional bands occur at 888, 764, and 501 cm^{-1} frequency.

Thermal characteristics

A Du Pont 900 Thermal Analyzer was used with a heating rate of 20°C per min through a range from room temperature to 1125°C with an alundum reference. Endotherms occur at about 125°C and 355°C, with another endotherm at about 820°C immediately followed by an exotherm at about 835°C. The impure sepiolite from the North Las Vegas terrace has a final endotherm at about 840°C followed by a strong exotherm at about 870°C. The thermogram for the Two Crows sepiolite is comparable to those given by Mackenzie (1966), especially the fibrous sepiolite.

When samples of sepiolite were heated to 1050°C and allowed to cool over a 6-hour period enstatite was the dominant mineral found. Dominant X-ray powder diffraction peaks were observed to occur at 3.173, 2.877, and 2.523 Å for the heat-treated Two Crows sepiolite indicating the formation of enstatite.

The structure of the sepiolite alters when heated, as described by Nagata et al. (1974). For example, when the North Las Vegas soil is heated to 310°C the 12.2 Å peak shifts to about 12.0 Å, then disappears with new peaks forming at about 10.25 Å and 8.15 Å by 530°C. These less intense peaks then persist past 530°C. The sepiolite anhydrite structure has been observed to persist until about 750°C. When heated to 500°C the Two Crows sepiolite also shows a new diffraction pattern with peaks occurring at 11.85, 10.50, and 8.16 Å. A strong doublet is also present at 4.335 Å (031) and 4.620 Å (111).



Chemical analysis

There is some difficulty in determining the true weight of the sepiolite sample because the unit cell not only contains zeolitic water, bound water, and hydroxyls, but also contains surface adsorbed water, as described by Weaver and Pollard (1973). When a sample is heated to determine standard oven-dry weight some of the zeolitic water is lost along with the adsorbed water. I estimated the adsorbed water content by putting a preweighed air-dry sample in a sealed desiccator and measuring the sample weight loss at hourly intervals. The zeolitic water migration appears to be approximately a linear function of time for the first 24 hours, thus, by extending the straight line back to initial time the adsorbed surface water content was estimated (1.76%).

A sample of Two Crows sepiolite was analyzed using an electron microprobe. The analysis was performed by R. W. Wittkopp, Department of Geology, University of California at Davis, using an ARL electron microprobe with an accelerating voltage of 15 KeV and a sample current of approximately 0.05 μ A. The data results are given as the oxide analysis in Table 3. Following Weaver's procedure, the H_2O^- content is the zeolitic water, which can be driven off by heating the sample to about 250°C. The probe oxide analysis must be adjusted for zeolitic water loss, the probe sample having been stored in a chamber at about 2×10^{-5} mm Hg pressure for a week prior to scanning. The results compare well with the analyses compiled by Weaver and Pollard (1973).

Morphology

Characteristic examples of sepiolite morphology are given by Beutelspacher and Van der Marel (1962); Grim (1968); and Gard (1971). The scanning electron micrograph of North Las Vegas sepiolite (6000 \times) shown in Figure 3a, was prepared by McKyes at McGill University, and the transmission micrograph (25,000 \times) Figure 3b, was prepared by Sloane at the University of Arizona. The soil morphology suggests that the sepiolite may have formed with the dolomitic duripan, which has since been partially removed by leaching in the terrace when the groundwater table was higher. The fibrous nature of the sepiolite is apparent in the transmission microphotograph. The shadow cast replication of the sepiolite surface at high magnification shows low image contrast in all of our investigations.

The scanning electron micrograph of Amargosa Playa sepiolite, Figure 3c, and Two Crows sepiolite,

Table 3. Chemical analysis of Two Crows sepiolite (percent) for a clean surface using an electron microprobe. The probe analysis is adjusted for zeolitic water loss.

	Probe, %	Adjusted, %
SiO ₂	61.20	53.98
Al ₂ O ₃	0.23	0.20
FeO	0.01	0.01
CaO	0.04	0.04
MgO	25.85	22.80
Na ₂ O	0.66	0.58
K ₂ O	0.18	0.16
H ₂ O ⁺	9.60	8.46
H ₂ O ⁻		11.54
	97.77	97.77

Figure 3e, and Chambers sepiolite, Figure 3f, were made at the University of California, Davis, using a Mark 2A Cambridge Stereoscan electron microscope. The samples were split, cleaned, and coated with gold surfacing (400–500 Å) using a Hummer sputtering apparatus. The transmission micrograph detail for the Amargosa Playa sepiolite, Figure 3d, was made by Dr. Brown at Georgia Institute of Technology for P. Partridge, a mining consultant.

The Amargosa Playa sepiolite appears to have formed as coating about bacteria-like material in certain playa horizons, probably dependent on a fluctuating groundwater table. The same morphology was observed in scanning electron micrographs prepared at McGill University. The bacteria-like rods are about 0.25 μ m in diameter. When the playa sepiolite was pulverized to prepare a replica the fibrous nature of the sepiolite became apparent, Figure 3d, although the fibers appear smaller than in the other sepiolite samples.

The Two Crows sepiolite is shown (7500 \times) in Figure 3e and the Chambers sepiolite (7500 \times) in Figure 3f. Fibers of the Two Crows sepiolite can be seen when the sample is broken and finer strands are shown in the

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Fig. 3. The morphology of sepiolite from four different mineral deposits in the Las Vegas area. Figure 3a is a scanning image of North Las Vegas terrace sepiolite (6000 \times), Figure 3b is a transmission image of the terrace sepiolite (25,000 \times), Figure 3c is a scanning image of the Amargosa Playa sepiolite (10,000 \times), Figure 3d is a transmission image of the Playa sepiolite (20,500 \times), Figure 3e is a scanning image of the Two Crows sepiolite (7500 \times), and Figure 3f is a scanning image of the Chambers Mine sepiolite (7500 \times).

microphotograph. Single crystals appear even larger than those of the terrace sepiolite and give a much better X-ray powder diffraction pattern than any other sepiolite samples. The Chambers sepiolite is similar to the Two Crows sepiolite except that the fibers are not as well developed and the material appears more poorly crystalline.

SUMMARY

All four of the sepiolite deposits appear to have been formed by direct crystallization rather than alteration of previously existing minerals. Formation by hydrothermal deposition as seams in fault zones may occur as well as direct sedimentary deposition of sepiolite as described by Ispording (1973).

The lenticular terrace deposits of North Las Vegas are not of large extent and are readily stabilized or removed during housing construction. The Amargosa Playa deposits of sepiolite occur in large lenses and have been mined for commercial use; however, the removal of included dolomite is virtually impossible and close quality control is needed during extraction.

Both the Two Crows sepiolite seam and the Chambers seam have been claimed for mining. It remains to be seen whether there is sufficient material available for economic exploitation. The Two Crows sepiolite is quite pure where the seam crosses the highway and can be considered for use as a clay mineral standard source material. The deposit is very fibrous and exhibits a very crystalline nature.

ACKNOWLEDGMENTS

I wish to acknowledge the assistance of Dick Sloane in the preparation of this study and his guidance of my

work at the University of Arizona. Also, many thanks to Ted McKyes, Dr. Brown, and Dick Sloane for their electron optical photos. The Two Crows sepiolite deposit was first described for me by Keith Papke and its elemental analysis was done by Ray Wittkopp. With the kind assistance of Jack Pangborn, Advanced Instrumentation Lab, University of California, Davis, the electron microphotos were prepared.

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Резюме- Развитые вблизи Лас Вегаса, Невада, четыре вида отложений сепиолита различного происхождения, которые сравниваются и описываются, включают плейстоценовые осадки, долинные террасовые осадки и два вида жильных отложений. Приводятся физические и химические характеристики всех четырех разновидностей, рассматриваются технические и коммерческие аспекты и обсуждаются различные условия образования сепиолита. Приводятся данные исследований порошков методом дифракции рентгеновских лучей, спектры инфракрасного излучения, тепловые характеристики и химические анализы сепиолита "Ту Краус". Предлагается использовать жильные отложения в качестве эталонного глинистого материала, в связи с его чистотой и доступностью. Показана явная разнотипность морфологии сепиолитовых отложений одновременно с их общей лейстовидной структурой.