Core Logs of Three Test Holes in Cenozoic Lake Deposits Near Hector, California

GEOLOGICAL SURVEY BULLETIN 1296

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By BETH M. MADSEN

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A study of borates and related evaporites

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1970

UNITED STATES DEPARTMENT OF THE INTERIOR

WALTER J. HICKEL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

Library of Congress catalog=card No. 70-608172

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CORE LOGS OF THREE TEST HOLES IN CENOZOIC LAKE DEPOSITS NEAR HECTOR, CALIFORNIA

By BETH M. MADSEN

ABSTRACT

Cores and cuttings from three holes drilled into upper Cenozoic lake deposits in the Mojave Desert near Hector, Calif., were relogged and examined in detail mineralogically. An evaporite section penetrated by one of the holes consists of beds of laminated and massive anhydrite rock, mudstone, claystone, calcite rock, sandstone, and colemanite rock. Colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$) is the only borate mineral present except for a few blebs of howlite. A minor amount of celestite occurs throughout the core. beds of tuff in the cored intervals have been altered to clay minerals or the zeolites clinoptilolite, analcime, erionite, and chabazite.

INTRODUCTION

A study of the cores and cuttings obtained from three holes drilled near Hector, Calif., has revealed the presence of significant amounts of colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$) in an evaporite section penetrated by one of the holes. Hector is a small station on the Atchison, Topeka, and Santa Fe Railway, about 35 miles east of Barstow, Calif., in the Mojave Desert. The logs and descriptions presented here are based on the cuttings and cores of these holes (fig. 1): Hector 1, Hector 2, and Hector 3. The holes were drilled in 1964 for Congdon and Carey Mineral Exploration by Boyle Drilling Co., both of Denver, Colo., under the direction of Arthur J. Graves, geologist. Data in this report are published with the permission of the company.

A preliminary core description of the three holes was done by T. W. Dibblee, Jr., in 1964 and published as a part of the explanation for the geologic maps of the Cady Mountains quadrangle (Dibblee and Bassett, 1966b) and the Newberry quadrangle (Dibblee and Bassett, 1966a). Dibblee considered the section penetrated by these three holes to be lake deposits of Tertiary or Pleistocene age (Dibblee and Bassett, 1966a).

R. A. Sheppard (written commun., May 1969) regarded the section to be tuff of Miocene or Pliocene age.

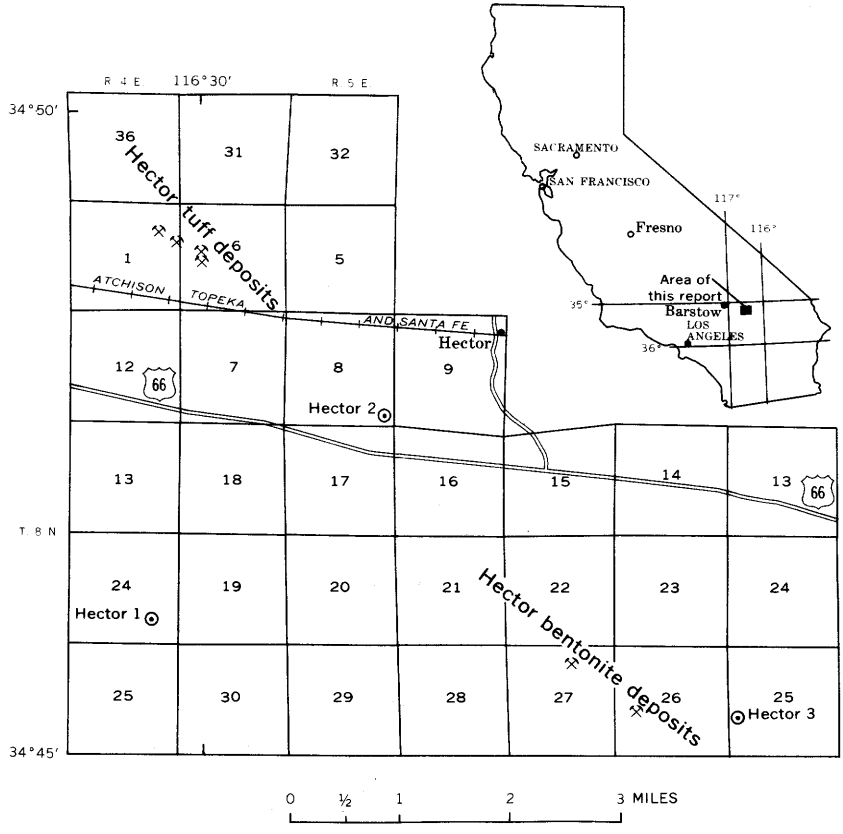


FIGURE 1.—Location of drill holes of Congdon and Carey Hector 1–3. Area shown is within Newberry and Cady Mountains quadrangles.

In March, 1965, A. J. Gude 3d and I collected small samples of the cored tuffs from Hector 3. We also sampled those tuffs that crop out in and near the Hector bentonite deposits and the Hector tuff deposits [see fig. 1] I think the rocks of both areas are the same and are the same or equivalent to those cored for Congdon and Carey. I suspect the age is Miocene or Pliocene but not Pleistocene. A key bed for this correlation is the thick (about 4 ft) clinoptilolite tuff in Hector 3 at 448–452 feet. A tuff of the same color, mineralogy, thickness, and texture (even to the abundance of clastic material in the upperfoot) crops out in the SW¼SW¼ sec. 31, T. 9 N., R. 5 E. A chemical analysis and X-ray diffraction data of clinoptilolite from this bed are listed by Ames, Sand, and Goldich 1958, table 1, analysis 4, and table 2, sample 2). Two thinner tuffs rich in erionite and clinoptilolite crop out several hundred feet stratigraphically above the clinoptilolite tuff. These probably correlate with the Hector 3 tuffs at 17.9 and 35.2 feet. These are the zeolitized tuffs noted in our preliminary publication (Sheppard and Gude, 1964). These erionite-rich tuffs also crop out near the Hector bentonite deposits where the dips are slight.

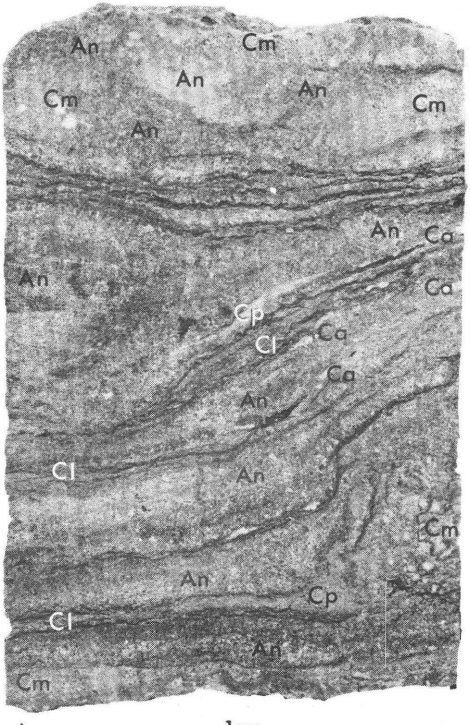
In 1965 the cores of Hector 1 and 2 were relogged in greater detail by Beth Madsen and G. I. Smith at Newberry, Calif., where they are stored by the company. The cores and cuttings of Hector 3 were removed with company approval to Menlo Park, Calif., for a detailed mineralogical examination.

The coring was discontinuous and represents only part of the section penetrated by any of the three holes. The color identifications follow the National Research Council Rock-color Chart and were made when the core was dry. The mineral composition of the cores was determined by petrographic and X-ray diffraction techniques. The lithology of the cores is presented in the graphic logs (pl. 1) and described in detail in the written logs.

EVAPORITE SECTION

The evaporite section consists primarily of rhythmic laminations of anhydrite, clay, and calcite and beds of claystone. The individual laminae, or rhythmites, are from less than 2 to 20 millimeters thick and are well defined and continuous in parts of the core and discontinuous or obscure in other parts. Much of the lamination is crinkled and discordant, probably as a result of volume changes during dehydration of gypsum to anhydrite; this deformation is commonly localized in parts of the section 1–2 feet thick that alternate with unaffected rock of the same anhydrite lithology. Two polished sections of typical laminated anhydrite rock are shown in figure 2. Generally anhydrite laminae are light gray (*N*7) to medium dark gray (*N*4). The laminated anhydrite rock is various shades of gray and brown: light gray (*N*7), medium light gray (*N*6), medium gray (*N*5), dark gray (*N*3), light olive gray (5*Y* 6/1), greenish gray 5*GY* 6/1), yellowish gray (5*Y* 8/1), olive gray (5*GY* 6/1), brownish gray (5*YR* 4/1), and pale yellowish brown (10*YR* 6/2). Beds of massive anhydrite up to several feet thick are common.

Thin-section examination of the laminated anhydrite rock shows the anhydrite to be fine to coarse grained with an average crystal size of 0.1–1.0 mm. The anhydrite crystals are elongate, straight, and subhedral to euhedral. The anhydrite occurs as an irregular, crisscrossed, intergrown, mutually interfering crystal mat; a typical thin section illustrating this texture is shown in figure 3. Some anhydrite crystals coalesce, and the interstitial space between crystals is filled by very fine grained calcite and detrital grains. Ogniben (1957) described this texture as bacillar, a texture typical of anhydrite that is epigenetic after gypsum. He called a finer grained rock of the same origin felty anhydrite.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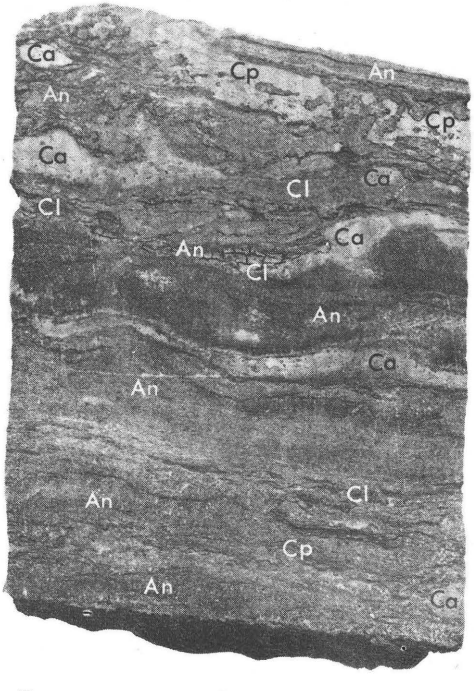
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This rock type is not as abundant as the bacillar anhydrite in this core. A minor amount of anhydrite occurs as clear euhedral coarse crystals in secondary fillings of veins, voids, and geodes. The microscopic character of the massive anhydrite rock is similar to that of the laminated anhydrite rock.

Calcite occurs in the massive and laminated anhydrite rock as laminae, discontinuous lenticules, beds, impurities in anhydrite crystals, and interstitial fillings between the anhydrite crystals. Calcite also occurs in the claystones as disseminated grains, laminae, nodules, blebs, and streaks. It is yellowish gray (5*Y* 8/1) to light olive gray (5*Y* 6/1) and has a grain size less than 0.05 mm. A considerable quantity of clay-sized detrital material is mixed with the calcite. Many fine laminae and lenticules of calcite are broken and pushed aside by the anhydrite crystals. It appears, therefore, that the calcite predates the anhydrite. Throughout the cores there is a scattering of blebs, less than 2 mm in size, of very fine grained white calcite.

Chalcedony spherulites, fans, and veins are common in the laminated anhydrite rock but were not observed in any of the other rock types. The spherulites and fans average 1.0 mm in diameter and are pale reddish brown in plane light. The chalcedony is secondary and later than the anhydrite.

Minor pyrite occurs locally within anhydrite laminae. The pyrite is cryptocrystalline and occurs as tiny disseminated grains, veinlets, and small clots of crystals.

Within the anhydrite rocks are numerous beds, laminae, streaks, and blebs of clay. This clay is light gray (5*Y* 6/1) to greenish gray (5*GY* 6/1), tuffaceous, zeolitic, and calcareous. The principle clay minerals in the clays associated with the anhydrite rock are Ca-montmorillonite, Na-montmorillonite, and illite; a few samples also contain a minor amount of kaolinite. The proportion of Ca-montmorillonite increases in the lower part of the cored sections. The clay minerals were determined by X-ray diffraction. A clay mineral with (001) *d* spacing of 10 A (angstrom) that does not change with glycolation or heating is classed as illite. A clay mineral with (001) *d* spacing of 12.4 A that expands on glycolation to 17 A and collapses to 10 A on heating to 550° C. is called Na-montmorillonite. Ca-montmorillonite is characterized

FIGURE 2.—Polished sections of typical laminated anhydrite rock showing undulation or crinkling and discordances. Constituents are anhydrite (An), calcite (Ca), clay (Cl), colemanite (Cm), and clinoptilolite (Cp). Samples are from Hector 3; *A* from depth 1,526.0 feet and *B* from depth 1,393.5 feet.

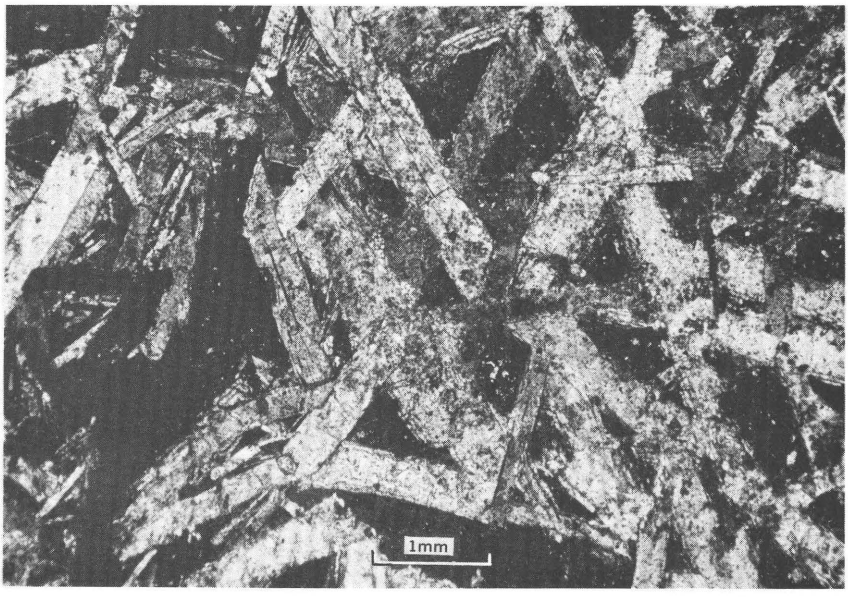


FIGURE 3.—Bacillar epigenetic anhydrite showing the elongation, crisscross intergrowth, and mutual interference of the anhydrite crystals. Sample is laminated anhydrite rock from a depth of 1,335.2 feet in Hector 3. Nicols crossed.

by a (001)*d* spacing of 15 A that expands on glycolation to 17 A and collapses to 10 A on heating to 550°C. The clay beds and laminae range from less than 1 to 15 mm in thickness. Much of the clay contains very fine grained blebs of white clinoptilolite and calcite. Some of the clay is mottled, in a leopardlike pattern, with streaks of medium-dark-gray (*N*5) clay. Interbedded with, but not a component of, the laminated anhydrite rock are beds of claystone of similar mineralogy and appearance as the clays of the laminated anhydrite rock. These claystone beds are massive to laminated, $<0.5->5.0$ feet thick, anhydritic, sandy, calcareous, tuffaceous, celestitic, colemanitic, silty, and of variable colors, pale yellowish brown (10*YR* 6/2), light brownish gray (5*YR* 6/1), light olive gray (5*Y* 6/1), greenish gray (5*GY* 6/1), medium light gray (*N*6), and light gray (*N*7).

Interspersed with the laminated anhydrite rock and the claystone are a few beds of sandstone 2–150 mm thick. The sandstone is very fine grained, tuffaceous, and calcareous and locally contains fragments of igneous rock. It varies from light brownish gray (5*YR* 6/1) to light gray (*N*7).

A few beds of mudstone similar to the mudstones above the

evaporites and described in the nonevaporite section are interbedded with the evaporite rocks.

Clinoptilolite in minor amounts is found throughout the evaporite section. It commonly occurs in the clay and claystone. The clinoptilolite occurs as very fine grained white blebs and streaks, generally less than 3 mm wide, as very fine grained clayey light-olive-gray (5*Y* 6/1) laminae and irregular streaks, and as disseminated particles. An irregular horizontal streak of clinoptilolite is shown in figure 2 at the top of polished section *B*.

Colemanite was the only borate mineral found in the cores in appreciable quantities. It has three distinct varieties of textures that are recognizable megascopically. These are medium grained, very fine grained, and spherulitic. An example of each texture in thin section is shown in figures 4–6. Most colemanite in this core is of the medium-grained type. The medium-grained colemanite rock is generally mottled pale yellowish brown (10*YR* 6/2), grayish orange (10*YR* 7/4), yellowish gray (5*Y* 8/1), and light olive gray (5*Y* 6/1) and less commonly, medium gray (*N*5), brownish gray (5*YR* 4/1), and pale brown (5*YR* 5/2). Also, it is dense and composed of anhedral to euhedral crystals 0.1–0.8 mm in diameter. The medium-grained colemanite rock commonly occurs as beds, but it also occurs as veins and lenses in the anhydrite rock.

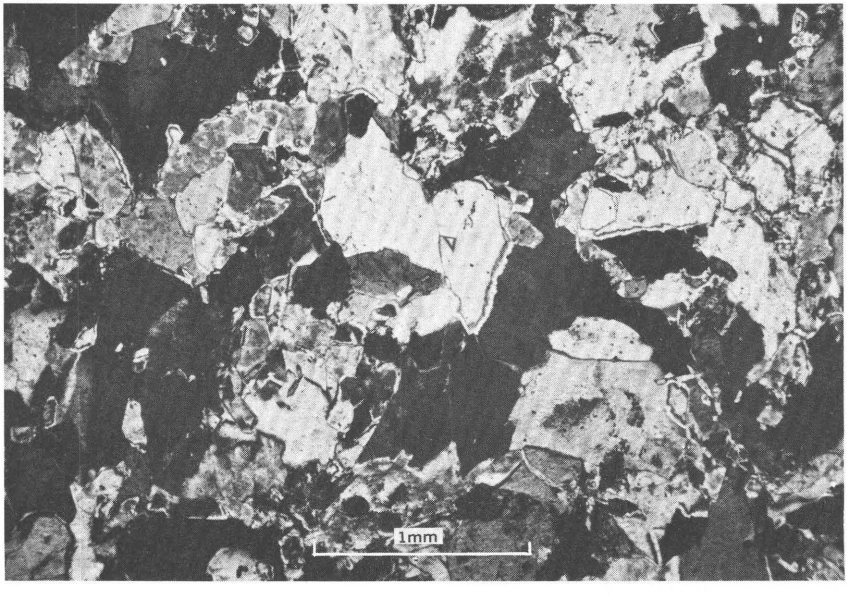
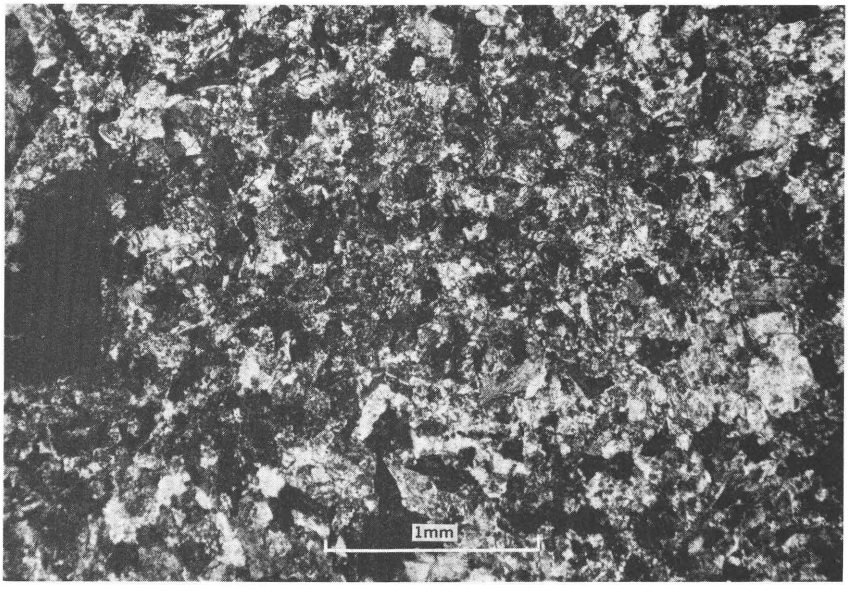


FIGURE 4.—Sample of medium-grained colemanite from Hector 3 at a depth of 1,461.5 feet. Nicols crossed.



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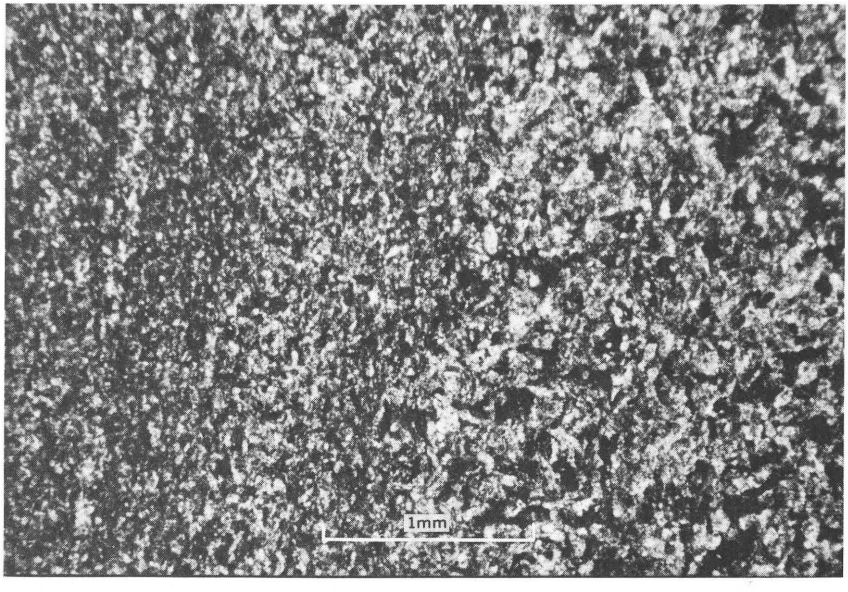
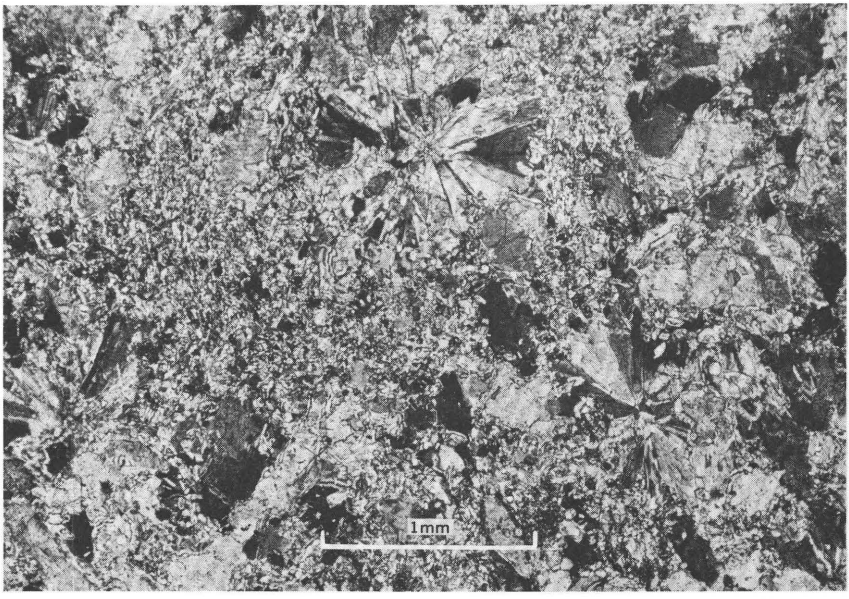


B

FIGURE 5.—Very fine grained variety of colemanite from Hector 3 containing much tuffaceous clay. *A*, very fine grained colemanite containing a few medium crystals of colemanite. From a depth of 1,512.0 feet. Nicols crossed. *B*, Laminated very fine grained colemanite. As the gain size increases, the tuffaceous clay content decreases. From a depth of 1,512.1 feet. Nicols crossed.



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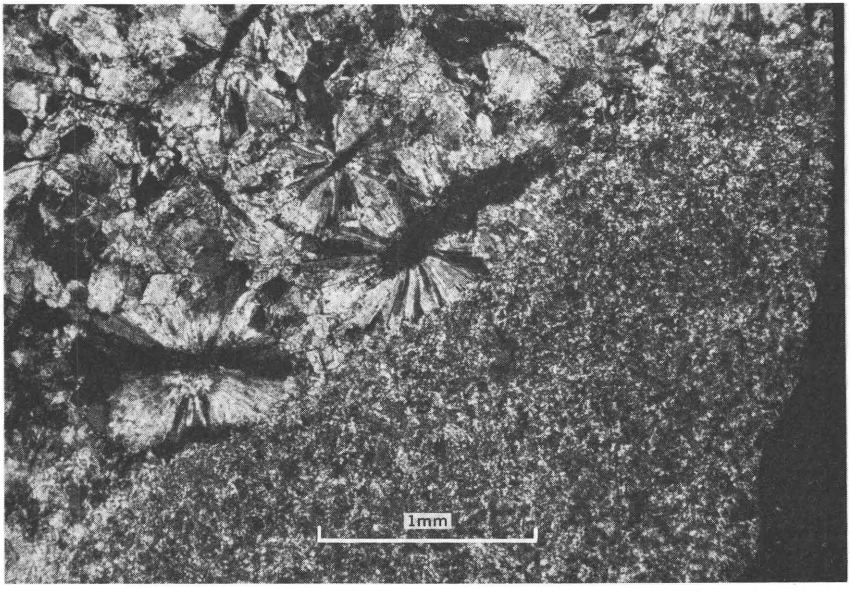


B

FIGURE 6.—Spherulitic colemanite from Hector 3. *A*, Spherulites in a matrix of very fine grained and medium-grained colemanite free of clay. From a depth of 1,510.0 feet. Nicols crossed. *B*, Vein of spherulitic colemanite in a matrix of very fine grained colemanite and tuffaceous clay. From a depth of 1,507.0 feet. Nicols crossed.

In addition, it contains some fine to medium anhydrite crystals. Most beds of colemanite are less than 2 feet thick, but a few are greater than 4 feet thick. All forms of colemanite rock contain some secondary veins; vuggy nodules; streaks composed of a mixture of coarse crystals of clear anhydrite and colemanite; and nodules and streaks of white medium-grained-anhydrite crystals.

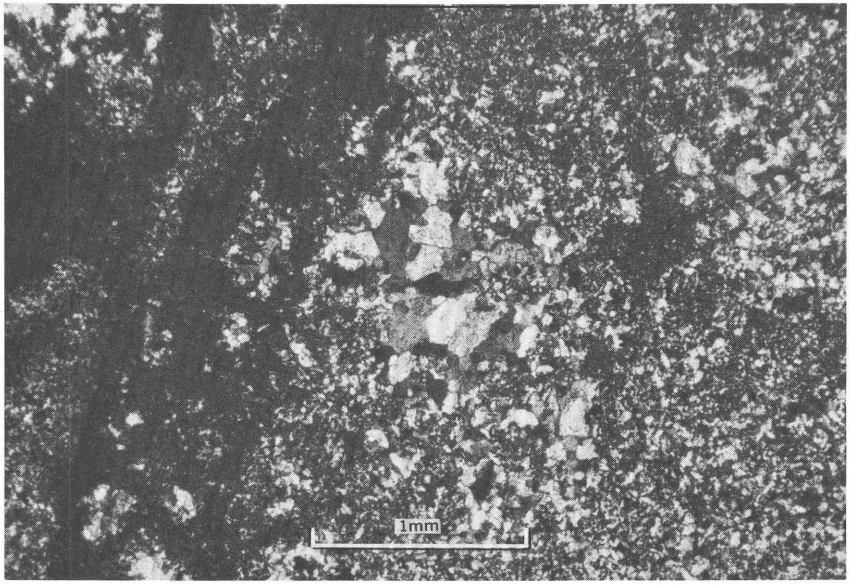
A less common variety of colemanite is the very fine grained variety. It occurs as veins, lenses, and laminae in medium-grained colemanite and anhydrite rock. The very fine grained colemanite is medium light gray (*N*6) to light olive gray (5*Y* 6/1), dense, and of a grain size less than 0.05 mm. In thin section the crystals of the very fine grained colemanite are anhedral and intimately mixed with more tuffaceous clay than the other varieties of colemanite. In figure 5, two examples of very fine grained colemanite are shown.

Spherulites of colemanite have developed in both the very fine grained colemanite and the medium-grained colemanite. The spherulites are from roughly less than 0.5 to 1.6 mm in diameter and consist of radiating blade-shaped crystals less than 0.3 to 1.0 mm long. The presence of clay or very fine grained tuffaceous detritals appears to have had no effect on the growth of the spherulites. Figure 6 shows spherulites in a matrix of very fine grained colemanite with and without clay.

All varieties of colemanite are found locally replacing anhydrite rock. Some colemanite has been in turn replaced by very fine grained anhedral celestite.

Howlite is the only other borate mineral in the core. It occurs in colemanite rock as very fine grained white blebs, less than 3 mm in diameter, and is generally associated with inclusions or streaks of clay. In thin section the howlite shows a fine-grained schistose, or foliated, texture.

Celestite occurs as disseminated particles, nodules, veins, and laminae of very fine grained dense rock that is a light olive gray (5*Y* 6/1). Within the evaporite section, the celestite crystals are anhedral and less than 0.16 mm long. Celestite resembles cryptocrystalline quartz and is secondary, replacing all varieties of colemanite, anhydrite, calcite, and clay. The celestite has formed preferentially in rock rich in tuffaceous debris. The celestite appears to have made a gradual infiltration of the host rock until it finally replaced the entire rock. Figure 7 shows the celestite replacement of calcite and colemanite.



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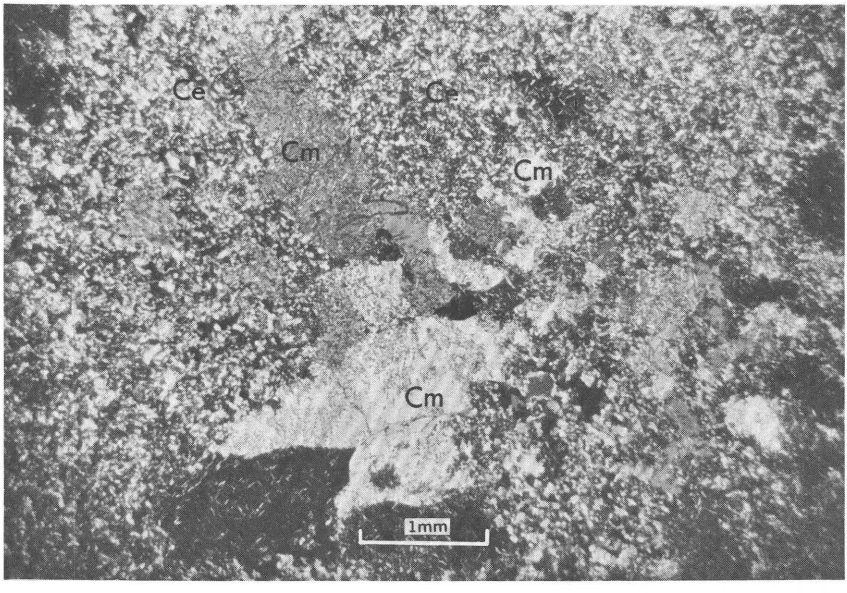

B

FIGURE 7.—Celestite replacement of calcite and colemanite from Hector 3. *A*, Fine-grained anhedral celestite (light) in a very fine grained tuffaceous calcite (dark) lamina. From a depth of 1,546.0 feet. Nicols crossed. *B*, Medium- to coarse-grained colemanite (Cm) rock partially replaced by very fine grained celestite (Ce). From a depth of 1,380.1 feet. Nicols crossed.

NONEVAPORITE SECTION

Mudstones make up most of the section above the evaporites; interbedded with the mudstones are a few beds of calcite, tuff, and sandstone. The nonevaporites vary in color from white to medium gray and through all shades of light and grayish reds, yellows, greens, and browns.

The mudstones are tuffaceous, calcareous, and sandy. Beds of mudstone are from less than 0.1 to 20 feet thick, are poorly to well indurated, and are massive to faintly laminated. The beds in the cores have apparent dips of as much as 5°. The tuffaceous material of the mudstone is altered to analcime, clinoptilolite, and clay minerals; no fresh glass was positively identified in thin section or grain mount. The mudstones in the upper 70 feet of the section contain pebbles, some of which are angular volcanic fragments.

The sand material in both the sandstone beds and the sandy mudstones is coarse to fine, angular, poorly sorted, and contains a considerable amount of volcanic material. The sandstones are calcareous, clayey, tuffaceous, and micaceous and contain, in the upper 30 feet, a few pebble-sized fragments of volcanic rock. The beds of sandstone are massive to faintly laminated and show dips similar to those of the mudstones. The tuffaceous material in the sandstone is altered to clinoptilolite and analcime.

The few beds of calcite rock in this part of the section vary from massive fine-grained dense well-indurated, almost pure limestone to a clayey tuffaceous "marl." A few of the calcite beds are replacements of tuff beds.

Celestite is a minor constituent of some of these beds and occurs as a late replacement of tuff, calcite, and mudstone. Generally, the celestite occurs as laminae, lens-shaped nodules, and veins of very fine anhedral crystals that are medium light gray (*N*6). The occurrence is similar to that of celestite in the evaporite section. Also a few veins of large clear subhedral to euhedral crystals of celestite cut the mudstone.

The tuff beds are sandy, calcareous, fine to very fine grained, massive to laminated, and well indurated and range in thickness from less than 0.5 to 4.0 feet. The tuffaceous material is replaced or altered to clay minerals, calcite, celestite, chalcedony, and the zeolites clinoptilolite, analcime, chabazite, and erionite. Mordenite was also identified in the lower part of one of the clinoptilolite-rich tuffs by R. A. Sheppard and A. J. Gude (written commun., May 1969.) Some of the tuff probably retains fresh unaltered glass, but none was positively identified. Ten of the tuffs were

thin sectioned; those that are now altered to analcime show no vitroclastic textures, and those altered to clinoptilolite, erionite, and chabazite still retain the original shard and pumice shapes and contain unfilled shard and pumice cavities and possibly contain some glass. The lack of vitroclastic texture in the analcime tuff could be explained by Hay's (1966) supposition that analcime may form at low temperatures from an earlier zeolite—in this case, clinoptilolite, chabazite, or erionite. Where the tuffs have been extensively altered to clay minerals or replaced by calcite, celestite, and chalcedony, there is still visible a vague vitroclastic texture outlined by thin films of clay minerals. Some of the tuffs are alveolated, and the holes can be lined or filled with clay, chalcedony, and calcite.

CORE LOGS OF THE THREE TEST HOLES

Hector 1

[Location: SE¼ sec. 24, T. 8 N., R. 4 E.]

Depth (feet)	*Unit thickness (feet)*	*Description*
300	300	No core.
306	6.0	Sand, pebbly, cobbly, gray-orange-pink (5*YR* 7/2), and 5–20 percent volcanic fragments.
501	195.0	No core.
505	4.0	Poor core; probably cavings similar to the sand; pebbles and cobbles at depth 306.0 ft.
859	354.0	No core.
861	2.0	Sandstone, tuffaceous, massive, grayish-orange-pink (5*YR* 7/2). The sand is poorly sorted, subangular, and medium to coarse. Some pebbles of volcanic rocks and quartz.
864	3.0	Sandstone, slightly tuffaceous and calcareous, massive, pebbly, grayish-orange-pink (5*YR* 7/2). The sand is poorly sorted, subangular, and fine to very coarse. At depth 862.5 ft is ½-in.-thick parting of grayish-orange-pink (5*YR* 7/2) clay. A few scattered blebs of very fine grained white calcite and clay. The tuffaceous material is altered to clinoptilolite.
869	5.0	Sandstone, pebbly, gray-orange-pink (5*YR* 7/2), coarse-grained.
1,102.5	233.5	No core. A color change from gray orange pink (5*YR* 7/2) to a light olive gray (5*YR* 5/2) at 950 ft was noted.
1,108.0	5.5	Sandstone, slightly calcareous and tuffaceous, massive, light-olive-gray (5*Y* 5/2). The sand is poorly sorted, subangular, and fine to very coarse. A scattering of blebs of very fine grained white clinoptilolite and quartz.

Hector 1—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,109.0	1.0	Sandstone, pebbly, light-olive gray (5 *Y* 5/2).
1,112.5	3.5	Sandstone; similar to sandstone at depth 1,108.0 ft.
1,131.0	18.5	Sandstone, cobbly, tuffaceous, light-olive-gray (5*Y* 5/2). The sand is poorly sorted, subangular, and fine to very coarse. There are interbedded layers of pebbles; these layers have a dip of 0°–5°. At depth 1,121.0 ft is cobble limestone that is massive, very sandy, >0.3 ft thick, and yellowish gray (5*Y* 7/2) in color. The sand of the cobble limestone bed is well sorted and medium to fine. A moderate amount of clinoptilolite throughout the interval.
1,132.0	1.0	Gravel, pebble to cobble.
1,134.0	2.0	Sandstone, tuffaceous, vaguely bedded, pale-yellowish-brown (10*YR* 6/2). The sand is poorly sorted, subangular, and fine to coarse. At depth 1,134.0 ft, 0.3-ft-thick clay bed; the clay is calcareous, massive, and pale brown (5*YR* 5/2) and grades into the sand at the lower contact. There is clinoptilolite throughout the interval.
1,148.0	14.0	Sandstone, pebbly, pale-yellowish-brown (10*YR* 6/2). At depth 1,146.0 ft is a 1.0-ft-thick caliche zone,
1,163.0	15.0	Sandstone, calcareous, tuffaceous, massive, pale-yellowish-brown (10*YR* 6/2). The sand is fairly well sorted, subangular, and medium. Small white very fine grained blebs of clinoptilolite; the tuffaceous material is altered to clinoptilolite.
1,168.0	5.0	Sandstone, pebbly, medium- to coarse-grained. At depth 1,164.5 ft is a 0.1-ft-thick bed of green clay.
1,169.0	1.0	Gravel, pebble, sandy; grades at the base to a pebbly sandstone.
1,169.5	.5	Sandstone, tuffaceous, slightly calcareous, massive, pebbly, light-olive-gray (5*Y* 5/2). The sand is poorly sorted, subangular, and fine to coarse. Clinoptilolite throughout the interval. The pebbles are volcanic and granitic.
1,170.0	.5	Tuff, pale-green (10*G* 6/2) to greenish-gray (10*GY* 5/2), and phenocrysts of feldspar (andesine) and hornblende.
1,182.0	12.0	Sandstone, pebbly, tuffaceous, slightly calcareous, massive, light-olive-gray (5*Y* 5/2). The sand is poorly sorted, subangular, and fine to coarse. Clinoptilolite throughout the section. The pebbles are basalt and other volcanic rocks.
1,183.0	1.0	Gravel, pebble.
1,186.0	3.0	Sandstone, pebbly.

Hector 1—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,187.0	1.0	Caliche and gravel.
1,211.0	24.0	Sandstone, pebbly, cobbly, coarse-grained.
1,212.0	1.0	Gravel, pebble to cobble.
1,221.0	9.0	Sandstone; similar to sandstone at depth 1,182.0 ft. A few irregular partings of clay.
1,500.0	279.0	No core. Ditch samples were reported to be arkosic sand.
		End of hole.

Hector 2

[Location: SE¼ sec. 8, T. 8 N., R. 5 E.]

Depth (feet)	*Unit thickness (feet)*	*Description*
20.0	20.0	No core.
116.4	96.4	Mudstone, silty, calcareous, massive, grayish-orange-pink (5*YR* 7/2). Minor clinoptilolite throughout the interval. A trace of analcime at depth 110.0 ft. A few streaks of black carbonaceous material at depth 70.0 ft.
119.0	2.6	Mudstone, silty, calcareous, massive, yellowish-gray (5*YR* 8/1). A few clastic dikes of pink and yellow clay. Minor amounts of analcime and a trace of clinoptilolite.
122.0	3.0	Mudstone; similar to mudstone at depth 116.4 ft. A few fragments of white clay.
144.0	22.0	Mudstone, silty, calcareous, massive, grayish-orange-pink (5*YR* 7/2). A few fine clear selenite crystals.
144.1	.1	Conglomerate, pebble, grayish-orange-pink (5*YR* 7/2).
148.0	3.9	Siltstone, sandy; gradational contact at base to the interval below.
175.0	27.0	Mudstone, slightly calcareous, massive, grayish-orange-pink (5*YR* 7/2). A few streaks and blebs of very fine grained white gypsum. Minor amount of analcime and a trace of clinoptilolite.
175.2	.2	Sandstone, grayish-orange-pink (5*YR* 7/2).
250.0	74.8	Mudstone, silty, gypsiferous, massive, grayish-orange-pink (5*YR* 7/2). Minor amounts of analcime and clinoptilolite.
251.0	1.0	Sandstone, silty, grayish-orange-pink (5*YR* 7/2), medium- to coarse-grained.
263.0	12.0	Sand in a matrix of clay, massive, grayish-orange-pink (5*YR* 7/2). A few blebs of very fine grained white gypsum and minor amounts of clinoptilolite.

Hector 2—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
270.0	7.0	Silt, sandy, grayish-orange-pink (5*YR* 7/2).
500.0	230.0	Not cored.
648.0	138.0	No core.
655.0	7.0	Sandstone, pebbly, tuffaceous, grayish-orange-pink (5*YR* 7/2) to light-brown (5*YR* 6/4). The sand is poorly sorted, subangular to subrounded, and fine to coarse. The pebbles are andesite and other volcanic rocks.
661.0	6.0	Gravel, pebble, sandy, tuffaceous, grayish-orange-pink (5*YR* 7/2).
661.2	.2	Caliche, pebbly, tuffaceous, very light gray (*N*8) to light-gray (*N*7). The pebbles are poorly sorted, are subangular, and are composed of andesite and other volcanic fragments.
664.0	2.8	Gravel; similar to gravel at depth 661.0 ft.
664.2	.2	Caliche; similar to caliche at depth 661.2 ft.
666.0	1.8	Gravel; similar to gravel at depth 661.0 ft.
674.0	8.0	Gravel, pebble, tuffaceous, calcareous (moderately cemented with calcite), grayish-orange-pink (5*YR* 7/2) to grayish-orange (10*YR* 7/4). The pebbles are poorly sorted and subangular to subrounded and are composed of andesite and other volcanic fragments.
682.0	8.0	Gravel, boulder to cobble, tuffaceous, grayish-orange-pink (5*YR* 7/2).
687.0	5.0	Gravel, pebble to cobble, tuffaceous, grayish-orange-pink (5*YR* 7/2).
689.0	2.0	Conglomerate, cobble to boulder.
700.0	11.0	Gravel, pebble, sandy, tuffaceous, grayish-orange-pink (5*YR* 7/2) to grayish-orange (10*YR* 7/4). The pebbles are poorly sorted, subangular to subrounded, poorly cemented, and in composition are andesite, basalt, and other volcanic rocks.
900	200.0	No core. End of hole.

Hector 3

[Location SW¼ sec. 25, T. 8 N., R. 5 E.]

Depth (feet)	*Unit thickness (feet)*	*Description*
10.0	10.0	No core. Cuttings are similar to interval below.
12.0	2.0	Mudstone, sandy, calcareous, very pale orange (10*YR* 8/2), massive, poorly indurated. Few pebbles and angular volcanic fragments. Sand is fine to coarse

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		and angular. Tuffaceous material is altered to clinoptilolite.
14.0	2.0	No core. Cuttings are similar to interval above.
15.4	1.4	Mudstone, very tuffaceous, sandy, slightly calcareous, grayish-orange-pink (5*YR* 7/2), massive, moderately well indurated. Few pebbles and angular volcanic fragments. Sand is fine to coarse and angular. Tuffaceous material is alterned to clinoptilolite and erionite.
17.9	2.5	Tuff, zeolitic, sandy, calcareous, white to pink-gray (5*YR* 8/1), laminated, well-indurated. Few pebbles and angular volcanic fragments. Tuff is altered to clinoptilolite and erionite. Upper 1 ft is impregnated and replaced by calcite (60 percent). In lower 1 ft, sand increases from less than 1 percent to about 50 percent; sand throughout interval is fine to coarse and angular. The lower contact to the interval below is sharp.
29.6	11.7	Sandstone, tuffaceous, clayey, slightly calcareous, light-brownish-gray (5*YR* 6/1) to pinkish-gray (5*YR* 8/1) to yellowish-gray (5*Y* 8/1), massive to faintly laminated, well-indurated. The sand is fine to coarse and poorly sorted. A few pebble-sized angular volcanic fragments. Tuffaceous material is altered to clinoptilolite. Lower 0.3 ft is about 50 percent calcite.
34.6	5.0	Mudstone, sandy, tuffaceous, slightly calcareous, pale-brown (5*YR* 5/2) to yellowish-gray (5*Y* 8/1), massive, well-indurated. Few pebbles and angular fragments of tuff and other volcanic rock. A few white blebs of very fine grained calcite. In upper 1.6 ft are numerous blebs (<1 mm diameter) of very fine grained clinoptilolite. Tuffaceous material is altered to clinoptilolite. Sand is fine to medium and angular.
35.2	.6	Tuff; similar to tuff at depth 17.9 ft.
51.9	16.7	Mudstone, tuffaceous, yellowish-gray (5*Y* 8/1) to light-olive-gray (5*Y* 6/1), massive to faintly laminated, and fairly well indurated. Locally 1–2-in.-thick beds are calcareous and (or) sandy. Sand is fine to coarse and angular. Numerous blebs (1–2 mm in diameter) and streaks of yellowish-gray (5*Y* 8/1) tuff totally altered to clinoptilolite. The tuffaceous material is altered to clinoptilolite and a minor amount of analcime.
52.1	.2	Mudstone, tuffaceous, slightly calcareous, pale-yellow-brown (10*YR* 6/2), massive, poorly indurated. Some white blebs (<0.5 mm in diameter) of very fine

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		grained clinoptilolite. Tuffaceous material is altered to clinoptilolite and a minor amount of analcime.
53.6	1.5	Alternating thin (1–2 in.) beds of mudstone, siltstone, sandstone, and zeolitic tuff. The beds are calcareous, tuffaceous, and white to yellowish gray (5*Y* 8/1) and have gradational contacts to each other. Sand is very fine and angular to subangular. Tuffaceous material is altered to clinoptilolite. A calcite bed at 53.4 ft is 0.3 ft thick and sandy and contains vugs, 1–10 mm wide, lined with fine clear euhedral calcite crystals.
54.8	1.2	Mudstone; similar to mudstone at depth 34.6 ft.
54.9	.1	Tuff, very sandy, zeolitic, slightly calcareous, very light gray (*N*8), massive, well-indurated. Sand is fine to medium, angular, and arkosic. Tuffaceous material is altered to clinoptilolite.
69.0	14.1	Mudstone, tuffaceous, calcareous, pale-red (10*R* 6/2), massive, well-indurated. A few pebbles and coarse to fine fragments of volcanic rock. A few beds <1 in. thick of tuff similar to interval above. The tuffaceous material is altered to clinoptilolite.
71.2	2.2	Mudstone, very tuffaceous, sandy, slightly calcareous, light-red (5*R* 6/6) to pale-red (5*R* 6/2), massive, poorly to well-indurated. Tuffaceous material is altered to clinoptololilite and analcime. Sand is poorly sorted, is angular, and is composed of mainly volcanic fragments.
76.0	4.8	Mudstone; similar to interval above except the mudstone is not sandy.
76.4	0.4	Tuff, zeolitic, slightly calcareous, white to pale-yellowish-orange (10*YR* 8/6), faintly laminated, well-indurated; full of alveolated holes (tend to be flattened). The holes are < 2 mm long and are sometimes lined or filled by clay and coarse anhedral calcite crystals. Tuff is almost entirely altered to clinoptilolite with a trace of analcime. A few thin (<0.5 mm in width) veins of dusky-red (5*R* 3/4) clay.
98.5	22.1	Mudstone, tuffaceous, slightly calcareous, pale-red (5*R* 6/2), massive, poorly to well-indurated. A few streaks and blebs of very fine grained white calcite. A few blebs of very fine grained white clinoptilolite. A few laminae (<5 mm wide) and streaks of tuff similar to the interval above. Tuffaceous material is altered to clinoptilolite and analcime. At 93.2 ft is a 1-in.-thick bed of fine angular sand composed predominantly of fresh volcanic material.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
99.3	.8	Tuff, zeolitic, calcareous, siliceous, white to very pale orange (10*YR* 8/2), holey, massive to faintly laminated, well-indurated. These vesicles range in size from 3.0 to 0.3 mm and sometimes are filled with grayish-red (10*R* 4/2) chalcedony. A few thin horizonal streaks and laminae of pale-red (5*R* 6/2 clay. Fine grained tuffaceous matrix has been altered to very fine grained quartz (chalcedony), clinoptilolite, and analcime.
106.6	7.3	Mudstone; similar to mudstone at depth 98.5 ft.
107.4	.8	Tuff; similar to tuff at depth 99.3 ft.
119.7	12.3	Mudstone; similar to mudstone at depth 98.5 ft. At 110.1 ft is a 0.2-ft-thick bed of sandstone, medium-grained, clayey. A few beds <5 mm thick of tuff, similar to tuff at depth 99.3 ft, at 110.3 ft.
120.4	.7	Tuff, calcareous, light-gray (*N*7), massive, well-indurated. Numerous medium to coarse plates of mica. Some very fine grained white blebs (1 mm in diameter) of calcite. Tuffaceous material is altered to clinoptilolite and analcime and silicified to chalcedony and cristobalite.
133.2	12.8	Mudstone; similar to mudstone at depth 98.5 ft. At base of interval is a 0.5-ft-thick bed of coarse sand and gravel in a matrix of clay.
133.3	.1	Tuff; similar to tuff at depth 120.4 ft, except that the tuff in this interval is not calcareous.
138.0	4.7	Mudstone; similar to mudstone at depth 98.5 ft.
140.0	2.0	Tuff; similar to tuff at depth 120.4 ft.
142.3	2.3	Mudstone; similar to mudstone at depth 98.5 ft. In the lower 0.4 ft is a gradual increase in tuff; the tuff is similar to the interval below.
144.1	1.8	Tuff, very clayey, calcareous, zeolitic, yellowish-gray (5*Y* 8/1), massive, well-induraated. Tuffaceous material is altered primarily to clay minerals and minor amounts of analcime and clinoptilolite. A few streaks of pale-red (5*R* 6/2) clay.
157.8	13.7	Mudstone; similar to mudstone at depth 98.5 ft. At 146.6 ft is a 0.1-ft-thick bed of tuff similar to tuff at depth 120.4 ft. A few beds <0.2 ft thick of bean-shaped concretions (<1 mm); the mineralogy of the concretions is same as mudstone matrix except they are slightly more calcareous.
158.0	.2	Mudstone, tuffaceous, calcareous, pale-brown (5*YR* 5/2), massive, poorly indurated. Tuffaceous material is altered to analcime.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
160.0	2.0	Mudstone, tuffaceous, calcareous, pale-yellowish-green (10*GY* 7/2), massive, moderately to poorly indurated. A few white fine-grained blebs (<1 mm in diameter) of calcite. Tuffaceous material is altered to analcime.
170.0	10.0	No core. Cuttings: similar to interval above.
180.0	10.0	No core. Cuttings: Mudstone, tuffaceous, calcareous, yellowish-gray (5*Y* 8/1).
250.0	70.0	No core. Cuttings: Mudstone; similar to mudstone at depth 98.5. A few fragments of black organic material. A few fragments of coarsely crystalline calcite.
260.0	10.0	No core. Cuttings: Tuff and calcite, sandy, clayey, grayish-orange-pink (5*YR* 7/2).
303.0	43.0	No core. Cuttings: similar to interval below.
305.0	2.0	Mudstone, tuffaceous, calcareous, grayish-orange-pink (5*YR* 7/2), massive, moderately to poorly indurated. A few streaks and blebs of very fine grained white calcite. Tuffaceous material is altered to analcime.
305.8	.8	Calcite rock, grayish-orange-pink (10*R* 8/2), very fine grained, massive.
310.0	4.2	No core. Cuttings: Mudstone and calcite; similar to mudstone at depth 305.0 ft and calcite at depth 305.8 ft.
448.0	138.4	No core. Cuttings: Mudstone; similar to mudstone at depth 305.0 ft. A few fragments of black organic material.
449.4	1.0	Tuff, white, faintly laminated, well-indurated. Numerous angular fragments and crystals (< 0.5 mm) of quartz, mica, hornblende, and feldspar give the rock a salt-and-pepper appearance. Numerous small holes <0.5 mm) filled with clay minerals, chalcedony, and zeolites. Tuffaceous material is almost completely altered to clinoptilolite, but contains a very minor amount of analcime.
452.4	3.0	Tuff, white to light-greenish-gray (5*GY* 8/1), massive to faintly laminated, well-indurated. In lower 1.5 ft of the interval are thin laminae and blebs (4–<1 mm in diameter) of grayish-green (10*GY* 5/2) clay. Tuffaceous material is altered to clinoptilolite; in thin section the shard shapes are still very sharp, but the glass is replaced by clinoptilolite and clay minerals. R. A. Sheppard (written commun., May 1969) reported mordenite in lower part of this interval.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
490	37.6	No core. Cuttings: Mudstone; similar to mudstone at depth 305 ft.
500	10.0	No core. Cuttings: Calcite and mudstone. Calcite is very fine grained, white, and dense. Mudstone is similar to mudstone at depth 305 ft.
580	80.0	No core. Cuttings: Mudstone; similar to mudstone at depth 305 ft.
633	53.0	No core. Cuttings: Mudstone; similar to mudstone at depth 633.5 ft.
633.5	.5	Mudstone, tuffaceous, light-olive-gray (5*Y* 6/1), massive, moderately indurated. Tuffaceous material is altered to analcime.
633.9	.4	Calcite rock, tuffaceous, light-brownish-gray (5*YR* 6/1), faintly laminated, very fine grained (<0.02 mm), dense. Irregular greenish-gray (5*G* 6/1) masses (5–15 mm) of very fine grained (<0.002 mm) calcite intermixed with clay. Tuffaceous material is is altered to analcime.
634.1	.2	Mudstone; similar to mudstone at depth 633.5 ft.
634.3	.2	Calcite rock and mudstone. The core is badly ground and discontinuous. Calcite is white, very fine grained, and soft; mudstone is similar to mudstone at depth 633.5 ft.
635.1	.8	No core.
638.0	2.9	Mudstone; similar to mudstone at depth 633.5 ft.
640.9	2.9	Mudstone, tuffaceous, slightly calcareous, silty, light-brownish-gray (5*YR* 6/1), faintly laminated to massive, fairly well indurated. Tuffaceous material is altered to analcime.
641.0	.1	Celestite rock, analcimic, micaceous, very fine grained, medium-light-gray (*N*6), massive, dense. Base of interval is a horizontal vein, 7 mm wide, of coarse columnar crystals of celestite.
642.2	1.2	Mudstone, tuffaceous, dusky-yellow (5*Y* 6/4), finely laminated to massive, well-indurated. Tuffaceous material is altered to analcime.
652.5	10.3	Mudstone, tuffaceous, calcareous, celestitic, light-brownish-gray (5*YR* 6/1), faintly laminated, well-indurated. At 649.2 ft is a 0.1-ft-thick bed of celestite similar to celestite at depth 641.0 ft. A few veins of coarse crystals of clear celestite from 642.8 to 649.2 ft. At 642.7 ft is 0.1-ft-thick bed of very fine grained yellowish-gray (5*Y* 8/1) calcite. From 642.9 to 652.5 ft there are thin streaks and laminae of the very fine grained yellowish-gray (5*Y* 8/1) calcite; in

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		lower 1.5 ft the calcite veins develop a netlike pattern. A gradational contact to the interval below. Tuffaceous material is altered to analcime.
653.5	1.0	Calcite rock, tuffaceous, sandy, medium-light-gray (*N*6), very fine grained, massive, well-indurated. At base of the interval is 0.3-ft-thick bed of sandstone; the sand in this bed and throughout the interval is fine to coarse. Tuffaceous material is altered to analcime.
659.9	6.4	Mudstone; similar to mudstone at depth 640.9 ft.
660.9	1.0	Sandstone, tuffaceous, calcareous, celestitic, clayey, micaceous, light-olive-gray (5*Y* 6/1), very fine grained, massive. Tuffaceous material is altered to analcime.
661.0	.1	Tuff, zeolitic, clayey, yellowish-gray (5*Y* 8/1), faintly laminated, poorly indurated. Tuffaceous material is altered to analcime.
665.5	4.5	Mudstone, tuffaceous, pale-red (5*R* 6/2), massive, well-indurated. Tuffaceous material is altered to analcime. At 663.0 ft is a 0.4-ft-thick bed of sandstone similar to sandstone at depth 660.9 ft. At 662.7 ft is a 0.1-ft-thick bed of calcite similar to calcite of the interval below.
665.7	.2	Calcite rock, analcimic, pale-yellowish-brown (10*YR* 6/2), fine-grained, dense, well-indurated. Altered tuff. Mottled with a few brilliant-green (5*G* 6/6) clay streaks. In the lower one-third of the interval is a bed, 12–17 mm wide, of medium-grained poorly sorted sandstone. Analcime occurs as a mosaic of euhedral crystals (<0.03 mm) in the larger (1–5 mm) grained calcite matrix.
670.7	5.0	Mudstone; similar to mudstone at depth 665.5 ft, except that it is laminated in lower half of interval. Middle of the interval is sandy; the sand is similar to the sand at depth 660.9 ft. A thin vertical and horizontal vein of calcite in the upper 3 ft of the interval.
671.0	.3	Analcime and celestite rock, very fine grained, very light gray (*N*8), massive to faintly laminated, well-indurated. Altered tuff. Mottled with streaks of moderate-green (5*G* 5/6) clay. In this section there is a coarse (1–5 mm) relict crystal texture completely replaced by very fine grained celestite, with a mosaic of subhedral to euhedral analcime crystal grains throughout. Similar to the interval at depth 665.7 ft with calcite replaced by celestite.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
671.7	.7	Mudstone; similar to mudstone at depth 665.5 ft.
672.5	.8	Tuff, very silty, light-olive-gray (5*Y* 6/1), massive, well-indurated. Tuffaceous material is altered to analcime. At base is a 0.1-ft-thick bed of light-olive-gray (5*Y* 6/1) mudstone.
675.3	2.8	Mudstone; similar to mudstone at depth 640.9 ft.
675.7	.4	Calcite rock, analcimic, celestitic, very fine grained, dense, light-gray (*N*7) to olive-gray (5*Y* 4/1), faintly laminated, well-indurated. Altered tuff. Analcime occurs as a mosaic of fine subhedral to euhedral crystals in larger calcite crystals similar to calcite at depth 665.7 ft. Lower 0.2 ft of calcite has been partially replaced by fine-grained celestite. A few streaks of light-olive gray (5*Y* 6/1) and moderate-green (5*G* 5/6)clay. Near base is a horizonal <2-mm-wide vein of fine-grained dense white analcime.
684.3	8.5	Mudstone; similar to mudstone at depth 665.5 ft. Bed <0.1 ft thick of sandstone at 680.1 ft; sand is angular and contains fresh igneous rock.
685.4	1.1	Calcite rock, "marl," clayey, tuffaceous, pale-red (5*R* 6/2), massive, moderately well indurated. Tuffaceous material is altered to analcime. Thin (<0.5 mm) veinlets of very fine grained white calcite.
687.8	2.4	Mudstone; similar to mudstone at depth 665.5 ft. A few streaks of grayish-green (5*G* 5/2) clay.
688.2	.4	Calcite rock, "marl," clayey, tuffaceous, light-brownish-gray (5*YR* 6/1), massive, fairly well indurated. Veinlets of very fine white calcite crystals. Tuffaceous material is altered to analcime. Near base is a bed, 10 mm wide, of coarse vertical clear shiny calcite crystals.
690.0	.8	Mudstone; similar to mudstone at depth 665.6 ft. A few discontinuous horizontal veins, <2 mm wide, of very fine grained white calcite. In lower one-half of the interval a few beds of greenish-gray (5*GY* 6/1) mudstone are interbedded with the red mudstone.
691.8	1.8	Calcite rock, "marl," clayey, tuffaceous, pale-red (5*R* 6/2) to greenish-gray (5*G* 6/1), vaguely laminated, well-indurated. Numerous streaks, inclusions, and laminae of clay; clay grades in color from pale red (5*R* 6/2) to greenish gray (5*G* 6/1). Tuffaceous material is altered to analcime.
705.0	13.2	Mudstone, tuffaceous, calcareous, grayish-red (10*R* 4/2) to pale-red (5*R* 6/2), massive to faintly bedded,

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		moderately to well-indurated. A few streaks of pale-green (5*G* 7/2) clay. A few streaks of very fine grained white calcite. Tuffaceous material is altered to analcime. At 699.2 and 704.5 ft are beds 0.3 and 0.1 ft thick, respectively, of calcite; the calcite is very fine grained, analcimic, celestitic, light olive gray (5*Y* 6/1), and massive.
706.1	1.9	Mudstone, calcareous, tuffaceous, light-olive-gray (5*Y* 6/1) to medium-light-gray (*N*6), moderately to poorly indurated, massive to faintly laminated. Numerous very fine grained white blebs, streaks, and laminae of analcime. In upper half of the interval are veins, 2–4 mm wide, of coarse crystals of celestite. Tuffaceous material is altered to analcime with a minor amount of clinoptilolite.
716.1	10.0	Mudstone; similar to mudstone at depth 705.0 ft. A few veins of coarse clear crystals of celestite; veins are 2 mm wide. In lower half of the interval and at 709.4 ft are beds 0.1–0.2 ft and 0.6 ft thick, respectively, of calcite; the calcite is very fine grained, clayey, analcimic, light brownish gray (5*YR* 6/1) to light olive gray (5*Y* 6/1), and laminated.
716.6	.5	Calcite rock, clayey, mottled-pale-red (5*R* 6/2) and light-brownish-gray (5*YR* 6/1), fairly well indurated; faint broad lamination. Gradational contact with interval below.
720.0	3.4	Mudstone, calcareous, tuffaceous, light-brownish-gray (5*YR* 6/1), poorly indurated, massive. Numerous veins of calcite similar to interval above in upper 1 ft of the interval. A few vugs and laminae of coarse-grained calcite and celestite in upper 1 ft of the interval. A few blebs of very fine grained white clinoptilolite in middle one-third of the interval. Tuffaceous material is altered to clinoptilolite.
721.5	1.5	Calcite rock, clayey, light-olive-gray (5*Y* 6/1) to light-brownish-gray (5*YR* 6/1), massive, fairly well indurated. A few beds, <2 in. thick, of mudstone similar to interval above. at top of the interval and the edge of the clay beds are veins of coarse (<4 mm) calcite crystals.
728.0	6.5	Mudstone, tuffaceous, calcareous, light-brownish-gray (5*YR* 6/1), massive to faintly laminated, moderately to well-indurated. A few streaks of pale-green (5*G* 7/2) clay. A few streaks and blebs of very fine grained white calcite. Thin laminae, streaks, and blebs of very fine grained sandy white clinoptilolite. Tuffaceous material is altered to clinoptilolite.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
731.2	3.2	Interbedded beds of mudstone and calcite. The beds are tuffaceous and celestitic. Calcite is very fine grained, soft, chalky, and white, contains about 25 percent celestite, and occurs in beds about 2–25 mm in width. Mudstone beds are <1–100 mm thick and pale red (5*R* 6/2) and greenish gray (5*GY* 6/1; the pale red beds are wider than the greenish-gray beds. Tuffaceous material is altered to clinoptilolite.
732.0	.8	Tuff, zeolitic, clayey, yellowish-gray (5*Y* 8/1), faintly laminated, well-indurated, very fine grained. Tuffaceous material has been altered to chabazite, clinoptilolite, and Na-montmorillonite.
737.0	5.0	Mudstone, tuffaceous, calcareous, olive-gray (5*Y* 4/1), massive, moderately to poorly indurated. A few blebs and laminae of fine-grained white calcite. A few 0.1–0.2-ft-thick beds of tuff similar to the interval above in the upper 1 ft. Tuffaceous material is altered to clinoptilolite.
743.0	6.0	Mudstone, calcareous, tuffaceous, gypsiferous, light-brownish-gray (5*YR* 6/1), massive, moderately well indurated to friable. A few blebs of very fine grained white calcite. A few beds, ½–2 in. wide, of swallow-tailed gypsum crystals in the lower 4 ft of the interval. Tuffaceous material is altered to clinoptilolite.
751.0	8.0	No core.
755.0	4.0	Mudstone; similar to mudstone at depth 743.0 ft. Numerous beds, 0.2–0.5 in. wide, of swallow-tailed gypsum crystals.
757.3	2.3	Mudstone; similar to mudstone at depth 743.0 ft. Abundant (10–50 percent) gypsum as both swallow-tailed crystals and fine-grained earthy beds and lenses. Lower 3 in. show nearly vertical slickensides.
759.7	2.4	Mudstone; similar to mudstone at depth 743.0 ft. A 2-in.-thick shaly zone at 759.3 ft.
760.1	.4	Tuff, clayey, zeolitic, light-greenish- gray (*GY* 8/1), massive, well-indurated. Altered to clay and clinoptilolite.
768.0	7.9	Mudstone; similar to mudstone at depth 743.0 ft. Upper 0.5 ft of the interval has 30 percent swallow-tailed gypsum crystals.
770.3	2.3	Mudstone, calcareous, tuffaceous, light-greenish-gray (5*G* 8/1) to greenish-gray (5*GY* 6/1), massive to laminated, well-indurated. Tuffaceous material is altered to clinoptilolite.
779.3	9.6	Mudstone; similar to mudstone at depth 743.0 ft.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
779.9	.6	Calcite rock, fine-grained, dense, medium-light-gray (*N*6).
780.0	.1	Mudstone, calcareous, very light gray (*N*8), massive to faintly laminated, moderately well indurated.
782.0	2.0	Mudstone, tuffaceous, yellowish-gray (5*Y* 8/1) to light-olive-gray (5*Y* 6/1), massive to laminated, moderately well indurated. Crossbedding at 781.0 ft and a minor unconformity or a slump at 781.5 ft. In the lower 0.5 in. there is some celestite. Tuffaceous material is altered to clinoptilolite.
782.1	.1	Calcite rock, very clayey, tuffaceous, yellowish-gray (5*Y* 8/1), massive, poorly indurated. Abundant mud balls, 1–5 mm in diameter, similar in composition to the mudstone in the interval above. Tuffaceous material is altered to clinoptilolite.
782.4	.3	Calcite rock, light-bluish-gray (5*B* 7/1) to medium-bluish-gray (5*B* 5/1), dense, massive, well-indurated. Contains fragments and inclusions of calcite similar to the calcite of the intervals above and below.
782.6	.2	Calcite rock; similar to calcite at depth 782.1 ft.
789.4	6.8	Mudstone, calcareous, tuffaceous, light-brownish-gray (5*YR* 6/1) to pale-red (5*R* 6/2), faintly laminated, moderately well indurated. Some very fine grained white blebs of clinoptilolite. Tuffaceous material is altered to clinoptilolite. At 786.7 and 787.8 ft are 0.5-in.-thick beds of silica: quartz, cristobalite, and minor amounts of clinoptilolite.
789.8	.4	Tuff, clayey, zeolitic, calcareous, yellowish-gray (5*Y* 8/1), faintly laminated, moderately well indurated. Extensively altered to clay and clinoptilolite.
794.8	5.0	Mudstone; similar to mudstone at depth 789.4 ft. In upper 2 ft of the interval are thin (¼–½ in.) partings of calcite, similar to calcite at depth 782.4 ft.
799.8	5.0	Mudstone; similar to mudstone at depth 789.4 ft except there is no clinoptilolite. A few thin (<⅛ in.) beds of very fine grained sandstone. Some crossbedding.
800.0	.2	No core.
970.0	170.0	No core. Cuttings: Mudstone, tuffaceous, calcareous, light-olive-gray (5*Y* 6/1) to light-brownish-gray (5*YR* 6/1). A few fragments of greenish-gray (5*GY* 6/1) clay, pale-red (5*R* 6/2) clay, and very fine grained white calcite. A 3-ft-thick bed of white tuff, altered to clay, in the 800–810-ft interval; scattering of fragments of white tuff throughout rest of interval.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,150.0	180.0	No core. Cuttings: Mudstone, calcareous, tuffaceous, sandy, light-olive-gray (5*Y* 6/1) to greenish-gray (5*GY* 6/1). Some fragments of dull white fine-grained calcite, clear crystalline calcite, fine-grained white tuff, clear crystalline gypsum, and very fine grained earthy white gypsum mixed with dark organic material and a trace of pyrite.
1,180.0	30.0	No core. Cuttings: Mudstone; similar to mudstone at depth 1,150.0 ft. Also some fragments of fine-grained greenish-gray (5*GY* 6/1) anhydrite.
1,330.0	150.0	No core. Cuttings: Mudstone, anhydritic, calcareous, tuffaceous, greenish-gray (5*GY* 6/1); 10–50 percent fine-grained greenish-gray (5*GY* 6/1) anhydrite. Some blebs and fragments of very fine grained white clinoptilolite. Some fragments of very fine grained dense white to yellowish-gray (5*Y* 8/1) calcite.
1,335.4	4.9	Anhydrite rock, laminated, calcareous, clayey, tuffaceous, greenish-gray (5*GY* 6/1), fine-grained; contains very minor amount of pyrite. The laminations are irregular in width, discordant, and slightly undulating. The clay laminae are <2–>10 mm thick. The clay is tuffaceous, calcareous, and greenish gray (5*GY* 6/1) and contains white blebs of very fine grained clinoptilolite. The laminae and lenticules of calcite are irregular and less than 3 mm in thickness. The calcite is a yellowish gray (5Y 8/1) and very fine grained. At depth 1,331.6 ft is a 1-in.-thick bed of spongy yellowish-gray (5Y 8/1) calcite (tufa) containing about 40 percent celestite. Throughout the interval there are a few veins and vugs filled with clear euhedral crystals of colemanite and anhydrite, and milky euhedral crystals of quartz.
1,335.8	.4	Anhydrite rock, colemanitic, celestitic, calcareous, tuffaceous, yellowish-gray (5*Y* 8/1) to light-olive-gray (5*Y* 6/1), fine to medium-grained; porous, spongelike texture of intergrown crystals. Few streaks, laminae, and lenticules of very fine grained yellowish-gray (5Y 8/1) calcite. Some lenses, 4 by 20 mm, of very fine grained light-olive-gray (5*Y* 6/1) celestite. Few streaks of dark-gray (*N*3) clay. Few blebs of very fine grained white howlite. Few small vugs filled with medium clear euhedral anhydrite crystals. Some streaks of colemanite intergrown with the anhydrite. (Colemanite, ±20 percent.)

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,338.5	2.7	Anhydrite rock; similar to anhydrite rock at depth 1,335.4 ft.
1,346.8	8.3	Anhydrite rock, laminated, calcareous, celestitic, clayey, medium-gray (*N*5) with horizontal streaks of yellowish-gray (5*Y* 8/1), medium- to fine-grained. The laminations are straight to slightly undulating; anhydrite laminae are 1–>5 mm thick, the calcite laminae and lenticules are <1.2–2.0 mm thick, and the clay laminae are <0.5 mm thick. The calcite is yellowish gray (5*Y* 8/1), celestitic, and very fine grained. The clay is medium gray (*N*5), tuffaceous, and clinoptilolitic and contains a few very fine grained white blebs of colemanite. At 1,343.5 and 1,345.0 ft are 1.5-in.-thick beds of claystone; the claystone is olive gray (5*Y* 4/1) to grayish olive (10*Y* 4/2). In the lower 0.2 ft the laminae of clay increase to 1–4 mm in thickness and make up about 30 percent of the rock.
1,347.3	.5	Colemanite rock, anhydritic, yellowish-gray (5*Y* 8/1) to pale-yellowish-brown (10*YR* 6/2), medium-grained. Intergrown with the colemanite are clear medium anhydrite crystals. A few veins or beds of light-gray (*N*7) medium-grained anhydrite. A few laminae, lenticules, and streaks of very fine grained yellowish-gray (5*Y* 8/1) calcite. A few laminae and streaks of light-olive-gray (5*Y* 6/1), tuffaceous clay. (Colemanite, ±75 percent.)
1,348.0	.7	Claystone, anhydritic, calcareous, tuffaceous, light-olive-gray (5*Y* 6/1) to olive-gray (5*Y* 4/1), laminated. Laminated with thin beds, 2–4 mm in width, of very fine grained yellowish-gray (5*Y* 8/1) calcite and medium-light-gray (*N*6) medium-grained anhydrite. The claystone interval contains minor celestite, quartz, feldspar, and clinoptilolite.
1,350.4	2.4	Anhydrite rock; similar to anhydrite rock at depth 1,335.4 ft.
1,351.0	.6	Claystone; similar to claystone at depth 1,348.0 ft.
1,353.3	2.3	Anhydrite rock medium- to fine-grained; mottled light olive gray (5*Y* 6/1) and olive gray (5*Y* 4/1). Massive except in upper 0.2 ft and lower 1.0 ft where it is faintly laminated. Few laminae of greenish-gray (5*GY* 6/1) clay. A few lenses and veins of coarse clear euhedral anhydrite crystals. A trace of calcite and quartz in the interval.
1,353.7	.4	Anhydrite and colemanite rock, calcareous, tuffaceous, light-olive-gray (5*Y* 6/1) mottled with yellowish

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		gray (5*Y* 8/1) and grayish orange (10*YR* 7/4), medium- to coarse-grained. Some very porous spongy matts of coarse crystals of anhydrite and colemanite growing into vugs and veins. A few veins of very fine grained dense light-gray (*N*7) anhydrite. A few streaks of very fine grained yellowish-gray (5*Y* 8/1) calcite. A trace of clay and howlite in the interval. (Colemanite, ±50 percent.)
1,354.3	.7	Anhydrite rock, calcareous, light-olive-gray (5*Y* 6/1) to medium-gray (*N*5), medium- to fine-grained; a few laminae of greenish-gray (5*GY* 6/1) clay, less than 5 mm wide. (Colemanite, ±10 percent.)
1,354.6	.3	Colemanite rock, calcareous, grayish-orange (10*YR* 7/4) to yellowish-gray (5*Y* 8/1). Intergrown mat of medium colemanite crystals with the interstitial areas filled with very fine grained yellowish-gray (5*Y* 8/1) calcite. (Colemanite, ±80 percent.)
1,355.0	.4	Anhydrite rock; similar to the anhydrite rock at depth 1,335.4 ft. A few vugs filled with colemanite similar to the interval above.
1,355.3	.3	Colemanite rock; similar to colemanite rock at depth 1,347.3 ft.
1,356.2	.9	Anhydrite rock; similar to anhydrite rock at depth 1,335.4 ft.
1,356.3	.1	Colemanite rock; similar to colemanite rock at depth 1,347.3 ft.
1,358.1	1.8	Anhydrite rock, laminated, calcareous, celestitic, colemanitic, clayey, light-olive-gray (5*Y* 6/1) to olive-gray (5*Y* 4/1), medium- to fine-grained. The laminations are irregular in width, discordant, and slightly undulating. The laminae of clay are <1–30 mm wide and greenish gray (5*GY* 6/1). The calcite laminae and lenticules are <1–5 mm wide, very fine grained, and yellowish gray (5*Y* 8/1). Numerous vugs and veins of colemanite throughout the interval and a 2-in.-thick bed of colemanite at base. The colemanite is similar to colemanite at depth 1,347.3 ft. (Colemanite, ±20 percent.)
1,358.3	.2	Claystone; similar to claystone at depth 1,348.0 ft. Also veins and vugs of clear medium crystals of anhydrite and colemanite.
1,360.0	1.7	Core lost.
1,361.0	1.0	Anhydrite rock, very calcareous, yellowish-gray (5*Y* 8/1), medium- to fine-grained. Numerous streaks, lenticules, and laminae of very fine grained yellow-

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		ish-gray (5*Y* 8/1) calcite. Numerous vugs and veins of colemanite similar to colemanite at depth 1,347.3 ft.
1,361.7	.7	Colemanite rock; similar to colemanite rock at depth 1,347.3 ft. At base is a 4-in.-thick bed of exceptionally pure colemanite, and the interval as a whole is celestitic.
1,362.2	.5	Anhydrite rock; similar to anhydrite rock at depth 1,361.0 ft. Veins, 1–5 mm wide, of very fine grained dense medium-gray (*N*5) colemanite. A few veins and nodules of medium-grained dense light-gray (*N*7), milky anhydrite.
1,362.7	.5	Anhydrite rock, calcareous, colemanitic, pale-yellowish-brown (10*YR* 6/2), medium- to coarse-grained. Porous, spongelike texture as though something has been leached out. Numerous veins and nodules of medium-grained dense light-gray (*N*7) milky anhydrite. Some streaks, disseminated grains, and lenticules of very fine grained very pale orange (10*YR* 8/2) calcite. Some veins and nodules of very fine grained dull dense pale-yellowish-brown (10*YR* 6/2) colemanite. A few streaks of medium-dark-gray (*N*6) clay. (Colemanite, ±10 percent.)
1,365.1	2.4	Anhydrite rock; similar to anhydrite rock at depth 1,358.1 ft.
1,368.0	2.9	Core lost.
1,370.3	2.3	Anhydrite rock, colemanitic, celestitic, calcareous, light-olive-gray (5*Y* 6/1) to yellowish-gray (5*Y* 8/1), medium-grained. Numerous veins, vugs, and nodules (>5 mm across) filled with medium to coarse crystals of anhydrite and colemanite. Some laminae and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. Few laminae and streaks of greenish-gray (5*GY* 6/1) clay. Two beds of claystone 0.1–0.2 ft in width at 1,369.6 and 1,370.0 ft; the claystone is similar to claystone at depth 1,348.0 ft and contains a few blebs of very fine grained white clinoptilolite. (Colemanite, ±15 percent.)
1,373.5	3.2	Anhydrite rock; similar to anhydrite rock at depth 1,358.1 ft.
1,373.8	.3	Anhydrite rock; similar to anhydrite rock at depth 1,370.3 ft.
1,375.0	1.2	Anhydrite rock; similar to anhydrite rock at depth 1,370.3 ft except it is a light brownish gray (5*YR* 6/1).

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,376.6	1.6	Calcite rock, anhydritic, colemanitic, celestitic, yellowish-gray (5*Y* 8/1), very fine grained. In the calcite matrix there is an intergrown mat of medium anhydrite and colemanite crystals. A few beds, 5–10 mm wide, of greenish-gray (5*GY* 6/1) and light-olive (5*Y* 6/1) clay. Rectangular fragments of what appears to have been a bed, about 15 mm wide, of very fine grained dense light-olive-gray (5*Y* 6/1) colemanite.
1,379.2	2.6	Anhydrite rock; similar to anhydrite rock at depth 1,358.1 ft.
1,380.6	1.4	Colemanite rock, laminated to massive, anhydritic, calcareous, celestitic, light-olive-gray (5*Y* 6/1) (mottled with pale yellowish brown (10*YR* 6/2) and yellowish gray (5*Y* 8/1)), fine- to medium-grained. Intergrown with the colemanite are numerous medium anhydrite crystals. Veins of coarse clear colemanite crystals. A few fragments, rectangular in shape, of very fine grained light-olive-gray (5*Y* 6/1) colemanite. A few vugs and veins partially filled with medium to coarse subhedral to euhedral colemanite and anhydrite crystals and very fine grained calcite. A few beds, 0.1 ft thick, of anhydrite rock similar to the intervals above and below. Few streaks, lenticules, and laminae of very fine grained yellowish-gray (5*Y* 8/1) calcite. Some laminae and beds of medium-light-gray (*N*6) clay. Few irregular masses of very fine grained light-gray (*N*7) celestite. (Colemanite, 50–70 percent.)
1,384.4	4.2	Anhydrite rock; similar to anhydrite rock at depth 1,358.1 ft. At 1,383.4 is 0.3-ft-thick bed of massive well-indurated greenish-gray (5*GY* 6/1) claystone. At 1,383.1 ft is a 0.3-ft-thick bed of colemanite similar to the colemanite at depth 1,380.6 ft.
1,384.9	.5	Colemanite rock; similar to colemanite rock at depth 1,380.6 ft.
1,385.2	.3	Anhydrite rock, laminated to massive, calcareous, colemanitic, dense, medium-gray (*N*5), fine- to medium-grained. A few laminae of medium-dark-gray (*N*4) clay. A few streaks and thin lenticules of very fine grained grayish-orange (10*YR* 7/4) calcite. A few veins and vug fillings of medium-grained porous colemanite. (Colemanite, 5–7 percent.)
1,385.8	.6	Anhydrite rock; similar to anhydrite rock at depth 1,370.3 ft.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,386.8	1.0	Colemanite rock; similar to colemanite rock at depth 1,380.6 ft. A few veins of very light gray (*N*8) coarse-grained anhydrite.
1,387.0	.2	Anhydrite rock; similar to anhydrite rock at depth 1,385.2 ft.
1,387.5	.5	Anhydrite rock, clayey, calcareous, celestitic, olive-gray (5*Y* 4/1), coarse- to fine-grained. A very badly crumpled zone; appearance of a recemented solution zone. Numerous beds, laminae, and streaks of greenish-gray (5*GY* 6/1) clay. Some lenticules, laminae, and streaks of very fine grained yellowish-gray (5*Y* 8/1) calcite. Beds and nodules of very fine grained light-olive-gray (5*Y* 6/1) celestite. A few porous veins and vugs of colemanite. (Colemanite, ±15 percent.)
1,388.5	1.0	Anhydrite rock; similar to anhydrite rock at depth 1,385.2 ft.
1,390.1	1.6	Anhydrite rock; similar to anhydrite rock at depth 1,370.3 ft.
1,395.4	5.3	Anhydrite rock; similar to anhydrite rock at depth 1,346.8 ft. At depth 1,393.8 ft is a 2-ft-thick claystone bed similar to claystone at depth 1,348.0 ft. At depth 1,391.2 ft is a 0.8-ft-thick bed of nonlaminated anhydrite similar to the anhydrite rock at depth 1,370.3 ft.
1,398.0	3.6	Anhydrite rock, very calcareous, celestitic, medium-light-gray (*N*6) (mottled with yellowish gray (5*Y* 8/1)), very fine to medium-grained. Faint broad (1–2 in. thick) laminations. Some small rounded nodules, 5–7 mm wide, of very fine grained light-olive-gray (5*Y* 6/1) calcite. Beds and streaks of medium-gray (*N*5) clay. Some porous vugs and veins of medium-grained grayish-orange (10*YR* 7/4) colemanite. Some porous horizontal vugs and veins of milky chalcedony and clear medium quartz crystals.
1,398.6	.6	Colemanite rock, massive and dense, grayish-orange (10*YR* 7/4), medium- to fine-grained. Very minor amounts of anhydrite, celestite, and calcite intermixed with the colemanite. A few streaks of medium-gray (*N*5) clay in lower 0.3 ft. (Colemanite, ±80 percent.)
1,399.0	.4	Claystone, silty, calcareous; rather jumbled appearance; possibly a solution breccia. Few irregular thin veins of medium-grained anhydrite similar to the interval below.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,401.2	2.2	Anhydrite rock, very calcareous, celestitic, pale-yellowish brown (10*YR* 6/2), fine- to medium-grained. Numerous lenticules, laminae, streaks, and disseminated grains of very fine grained yellowish-gray (5*Y* 8/1) calcite. Numerous beds and nodules of very fine grained dull olive-gray (5*Y* 6/1) celestite. 1-in.-thick bed of celestite at 1,399.5 ft. Some streaks and laminae of greenish-gray (5*GY* 6/1) clay increasing in lower 1 ft of the interval. Some blebs of very fine grained white colemanite.
1,401.7	.5	Colemanite rock; similar to colemanite rock at depth 1,380.6 ft.
1,401.8	.1	Interbedded anhydrite rock, colemanite rock, and celestite rock. The beds are slightly undulating, 1–8 mm thick, light gray (*N*7) to medium gray (*N*6), and slightly calcareous. Anhydrite rock is medium grained; celestite rock is very fine grained; colemanite is medium to fine grained. A few partings of medium-gray (*N*5) clay. (Colemanite, ±30 percent.)
1,406.1	4.3	Interbedded claystone and anhydrite rock. calcareous, tuffaceous, greenish-gray (5*GY* 6/1) to light-olive-gray (5*Y* 6/1). The beds are <1–2 mm thick and are undulating, crinkled, and disordered. Anhydrite is fine to medium grained. The clay is tuffaceous, silty, clinoptilolitic, and greenish gray (5*GY* 6/1) and contains white very fine grained blebs of clinoptilolite and streaks of medium-dark-gray (*N*4) clay. A few beds, 5 mm thick, of tuffaceous siltstone. A few laminae and lenticules of very fine grained light-olive-gray (5*Y* 6/1) calcite. A few very minor veins of medium-grained porous colemanite. Minor celestite throughout the interval. (Colemanite, ±5 percent.)
1,406.3	.2	Claystone, calcareous, tuffaceous, greenish-gray (5*GY* 6/1). A few laminae or veins of medium- to fine-grained white to light-olive-gray (5*Y* 6/1) colemanite. A few laminae of medium to fine clear anhydrite crystals. A stringer of badly altered igneous rock. The stringer varies in width from 5 to 30 mm and is nearly horizontal. It is medium dark gray (*N*4), medium grained, and friable and contains approximately 50 percent labradorite, 5 percent amphibole, 10 percent pyrite, 5 percent clinoptilolite, 2 percent ilmenite, and 28 percent clay. A few lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite in the igneous rock.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,410.0	3.7	Interbedded claystone and anhydrite rock; similar to interbedded claystone and anhydrite rock at depth 1,406.1.
1,411.0	1.0	Colemanite rock; similar to colemanite rock at depth 1,380.6 ft, except the color is pale yellowish brown (10*YR* 6/2) mottled with light olive gray (5*Y* 6/1) and yellowish gray (5*Y* 8/1). A few irregular nodules and veins of very light gray (*N*8) coarse-grained anhydrite.
1,416.5	6.5	Interbedded beds of claystone and anhydrite rock; similar to the interbedded claystone and anhydrite rock at depth 1,406.1 ft. At 1,413.3 ft is a colemanite bed, 0.2 ft thick, similar to colemanite at depth 1,411.0 ft.
1,418.0	1.5	Anhydrite rock, calcareous, celestitic, light-olive-gray (5*Y* 6/1), medium- to fine-grained. Indistinct, irregular, ropy-patterned lamination. Numerous laminae, beds, and lenses of greenish-gray (5*GY* 6/1) clay. Numerous laminae and lenticules of very fine grained yellowish-gray (5*Y* 8/1) to light-olive-gray (5*Y* 6/1) calcite. At 1,417.4 ft is a 15 mm-thick bed of colemanite similar to the colemanite at depth 1,411.0 ft.
1,419.4	1.4	Anhydrite rock, laminated, calcareous, celestitic, medium-gray (*N*5) (mottled with yellowish gray (5*Y* 8/1), greenish gray (5*GY* 6/1), and dark gray (*N*3)), fine- to medium-grained. The laminations are very slightly disturbed with a very moderate undulation. Numerous laminae, beds, and lenticules, <1–4 mm wide, of very fine grained yellowish-gray (5Y 8/1) calcite. Numerous beds, laminae, streaks, and lenses of greenish-gray (5*GY* 6/1) to dark-gray (*N*3) clay. At 1,419.0 ft is a 10-mm-wide bed of colemanite similar to the colemanite at depth 1,411.0 ft.
1,424.0	4.6	Claystone, calcareous, tuffaceous, celestitic, clinoptilolitic, light-olive-gray (5*Y* 6/1) to greenish-gray (5*GY* 6/1); a few streaks of dark-gray (*N*3) clay. Numerous beds, laminae, and lenticules of light-olive-gray (5*Y* 6/1) very fine grained calcite. Some of the calcite beds are >10 mm thick. Some beds and veins, <4 mm thick, of medium-grained anhydrite. A few beds and veins, <2 mm thick, of colemanite.
1,428.9	4.9	Anhydrite rock, very colemanitic, celestitic, calcareous, medium-light-gray (*N*6) to light-olive-gray (5*Y*

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		6/1) (mottled with greenish gray (5*GY* 6/1)), medium- to fine-grained. Numerous streaks and irregular, angular, elongated masses and beds, <1– >5 mm wide, of very fine grained light-olive-gray (5*Y* 6/1) dull colemanite. Veins and cavity fillings, 8–1 mm wide, of coarse clear anhydrite crystals. Trace of very fine grained white blebs of colemanite and clinoptilolite. A few vuglike fillings of coarse clear colemanite crystals. Irregular beds, laminae, and lenticules, <5 mm wide, of very fine grained light-olive-gray (5*Y* 6/1) calcite. Beds and laminae, <1– >10 mm thick, of greenish-gray (5*Y* 6/1) clay. (Colemanite, ±35 percent.)
1,430.0	1.1	Anhydrite rock, celestitic, calcareous, tuffaceous, clayey, medium-light-gray (*N*6) (mottled with light olive gray (5*Y* 6/1)), fine- to medium-grained. Vague irregular lamination. A few blebs of very fine grained white howlite in the upper 0.3 ft of the interval. Beds and streaks, <1– >20 mm, of clinoptilolitic greenish-gray (5*GY* 6/1) clay in lower 0.2 ft of the interval; the clay color changes to brownish gray (5*YR* 4/1). Nodules, blebs, and lenticules of very fine grained yellowish-gray (5*Y* 8/1) to light-olive-gray (5*Y* 6/1) to light-brownish-gray (5*YR* 6/1) calcite. The calcite is extensively replaced by very fine grained celestite, as is some of the clay. Some vugs and veins of the clear coarse euhedral anhydrite crystals and milky quartz.
1,432.8	2.8	Anhydrite rock, colemanitic, clayey, celestitic, calcareous, light-olive-gray (5*Y* 6/1) to medium-gray (*N*5), fine- to medium-grained. Numerous veins and vugs of medium- to coarse-grained colemanite similar to colemanite at depth 1,411.0 ft throughout the interval, and at 1,430.5 ft is a 0.4-ft-thick bed, at 1,431.1 ft is 0.2-ft-thick bed, and at 1,432.0 ft is a 0.1-ft-thick bed. A few beds, 5–10 mm thick, of very fine grained dull light-olive-gray (5*Y* 6/1) colemanite at 1,432.6 ft. A few laminae and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. Numerous laminae, beds, and streaks of light-olive-gray (5*Y* 6/1) clay. (Colemanite, ±20 percent.)
1,434.3	1.5	Anhydrite rock; similar to anhydrite rock at depth 1,419.4 ft.
1,436.0	1.7	Anhydrite rock, laminated (very regular), dense, medium-light-gray (*N*6), medium-grained. Numerous laminae and beds, 1–2 mm thick, of medium-gray

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		(*N*5) clay. Within the clay are a few small (<2 mm) clots of very fine grained pyrite. Numerous beds, laminae, and lenticules <1–2 mm wide, of very fine grained yellowish-gray (5*Y* 8/1) calcite. Beds, 2 mm thick, of very fine grained light-olive-gray (5*Y* 6/1) celestite. A few veins and spherulites of milky quartz. At 1,434.8 ft is a 0.5-ft-thick bed of colemanite similar to the colemanite at depth 1,411.0 ft. (Colemanite, ±15 percent.)
1,440.1	4.1	Anhydrite rock; similar to anhydrite rock at depth 1,430.0 ft.
1,442.9	2.8	Anhydrite rock, colemanitic, clayey, tuffaceous, medium-light-gray (*N*6), very fine grained. Beds, 5 >50 mm thick, of clay; the clay is greenish gray (5*GY* 6/1) and tuffaceous and contains very fine grained white blebs of clinoptilolite. A few veins and disseminated crystals of medium to coarse clear anhydrite and colemanite crystals. A few beds, 5–20 mm thick and at the base of the interval 80 mm thick, of sandstone; the sandstone is very fine grained, very tuffaceous, medium light gray (*N*6), faintly laminated, slightly calcareous, and colemanitic; sand is angular. (Colemanite, ±10 percent.)
1,448.6	5.7	Claystone, anhydritic, calcareous, tuffaceous, sandy, clinoptilolitic, medium-light-gray (*N*6) to greenish-gray (5*GY* 6/1) to light-olive-gray (5*Y* 6/1). Blebs of very fine grained white clinoptilolite. In upper half of the interval are beds, 5–10 mm thick, of sandstone; the sandstone is tuffaceous, faintly bedded, and gradational to the claystone. In lower half of the interval are a few lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. Beds, increasing downward, of medium-grained clayey anhydrite.
1,450.3	1.7	Anhydrite rock; similar to anhydrite rock at depth 1,430.0 ft. At depth 1,449.2 ft is a 0.3-ft-thick bed of claystone similar to claystone at depth 1,448.6 ft.
1,455.3	5.0	Anhydrite rock; similar to anhydrite rock at depth 1,419.4 ft. Some laminae and beds, <1–5 mm wide, of very fine grained light-olive-gray (5*Y* 6/1) celesite. Beds, 3–15 mm thick, of medium-grained colemanite and anhydrite. (Colemanite, ±15 percent.)
1,457.0	1.7	Claystone, silty, sandy, clinoptilolitic, medium-light-gray (*N*6); mainly massive with few beds, 10–30 mm wide, of very thin lamination. Numerous very fine grained white blebs of clinoptilolite and dis-

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		seminated clinoptilolite throughout the interval. A few beds, 10– >30 mm thick, of very fine grained tuffaceous medium-light-gray (*N*6) sandstone.
1,457.7	.7	Colemanite and anhydrite rock, clinoptilolitic, very light gray (*N*8) to yellowish-gray (5*Y* 8/1), medium- to coarse-grained. A few laminae, partings, and streaks of greenish-gray (5*GY* 6/1) clay. White very fine grained blebs of clinoptilolite in the clay and clinoptilolite throughout the interval. Angular fragments of very fine grained greenish-gray (5*GY* 6/1) colemanite. (Colemanite, 40–50 percent.)
1,459.6	1.9	Claystone, tuffaceous, clinoptilolite, greenish-gray (*GY* 6/1); rather broad irregular lamination. Numerous very fine grained white blebs of clinoptilolite. Beds, 2–10 mm thick, of medium-grained anhydrite, Beds of colemanite and anhydrite rock, 2– >10 mm thick, similar to the interval above. A few beds of very fine grained tuffaceous medium-light-gray (*N*6) sandstone. A few lenticules, averaging 5 mm in thickness, of very fine grained light-olive-gray (5*Y* 6/1) calcite.
1,460.7	1.1	Anhydrite rock, brownish-gray (5*YR* 4/1), medium-grained; massive at top grading to irregular lamination at base. A few laminae and partings, <4 mm wide, of greenish-gray (5*GY* 6/1) clay. A few beds and nodules, <4 mm wide, of very fine grained yellowish-gray (5*Y* 8/1) calcite. Some celestite in the lower half of the interval.
1,461.1	.4	Colemanite and anhydrite rock, laminated, medium-gray (*N*5) to brownish-gray (5*YR* 4/1), medium-grained. The lamination is undulating and irregular. Some lenticules and beds of very fine grained yellowish-gray (5*Y* 8/1) calcite. (Colemanite, ±50 percent.)
1,462.0	.9	Colemanite rock, anhydritic, massive, dense, medium-gray (*N*5) to brownish-gray (5*YR* 4/1) (mottled with grayish orange (10*YR* 7/4)), coarse- to medium-grained. A few vuggy nodules and porous veins of coarse clear subhedral to euhedral anhydrite crystals and colemanite crystals. A few white blebs of fine-grained howlite. A few streaks of medium-gray (*N*5) clay and very fine grained yellowish-gray (5*Y* 8/1) calcite. Minor amount of celestite and clinoptilolite in the interval. (Colemanite, 70–80 percent.)

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,464.6	2.6	Anhydrite rock; similar to the anhydrite rock at depth 1,385.2 ft. Increase in the calcite lenticules and minor celestite and clinoptilolite in this interval.
1,470.8	6.2	Interbedded anhydrite rock and claystone, calcareous, clinoptilolitic, light-gray (*N*7) to medium-gray (*N*5). Beds of clay and anhydrite are 1–10 mm wide, laminated, and slightly undulating. The clay is medium light gray (*N*6) and contains a few blebs of very fine grained white clinoptilolite. The anhydrite is medium to fine grained. A few thin beds and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite.
1,474.1	3.3	Claystone; similar to claystone at depth 1,459.6 ft. At 1,472.0 ft is a 0.2-ft-thick bed of sandstone similar to the beds of sandstone in the interval at depth 1,459.6 ft.
1,474.2	.1	Anhydrite rock; similar to anhydrite rock at depth 1,385.2.
1,474.7	.5	Colemanite rock; similar to colemanite rock at depth 1,411.0 ft. Interval also contains numerous veins and nodules of very fine grained dense light-olive-gray (5*Y* 6/1) calcite.
1,482.7	8.0	Claystone; similar to claystone at depth 1,459.6 ft. Increase in calcite beds in the lower 2 ft of the interval.
1,484.0	1.3	Anhydrite rock, laminated, dense, medium-gray (*N*5), fine- to medium-grained. Numerous thin laminae, <2 mm thick, of tuffaceous greenish-gray (5*GY* 6/1) clay.
1,486.5	2.5	Claystone, calcareous, tuffaceous, clinoptilolitic, light-olive-gray (5*Y* 6/1). Numerous beds, laminae, and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. A few blebs of very fine grained white clinoptilolite. A few streaks of medium-gray (*N*4) clay. A few beds and veins of anhydrite similar to the anhydrite at depth 1,385.2 ft. At the base is a 0.2-ft-thick bed of this anhydrite.
1,494.3	7.8	Claystone; similar to claystone at depth 1,457.0 ft, including the sandstone beds.
1,496.5	2.2	Claystone; similar to claystone at depth 1,486.5 ft.
1,497.0	.5	Sandstone, clayey, clinoptilolitic, tuffaceous, vaguely laminated, medium-light-gray (*N*6). The sand is very fine and angular.
1,498.5	1.5	Anhydrite rock, laminated, calcareous, clayey, slightly clinoptilolitic, medium-light-gray (*N*6) to medium-

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		gray (*N*5), fine- to medium-grained. Some laminae, beds, and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. Numerous beds and laminae of tuffaceous, clinoptilolitic, greenish-gray (5*GY* 6/1) clay. Laminations are slightly undulating.
1,500.2	1.7	Claystone, laminated, tuffaceous, clinoptilolitic, calcareous, light-olive-gray (5*Y* 6/1). Numerous beds, laminae, lenticules, and streaks of very fine grained yellowish-gray calcite. A few beds, 5–7 mm wide, of sandstone similar to the sandstone at depth 1,497.0 ft. The laminations are crinkled.
1,507.0	6.4	Anhydrite rock; similar to anhydrite rock at depth 1,498.5 ft. Upper 1 ft of the interval is relatively free of clay. At 1,500.5 ft is a 0.2-ft-thick bed of claystone similar to claystone at depth 1,500.2 ft. At 1,501.3 ft is a bed of colemanite, very fine grained, dense, and medium gray (*N*5) to light olive gray (5*Y* 6/1). Minor amount of colemanite and celestite in the interval.
1,510.5	3.5	Colemanite rock, massive, dense, pale-brown (5*YR* 5/2) (mottled with medium light gray (*N*6) to light brownish gray (5*YR* 6/1)), fine- to medium-grained. A few blebs of very fine grained white howlite. A few veins and angular fragments of very fine grained light-olive-gray (5*Y* 6/1) celestite. A few veins of greenish-gray (5*GY* 6/1) clay. A few streaks and lenticules of very fine grained yellowish-gray calcite. A few porous vug and vein fillings of coarse-grained clear anhydrite and colemanite. A few veins of spherulitic coarse-grained colemanite. (Colemanite, 70–90 percent.)
1,511.0	.5	Colemanite rock, vaguely laminated, calcareous, light-olive-gray (5*Y* 6/1), fine- to medium-grained. The lamination is crumpled and distorted. Some lenticular fragments of very fine grained medium-light-gray (*N*6) colemanite. A few blebs and nodules, 1–5 mm in width, of very fine grained white howlite. A few beds of medium-grained clear colemanite showing good spherulites. Some laminae and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. A few laminae of medium-dark-gray (*N*4) clay. Minor celestite and anhydrite in the interval. (Colemanite, ±90 percent.)
1,511.5	.5	Colemanite and anhydrite rock, slightly calcareous, slightly celestitic, slightly clinoptilolitic, grayish-brown (5*YR* 3/2) (mottled with dusky brown (5*YR*

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		2/2), fine- to medium-grained. The colemanite is fine grained and grayish brown (5*YR* 3/2) and intergrown with medium-grained dusky-brown (5*YR* 3/2) anhydrite. (Colemanite, ±60 percent.)
1,512.0	.5	Claystone, tuffaceous, clinoptilolitic, slightly celestitic, greenish-gray (5*GY* 6/1); mottled with medium-gray (*N*5) clay. A few veins, <1 mm wide, of clear medium colemanite crystals. (Colemanite, ±10 percent)
1,512.6	.6	Colemanite rock, anhydritic, celestitic, pale-brown (5*YR*) 5/2) to light-brownish-gray (5*YR* 4/1), fine- to medium-grained. In upper 0.2 ft are numerous nodules, 2–25 mm wide, of very fine grained white anhydrite. In the lower 0.3 ft of the interval are very fine grained streaks and nodules of light-gray (*N*7) celestite. A few laminae of medium-gray (*N*5) clay in the middle of the interval. (Colemanite, 60–80 percent.)
1,513.0	.4	Claystone; similar to claystone at depth 1,512.0 ft.
1,519.9	6.9	Core lost.
1,522.8	2.9	Claystone; similar to claystone at depth 1,512.0 ft. Some streaks and blebs of very fine grained white clinoptilolite.
1,523.9	1.1	Claystone, laminated, celestitic, calcareous, tuffaceous, anhydritic, clinoptilolitic, greenish-gray (5*GY* 6/1). Numerous beds, laminae, and streaks of very fine grained dense light-olive-gray (5*Y* 6/1) celestite. Beds, laminae, and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite.
1,526.9	3.0	Anhydrite rock, laminated, calcareous, celestitic, colemanitic, clinoptilolitic, medium-light-gray (*N*6), fine- to medium-grained. Lamination is undulating to undisturbed. Some laminae and beds, <1–4 mm thick, of greenish-gray (5*GY* 6/1) clay that contains blebs of very fine grained white clinoptilolite. A few laminae of medium-light-gray (*N*6) clay. A few beds, 2–10 mm wide, of sandstone; the sand is angular and fine with medium to coarse plates of biotite. Some beds, laminae, and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. A few beds and nodules of very fine grained yellowish-gray (5*Y* 8/1) celestite. Some beds, lenticules, streaks, and veins of fine-grained grayish-orange (10*YR* 7/4)

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		colemanite. A few blebs of very fine grained white colemanite. (Colemanite ±7 percent.)
1,530.5	3.6	Claystone, laminated to massive, very tuffaceous, medium-light-gray (*N*6) to light-gray (*N*7), clinoptilolitic. Numerous white blebs and streaks, <2 mm wide, of very fine grained clinoptilolite. A few beds of fine- to medium-grained light-gray (*N*6) anhydrite; at 1,528.0 ft is 0.3-ft bed of the anhydrite. A few veins of medium-grained clear anhydrite. Gradational contact to interval below.
1,538.7	8.2	Claystone, laminated, very tuffaceous, clinoptilolitic, sandy, light-brownish-gray (5*YR* 6/1). Numerous beds of faintly laminated sandstone 1–100 mm thick; sand is tuffaceous, angular, fine to medium, and light brownish gray (5*YR* 6/1). At the base of the interval is a 0.4-ft-thick bed of sandstone. There are blebs of very fine grained white clinoptilolite in both the claystone and the sandstone, increasing downward. A few crystals and veins of clear fine-grained anhydrite. At 1,536.1 ft is a 0.1-ft-thick bed of very fine grained yellowish-gray (5*Y* 8/1) calcite. At 1,536.7 ft is 0.1-ft-thick bed of greenish-gray (5*GY* 6/1) clay.
1,542.4	3.7	Claystone, tuffaceous, calcareous, celestitic, anhydritic, massive to faintly irregularly laminated, light-olive-gray (5*Y* 6/1) to greenish-gray (5*GY* 6/1). Some blebs of very fine grained white clinoptilolite. Numerous beds, laminae, and lenticules, <1–10 mm thick, of very fine grained yellowish-gray (5*Y* 8/1) calcite. Numerous nodules, clots, and veins of coarse anhydrite crystals.
1,547.0	4.3	Anhydrite rock, laminated, calcareous, clinoptilolitic, clayey, medium-gray (*N*5) to light-olive-gray (5*Y* 6/1), fine-grained. Lamination is undisturbed to slightly undulating. Anhydrite laminae are 4– <1 mm wide and medium gray (*N*5) and alternate with laminae, 5–<1 mm wide, of clay and calcite. The clay is light olive gray (5*Y* 6/1) and tuffaceous and at 1,542.6 ft is a 70-mm-thick bed of the clay. The calcite is very fine grained and light olive gray (5*Y* 6/1). There are blebs and streaks of very fine grained white clinoptilolite throughout the interval.
1,552.4	5.4	Claystone; similar to claystone at depth 1,542.4 ft. At the base of the interval is a 2-mm-wide bed of very fine grained white clinoptilolite.
1,556.0	3.6	Claystone; similar to claystone at depth 1,538.7 ft. A

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
		black nodule, 20 by 10 mm, of calcite at 1,554.0 ft. A 5-mm-thick bed of light-olive-gray (5*Y* 6/1) claystone at 1,553.7 ft.
1,557.6	1.6	Claystone; similar to claystone at depth 1,542.4 ft. A few beds of fine- to medium-grained calcareous light-gray (*N*7) anhydrite; at the base is a 30-mm-thick bed of the anhydrite.
1,563.3	5.7	Claystone, faintly laminated, tuffaceous, sandy, clinoptilolitic, light-olive-gray (5*Y* 6/1) to light-brownish-gray (5*YR* 6/1). Throughout the interval are blebs and streaks of very fine grained white clinoptilolite. Some beds, 2–20 mm thick, of sandstone; sandstone is tuffaceous, very fine grained, and massive to faintly laminated. A few beds, 2–4 mm thick, of a dusky-yellow-green (5*GY* 5/2) clay (bentonite) with numerous mica plates.
1,564.3	1.0	Claystone; similar to claystone at depth 1,542.4 ft.
1,567.5	3.2	Anhydrite rock; similar to anhydrite rock at depth 1,547.0 ft.
1,571.3	3.8	Anhydrite rock, laminated, very slightly calcareous, colemanitic, celestitic, clinoptilolitic, pyritic, medium-gray (*N*5) to light-gray (*N*7), fine- to medium-grained. The laminations are very slightly undulating to undisturbed and 1–16 mm thick and are made up of light-gray (*N*7) anhydrite, medium-gray (N5) anhydrite, and light-olive-gray (5*Y* 6/1) clay. The light-gray (*N*7) anhydrite is colemanitic and celestitic. The clay is tuffaceous and calcareous and contains a few blebs of very fine grained white clinoptilolite. At the top of the interval is 0.3-ft-thick bed of clay. A few laminae and lenticules of very fine grained yellowish-gray (5*Y* 8/1) calcite. Small clots and streaks and veins, <2 mm wide, of very fine grained pyrite.
1,574.1	2.8	Claystone, massive, tuffaceous, moderately calcareous, greenish-gray (5*GY* 6/1); contains a few blebs of very fine grained white clinoptilolite. Some mottling by streaks of medium-gray (*N*5) clay; zebra appearance. Gradual contact to the interval below.
1,576.1	2.0	Claystone; similar to claystone at depth 1,538.7 ft.
1,578.2	2.1	Claystone, massive to faintly laminated, calcareous, anhydritic, light-olive-gray (5*Y* 6/1) to pale-yellowish-brown (10*YR* 6/2). A few beds, 2–10 mm thick, of fine- to medium-grained medium-gray (*N*5) anhydrite. A few beds, 1–3 mm thick, of very fine grained yellowish-gray (5*Y* 8/1) calcite.

Hector 3—Continued

Depth (feet)	*Unit thickness (feet)*	*Description*
1,581.5	3.3	Claystone; similar to claystone at depth 1,538.7 ft.
1,660.0	78.5	No core. Cuttings: Claystone, greenish-gray (5*GY* 6/1) and light-brownish-gray (5*YR* 6/1). Few fragments of fine grained yellowish-gray (5*Y* 8/1) calcite. Few fragments of fine-grained clear to medium light-gray (*N*6) anhydrite. Few fragments between 1,640–1,650 ft of fine-grained white calcite. In lower half of the interval are fragments of pale-red (5*R* 6/2) clay. Bit sample: Claystone, olive-gray (5*Y* 4/1), well-indurated; contains a few blebs, 2–3 mm, of white calcite.
		End of hole.

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1970 O—386–879