(Nevada Terminal Waste Storage-1)

USGS-1543-1

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Mail Stop 954, Federal Center, Box 25046
Denver, Colorado 80225

GEOLOGY AND LITHOLOGIC LOG FOR DRILL HOLE UE17a, NEVADA TEST SITE

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Compiled by

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CONTENTS

ILLUSTRATIONS

TABLES

(Nevada Terminal Waste Storage-1)
1978

USGS-1543-1
1978

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ABSTRACT

The UE17a vertical exploratory drill hole is located at Nevada State coordinates N. 257,902.89 m and E. 196,897.91 m (N. 846,138.12; E. 645,990.55 ft) at an altitude of 1,431.48 m (4,696.48 ft). It is one of a series of holes drilled to evaluate the suitability of unit J of the Eleana Formation as a medium for nuclear waste storage. Total depth of the drill hole is 370 m (1,214 ft). The hole penetrated 22.3 m (73 ft) of alluvium of Quaternary age, 144.2 m (473 ft) of Tippipah Limestone of Early Pennsylvanian to Early Permian(?) age, and 203.6 m (668 ft) of argillite with interbedded quartzite of unit J of the Eleana Formation of Mississippian age.

INTRODUCTION

UE17a provides data important to the preliminary investigation of the Eleana Formation as a possible repository for nuclear waste. It is one of a series of shallow holes drilled to determine the thickness of alluvium and the lithologic and stratigraphic character of the underlying Paleozoic rocks.

The UE17a vertical exploratory drill hole is located in Area 17 of the NTS (Nevada Test Site) at Nevada State coordinates N. 257,902.89 m and E. 196,897.91 m (N. 846,138.12; E. 645,990.55 ft) at a ground-level altitude of 1,431.48 m (4,696.48 ft) (fig. 1). This location is approximately 48 km (30 mi) north of Mercury, Nev., in the west-central part of Yucca Flat. The drill hole is within the Syncline Ridge structural block, northwest of Syncline Ridge (fig. 1). The hole was drilled to a total depth of 370 m (1,214 ft) and bottomed in the quartzite subunit of unit J of the Eleana Formation. It was drilled into the zone of saturation to determine the presence of ground water and to define the static water level. Stratigraphic sequences were confirmed by the cuttings collected at 3.05-m (10-ft) intervals and by the cores taken at three selected intervals.

This report is one of a series of basic-data reports on drill holes in the Syncline Ridge area. The data from the drill-hole reports and other investigations on the geology of Syncline Ridge are presently being compiled.

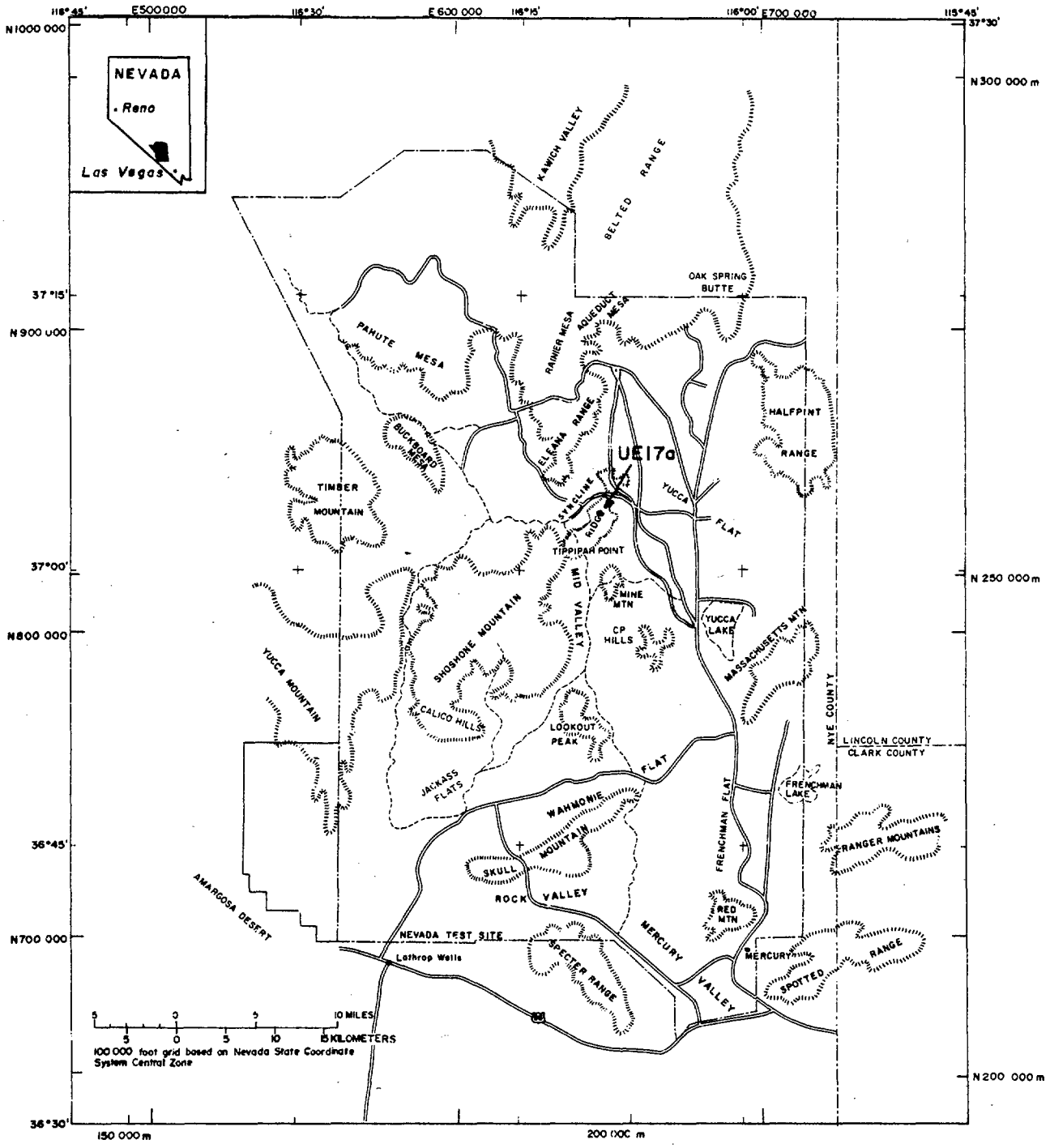

Figure 1.--Index map showing location of the Nevada Test Site and hole UE17a.

Hole Construction

UE17a was spudded on July 2, 1976, and completed on September 23, 1976. A 1.63-m (64-in.)-diameter hole was drilled to a depth of 1.2 m (4 ft) using an auger rig; a 1.22-m (48-in.)-ID (inside-diameter) casing was set. Then a 66.04-cm (26-in.) hole was drilled to 11.6 m (38 ft), and a 19.36-cm (7 5/8-in.)-OD (outside-diameter) casing was set with cement at 11.2 m (36.6 ft). The auger was replaced by a Failing-1500[1] rig, which drilled the hole to a total depth of 370 m (1,214 ft) using a 15.87-cm (6 1/4-in.) bit. Three cores totaling 8.78 m (28.8 ft) were taken from 114.3 to 119.4 m (375-391.8 ft) and 177.1 to 180.7 m (581-593 ft). Attempts to get a bottom-hole core failed because of caving.

Airfoam mist was used as the circulating medium during drilling; however, sepiolite airfoam was inadvertently added to the hole. The existing water in the hole caused the sepiolite to settle out of the drilling fluid. Caving of the hole between 251.5 and 289.6 m (825 and 950 ft) caused many drilling problems. High-viscosity bentonite mud was introduced into the hole to stop the caving and to hold the hole open for geophysical logging.

UE17a was cased to a depth of 368.8 m (1,210 ft) with 10.8-cm (4 1/4-in.)-diameter steel casing, and the drilling mud was circulated out of the hole with water. The casing was gun-perforated by Birdwell Co. in the following intervals: 227.1-251.5, 306.3-309.4, and 324.6-362.7 m (745-825, 1,005-1,015, and 1,065-1,190 ft). The perforations are approximately 1.27 cm (0.5 in.) in diameter and average two perforations per 0.3 m (1 ft) within each interval. Debris from the perforating operation was pushed downhole by means of drilling tools to a depth of 367.9 m (1,207 ft). Hydrologic testing was then conducted by the USGS (U.S. Geological Survey).

GEOLOGY

Stratigraphy

The UE17a vertical drill hole, which is located on the north side of Pahute Mesa road just northwest of the gap in Syncline Ridge (fig. 1), defines the top of the Eleana Formation and gives information pertinent to ground-water movement and static water level. UE17a

[1]Use of brand names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

drill hole is at the boundary between the northern and central structural blocks of the Syncline Ridge area. UE17a was drilled through 22.3 m (73 ft) of alluvium of Quaternary age, 144.2 m (473 ft) of Tippipah Limestone of Early Pennsylvanian to Early Permian(?) age, and 203.6 m (668 ft) of unit J of the Eleana Formation of Mississippian age (table 1).

The alluvium is composed of wash gravel and sand. Mapping in the area of the drill hole indicates that the alluvium is of middle Quaternary age. (The Quaternary in the Syncline Ridge is divided into three major units for mapping purposes. These units are termed younger, middle, and older without specific reference to absolute age.) The gravel and sand are made up of angular clasts of quartzite, siliceous conglomerate, sandstone, siltstone, and tuff. The gravel shows weathering but very little caliche; there is, however, a small amount of calcareous coating on individual particles. Below 15.2 m (50 ft), the gravel grades downward to very coarse grained sand.

The Tippipah Limestone is predominantly a very thick bedded limestone interbedded with thinly laminated calcareous siltstone; it varies in color from medium to dark gray and from light brown to light grayish purple. The limestone ranges from finely to coarsely crystalline and breaks into sharp platy fragments. The upper 7 m (23 ft) of limestone is strongly calichified. The 5.1-m (16.8-ft) core from the 114.3- to 119.4-m (375- to 391.8-ft) depth has no apparent bedding and is a highly fractured, medium-dark-gray limestone. The fractures contain calcite and iron stains; however, some fractures contain calcite crystals.

Unit J of the Eleana Formation has been divided into lower, argillite, and quartzite subunits (fig. 2). UE17a penetrates the quartzite of unit J, which consists of quartzite and thick-bedded argillite. The argillite was divided into high-quartz argillite and low-quartz argillite by visual and laboratory analysis. The high-quartz argillite has a high quartz content (greater than 25 percent) and the low-quartz argillite has a low quartz content (less than 25 percent). The quartzite subunit of unit J of the Eleana Formation was penetrated in UE17a at a depth of 166.4 m (546 ft). Coarse-grained quartzite varies in color from medium dark gray to light olive gray and is interbedded with sandstone and limestone, which varies from medium dark gray to light olive gray and moderate brown to moderate yellowish brown. The 3.4 m (11 ft) of core taken from the 177.1- to 180.7-m (581- to 593-ft) depth was strongly brecciated quartzite which exhibits shear planes that dip 25°. The fractures contain calcite and iron stains. At the 251.5-m (825-ft) depth,

Table 1.--Lithologic log of UE17a

Thickness in meters (feet)	Lithology	Stratigraphic unit
0-22.3 (0-73)	Alluvium, very coarse grained to coarse-grained sand mixed with angular clasts of quartzite (50 percent), sandstone (20 percent), siltstone (10 percent), siliceous conglomerate (5 percent), and tuff (15 percent); small amount of caliche coating; minor calcareous cement; beginning at 15.2 m (50 ft), sand becomes dominant with depth	Alluvium.
22.3-29.3 (73-96)	Limestone, dark-gray, finely to coarsely crystalline, weathered; calcite veins; abundant caliche	Tippipah Limestone.
29.3-75.6 (96-248)	Limestone, finely to coarsely crystalline, dark-gray, thick-bedded; abundant calcite stringers and calcite crystals; iron-oxide staining; small amount of caliche; possible fault at 75.6 m (248 ft)	Tippipah Limestone.
75.6-114.3 (248-375)	Limestone, medium- to dark-gray, light-brown to light-grayish-purple, finely crystalline, thick-bedded; interbedded with laminated to thin-bedded silty limestone; platy fragments; crystalline calcite; iron-oxide staining suggests possible fault zone at 100.6-106.1 m (330-348 ft)	Tippipah Limestone.
114.3-119.4 (375-391.8) (core)	Limestone, medium-dark-gray, finely to coarsely crystalline, thick-bedded; interbedded with thinly laminated, light-brown to light-grayish-purple, silty limestone; calcite-filled fractures and vugs; fractures iron-oxide coated	Tippipah Limestone.

Table 1.--Lithologic log of UE17a--Continued

Thickness in meters (feet)	Lithology	Stratigraphic unit
119.4-151.2 (391.8-496)	Limestone, medium- to dark-gray, light-brown to light-grayish-purple, finely crystalline, thick-bedded; interbedded with laminated to thin-bedded silty limestone; platy fragments; crystalline calcite; iron staining indicates possible fault at 146.0 m (479 ft)	Tippipah Limestone.
151.2-166.4 (496-546)	Limestone, grayish-black, finely crystalline, thick-bedded; small amount of clay in unwashed samples; platy fragments	Tippipah Limestone.
166.4-177.1 (546-581)	Quartzite, medium-gray to moderate-yellowish-brown, coarse-grained; bedded with sandstone and limestone; siliceous cement and minor amounts of calcareous cement; crystalline calcite	Eleana Formation; unit J, quartzite subunit.
177.1-180.7 (581-593) (core)	Quartzite, medium-dark-gray to light-olive-gray, coarse-grained; shear zone, core strongly brecciated and recemented; fractures are iron stained and coated with calcite; 25° shear planes; some polishing of surfaces	Eleana Formation; unit J, quartzite subunit.
180.7-195.7 (593-642)	Quartzite, medium-gray to moderate-yellowish-brown, coarse-grained; interbedded with sandstone and limestone; siliceous cement and minor calcareous cement	Eleana Formation; unit J, quartzite subunit.

Table 1.--Lithologic log of UE17a--Continued

Thickness in meters (feet)	Lithology	Stratigraphic unit
195.7-251.5 (642-825)	Quartzite, brownish-gray to moderate-brown, coarse-grained, small angular fragments; calcareous cement; iron staining suggests possible fault at 222.8 m (731 ft)	Eleana Formation; unit J, quartzite subunit.
251.5-370.0 (825-1,214)	High-quartz argillite, dark-gray to black, fine-grained, thick-bedded; with some limestone, low-quartz argillite, and sandstone; low-quartz argillite absent at 268.2 m (880 ft); calcareous; fossils (brachiopods and horn corals); pyrite cubes; polished shear planes; foliated structure; sandstone is believed to be debris from uphole or debris washed into hole from water-bearing zones; light-tan to grayish-purple, well-rounded sandstone fragments, sizes as large as 2.54 cm (1 in.) in diameter; possible faults at 300.2 and 342.3 m (985 and 1,123 ft)	Eleana Formation; unit J, quartzite subunit.
	Total depth 370.0 (1,214)	

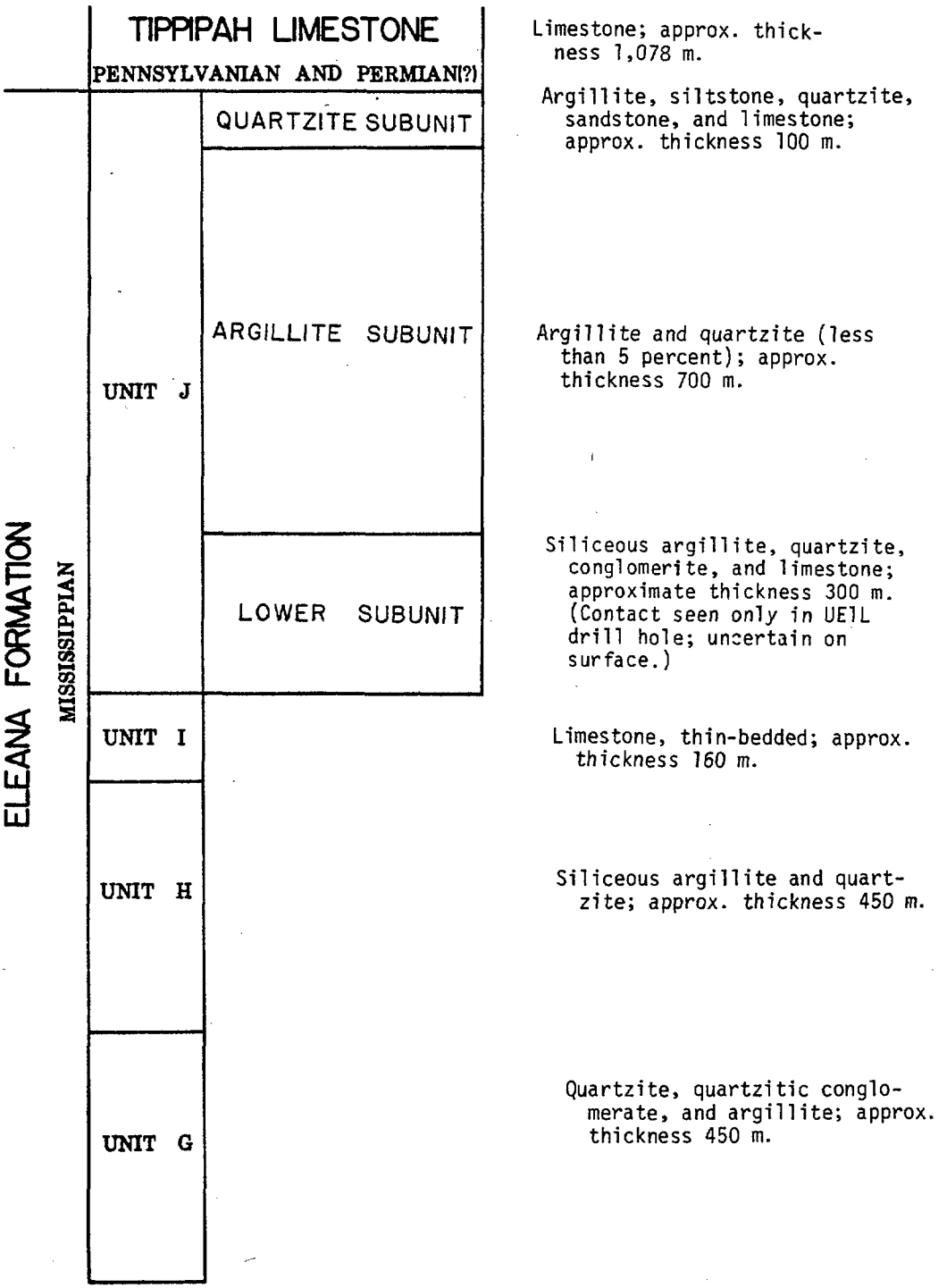

Figure 2.--Stratigraphic units of the Syncline Ridge area.

the thick-bedded, dark-gray to black, high-quartz argillite of the quartzite subunit of unit J was penetrated. Below this thick-bedded section of argillite, the high-quartz argillite is interbedded with thin layers of low-quartz argillite, limestone, and sandstone. Cubes of pyrite and two fossils, a brachiopod and a horned coral, were found in the cuttings.

Structure

An east-trending pre-Tertiary strike-slip fault lies between the drill hole and UE16c, about 0.6 km (0.4 mi) south of UE17a. The lateral displacement, estimated in the Eleana Range and Syncline Ridge, west and east, respectively, of the drill hole, is at least 1 km (0.62 mi). UE16c penetrated through the alluvium into unit J of the Eleana Formation at a depth of 36.6 m (120 ft). The vertical displacement on the fault is at least the 144.2-m (473-ft) thickness of the Tippipah Limestone missing from the UE16c drill hole but penetrated by UE17a drill hole.

Numerous small faults and fracture zones are penetrated by UE17a (table 2). The faults were identified by the iron staining on the cuttings and with the aid of the electric log. The core from 114.3 to 119.4 m (375 to 391.8 ft) shows highly fractured limestone healed by calcite, with iron staining present. The core from 177.1 to 180.7 m (581 to 593 ft) is strongly brecciated and recemented with calcite, silica, and iron; shear planes in this core have dips of approximately 25°. Fragments of what appear to be polished shear planes seen throughout the cuttings suggest a strongly foliated structure.

Hydrology

The first occurrence of ground water was at 176.8 m (580 ft); there was a minor yield, soon obscured by the circulating airfoam. A conspicuous inflow of water was obtained when drilling reached 324.6 m (1,065 ft); this flow persisted through the remainder of drilling. The water appeared to be coming from open fractures.

ENGINEERING GEOLOGY

A total of 8.78 m (28.8 ft) of rock was cored during the drilling of UE17a. Three cores were taken from two separate intervals within the hole: 114.3 to 119.4, and 177.1 to 180.7 m (375 to 391.8, 581 to 593 ft). Core recovery was 79 percent. A CI (core index) was calculated for each cored interval to determine the rock competency. A fracture analysis was done on the first two cored intervals to determine the fracture frequency.

Table 2.--Probable faults penetrated by UE17a

Depth		Stratigraphy and lithology	Cuttings or core
Meters	Feet		
75.6	248	Tippipah Limestone	Cuttings.
100.6-106.1	330-348	Tippipah Limestone	Do.
114.3-119.4	375-391.8	Tippipah Limestone	Core.
146.0	479	Tippipah Limestone	Cuttings.
177.1-180.7	581-593	Eleana Formation (quartzite)	Core.
222.8	731	Eleana Formation (quartzite)	Cuttings.
300.2	985	Eleana Formation (argillite)	Do.
342.3	1,123	Eleana Formation (argillite)	Do.

Core Index

The CI is a measure of rock competency. The CI is a dimensionless number from 0 to 100, 50 being the dividing point between competency (0-50) and incompetency (51-100). Incompetency in the rock is generally caused by jointing, faulting, and(or) brittleness. The CI is calculated by the following formula:

$$CI = \frac{\text{core lost (m)} + \text{core broken (m)} + 1/10 \text{ number of fractures}}{\text{drilled interval (m)}} \times 100$$

Lost core is defined as core that was not recovered from the drilled interval. Broken core is defined as the length of recovered core fragmented into pieces less than 10 cm (4 in.) in length. Fractures are defined as the number of natural fractures in the core, excluding the fractures in the broken-core intervals. All natural fractures will limit the size of intact core pieces greater than 10 cm (4 in.) in length. The total number of fractures is divided by 10, thereby relating the standard length of unfractured core to 10 cm (4 in.), the upper limit of broken core (J. R. Ege and M. J. Cunningham, unpub. data, 1975). The CI information for the three cored intervals in UE17a is given below:

Interval (meters)	Thickness (length)	Recovered core	Lost core	Broken core	Number of fractures	Core Index
	(meters)					
114.3-116.6	2.3	2.3	-0-	1.3	6	83
116.6-119.4	2.8	2.8	-0-	.8	19	95
177.1-180.7	3.6	1.8	1.8	1.4	4	98

Fracture Analysis

The fracture analysis is a detailed study of the core and includes data on the amount of core recovered, number of fractures divided according to angle, the total number of fractures for each interval, and the calculated fracture frequency. The fracture angles are measured from the vertical directly from the core, assuming the core is vertical. The fracture frequency is the number of fractures per meter and is obtained by dividing the total number of fractures in each interval by the amount of core recovered. The data obtained from UE17a are shown graphically in figure 3. The exact numbers used to construct

the rosette diagrams can be found on table 3. In UE17a, 63 percent of the fractures were closed and 37 percent were open. The only types of fillings found in the fractures were calcite and iron. There were a few bedding-plane fractures, classified as clean (free of any filling or staining).

Table 3.--Fracture analysis data for cored interval in Tippipah Limestone from UE17a

[Cored interval: 114.3-119.4 m (375-391.8 ft); total amount of core recovered: 5.1 m (16.8 ft)]

Angle	Total fractures		Open fractures		Closed fractures		Iron-oxide staining		Calcite filling	Number of fractures parallel to bedding
0-10	2		2		-0-		2		-0-	-0-
11-20	-0-		-0-		-0-		-0-		-0-	-0-
21-30	8		2		6		2		6	2
31-40	10		3		7		5		5	4
41-50	9		7		2		7		2	4
51-60	14		4		10		3		11	-0-
61-70	22		7		15		6		16	-0-
71-80	5		3		3		-0-		6	-0-
81-90	7		1		6		-0-		7	-0-
Total fractures	78	=	29	+	49	=	25	+	53	(10)

Fracture frequency=15.2 fractures per meter.

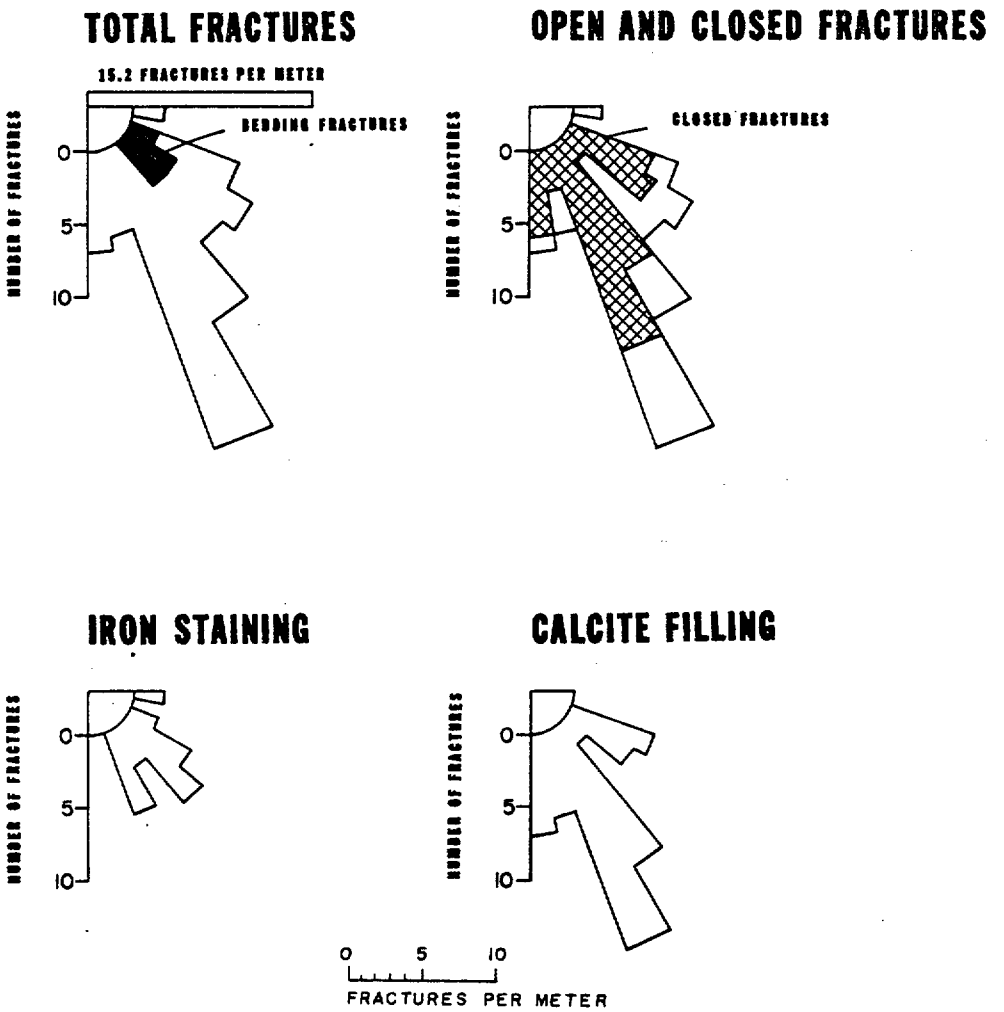

Figure 3.--Rosette diagrams for fracturing in core from UE17a, 114.3- to 119.4-m- (375- to 391.8-ft-) depth interval in Tippipah Limestone. The rosette diagrams depict the fracture angle by its position in the clockwise rotation of rays from 0° to 90°; the number of fractures is shown by the length of the respective ray. The horizontal bar across the top of rosette diagram for total fractures indicates the fracture frequency.

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