 USGS-1543-6

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Mail Stop 954, Federal Center, Box 25046
Denver, Colorado 80225

PRELIMINARY GEOLOGIC AND GEOPHYSICAL DATA OF THE UE25a-3 EXPLORATORY DRILL HOLE, NEVADA TEST SITE, NEVADA

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Florian Maldonado[1], D. C. Muller[1], and J. N. Morrison[2]

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ABSTRACT

The UE25a-3 drill hole, located in the Calico Hills area, southwestern part of the Nevada Test Site, was drilled as part of an effort to evaluate the Calico Hills area as a possible nuclear waste repository site. The purpose of the drill hole was to verify the existence of an intrusive crystalline body in the subsurface and to determine the stratigraphy, structure, and nature of fractures of the cored rocks. Cored samples were obtained for mineral, chemical, and material property analyses.

Continuous cores were taken from 30.5 m (100 ft) to total depth of 771.2 m (2,530.1 ft) of units J and I(?) (Late Mississippian age) of the Eleana Formation. The drill hole penetrated 416.1 m (1,365 ft) of argillite, and 304.5 m (999 ft) of thermally altered argillite of unit J, and 50.6 m (166 ft) of marble of unit I(?). No crystalline rocks were intersected by the drill hole.

Numerous high-angle faults and brecciated zones were intersected by the drill hole. The units cored were intensely fractured with fracture analysis of the core consisting of frequency of fractures, dips of fractures, open and closed (sealed) fractures and types of fracture sealing or coating material. Twenty-four hundred and thirty fractures, representing approximately 30 percent of the fractures present, indicate an average fracture frequency of 13.2 fractures per meter, predominantly high-angle dips with 66 percent of the fractures closed. Fractures in the argillite interval are sealed or coated predominantly with kaolinite, nacrite, and dickite. Calcite, chlorite, and magnetite are present in fractures in the altered argillite interval. Fractures in the marble interval are sealed or coated with calcite, dolomite, and ferruginous clay. The core index indicates that the lower half of the drilled interval is more competent than the upper half.

Borehole geophysical logs were run by the Birdwell Division of Seismograph Service Corporation for geologic correlations and lithologic characterizations. The logs include: caliper, density, resistivity, spontaneous potential, Vibroseis, 3-D velocity, neutron, and gamma-ray logs. Lithologic boundaries and structures correlate to responses in the logs.

INTRODUCTION

The UE25a-3 exploratory drill hole was drilled as part of an effort to evaluate the Calico Hills area for a possible nuclear waste repository site. The purpose of the drill hole was to verify the existence of an intrusive crystalline body in the subsurface, to determine the stratigraphy, structure, and nature of fractures, and to obtain cores for determining mineral, chemical, and material properties analyses.

The drill hole is located in the Calico Hills area, southwestern part of the Nevada Test Site, in Area 25 (fig. 1) at Nevada State Coordinates N. 234,498, E. 183,772 m (N. 769,350, E. 602,925 ft) with surface elevation of 1,386.8 m (4,550 ft). Total depth of the vertical drill hole is 771.2 m (2,530.1 ft).

10 km ENE of P1

Acknowledgments

Appreciation is expressed to the following Fenix & Scisson, Inc., geologists who monitored the drilling operation: M. J. Baldwin, R. M. Beathard, M. P. Chornack, E. P. Eshom, and T. Tomko. Appreciation is also expressed to J. E. Kibler for the digitizing, special computer processing, and quality control involved with the Birdwell geophysical log data, and to P. D. Blackmon and P. L. Hauff for X-ray diffraction analysis, all of the U.S. Geological Survey.

Hole History

UE25a-3 was spudded August 11 and completed October 10, 1978. The surface casing was set August 11, but the core drilling did not begin until August 26, 1978. The hole casing consisted of 340 mm (13 7/8 in.) OD (outside diameter) set from the surface to a depth of 23.9 m (77 ft) followed by 194 mm (7 5/8 in.) OD casing to 25 m (82 ft) and 114 mm (4 1/2 in.) OD casing set to 57.9 m (190 ft). The hole was cored from a depth of 30.5 m (100 ft) to a depth of 771.2 m (2,530.1 ft). Core size was 99 mm (3.9 in.) to 598.5 m (1,963.5 ft) and 77 mm (3.032 in.) to 771.2 m (2,530.1 ft).

The drilling was completed October 2, 1978; however, the borehole geophysical logging was completed October 10, 1978. The logs were run by Birdwell Division of Seismograph Service Corp. and include the following: caliper, density, resistivity, spontaneous potential, Vibroseis, 3-D velocity, neutron, and gamma-ray logs. A suite of logs was also run by the U.S. Geological Survey but not considered in this report. Subsequent to the geophysical logging, a 60-mm (2 3/8-in.) tubing was hung at 748.3 m (2,455 ft) for the purpose of measuring water levels.

The water levels measured at various periods subsequent to the drilling operation occurred at the following levels: 638.9 m (2,096 ft), December 8, 1978; and 639.2 m (2,097 ft), January 10, 1979; February 13, 1979; and March 6, 1979.

General Geology of the Calico Hills

The Calico Hills area is a structural dome (fig. 2). The oldest exposed rocks are Devonian limestones and dolomites that overlie argillites of the Eleana Formation

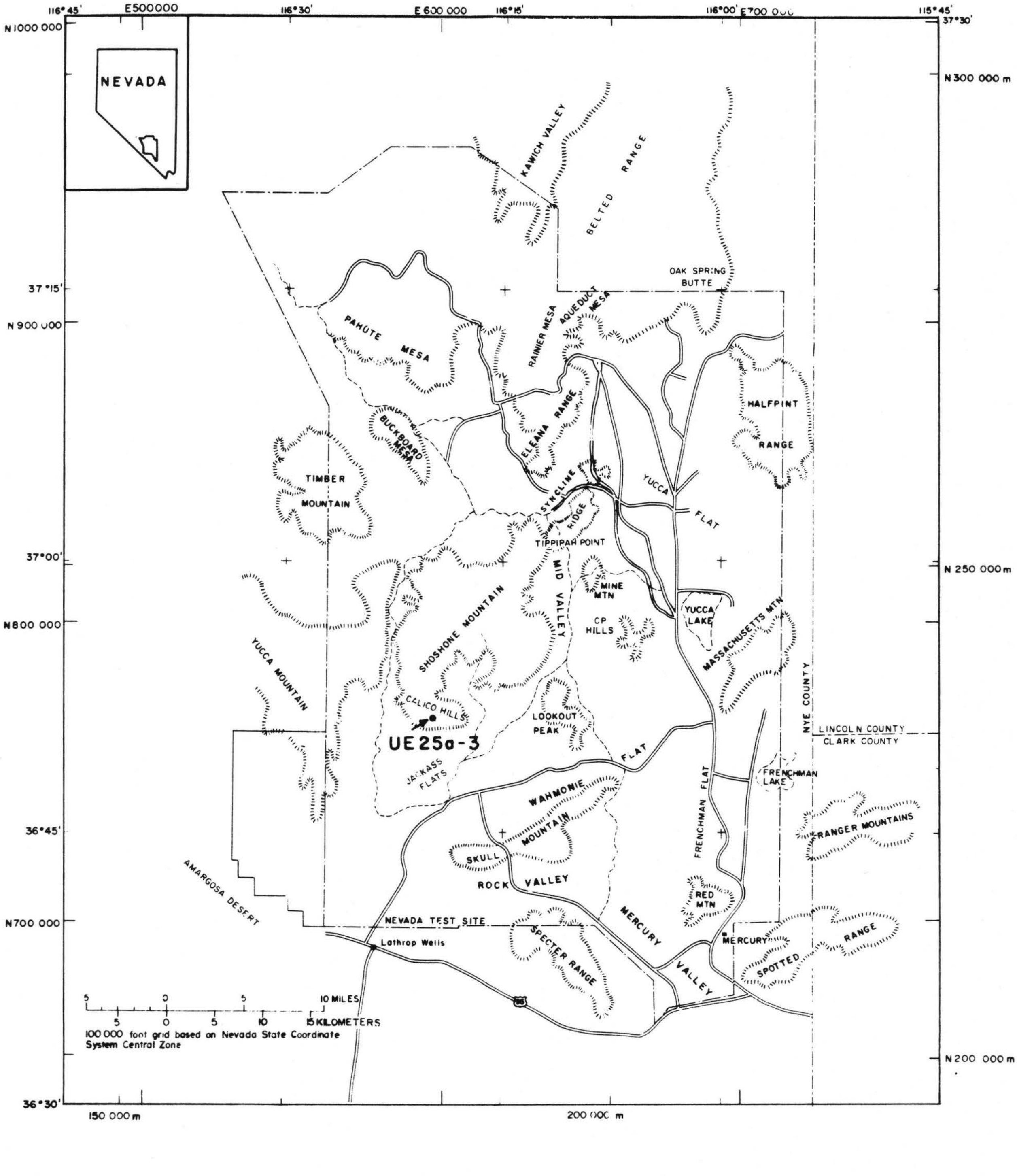

Figure 1.--Location of UE25a-3 drill hole.

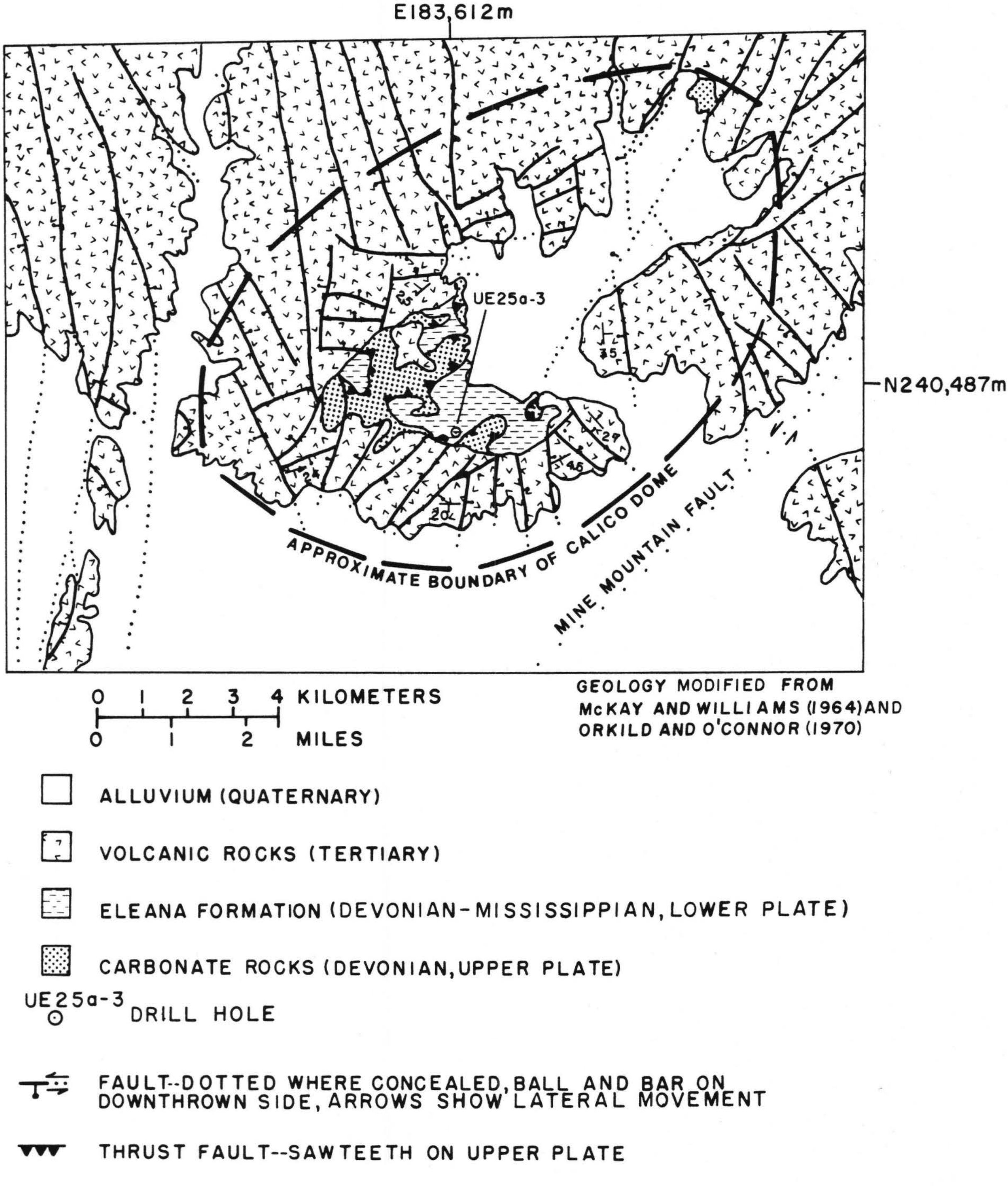

Figure 2.--Generalized geologic map Calico Hills area

(Mississippian-Devonian) as thrust plates. These older rocks are, in turn, overlain unconformably by volcanic rocks of Tertiary age that range from approximately 8 to 14 m.y. (million years). Porphyritic rhyolitic plugs and an andesite dike of Tertiary age intrude the Eleana Formation.

The Eleana Formation is exposed in the central part of the Calico Hills and consists mostly of argillite, with minor interbedded quartzites and limestones. These exposed rocks are equivalent to unit J of the Eleana Formation.

The principal structures in the area are the Mesozoic(?) thrust faults, the Calico Hills dome, concentric and radial faults associated with the doming, and high-angle faults related to Basin and Range faulting.

The doming of the Calico Hills was possibly caused by an intrusive crystalline body. Uplift was accompanied by extensive hydrothermal alteration. Volcanic rocks were pervasively altered; however, the carbonate and argillite rocks were only locally altered (E. J. McKay, 1963, written commun.). Intense alteration of the volcanic rocks has destroyed the pyroclastic texture by superposing processes of silicification, alunitization, pyritization, kaolinization, and calcitization (E. J. McKay, 1963, written commun.). The carbonate rocks are locally altered to calcite, quartz, montmorillonite, and in places metamorphosed to a white marble. The argillites of the Eleana Formation have been locally altered resulting in irregular bleaching of the rock, and in some areas altered to hornfels.

A broad aeromagnetic high was measured over the Calico Hills area (G. D. Bath, 1978, written commun.) and is elongated in an east-west direction. Three smaller magnetic highs are superimposed on this anomaly. One magnetic high occurs near the western end and the other two near the eastern end of the anomaly. The UE25a-3 drill hole is located on the western flank of one of the eastern occurring magnetic highs (fig. 3).

GEOLOGIC DATA OF DRILL HOLE

Stratigraphy

The Eleana Formation, Devonian and Mississippian in age, consists predominantly of clastic rocks approximately 2,350 m (7,700 ft) thick. The formation has been divided in 10 major lithologic units, in ascending order A through J (Poole and others, 1961). Only unit J and I(?) (at drill hole) have been identified in the Calico Hills area. The unit J, in the Syncline Ridge area, has been broken down (Hodson and Hoover, 1979) into three stratigraphic subunits in ascending order: lower, argillite, and quartzite. The lower subunit is predominantly dark-gray to black siliceous argillite with minor intercalated quartzite, limestone, and conglomerite beds; the argillite subunit consists predominantly of argillite with minor quartzite beds and fossiliferous limestone at the base; the quartzite subunit consists of argillite limestone, quartzite, and siltstone beds. All the three subunits are present at the Calico Hills area, either on the surface or in the drill hole.

The quartzite subunit is missing at the drill site. The drill hole penetrated 422.5 m (1,386 ft) of the argillite subunit, 298.1 m (978 ft) of the lower subunit of unit J, and 50.6 m (166 ft) of unit I (table 1). Hodson and Hoover (1979) report a thickness of 700 m of the argillite subunit for the Syncline Ridge area. This subunit is incomplete at the

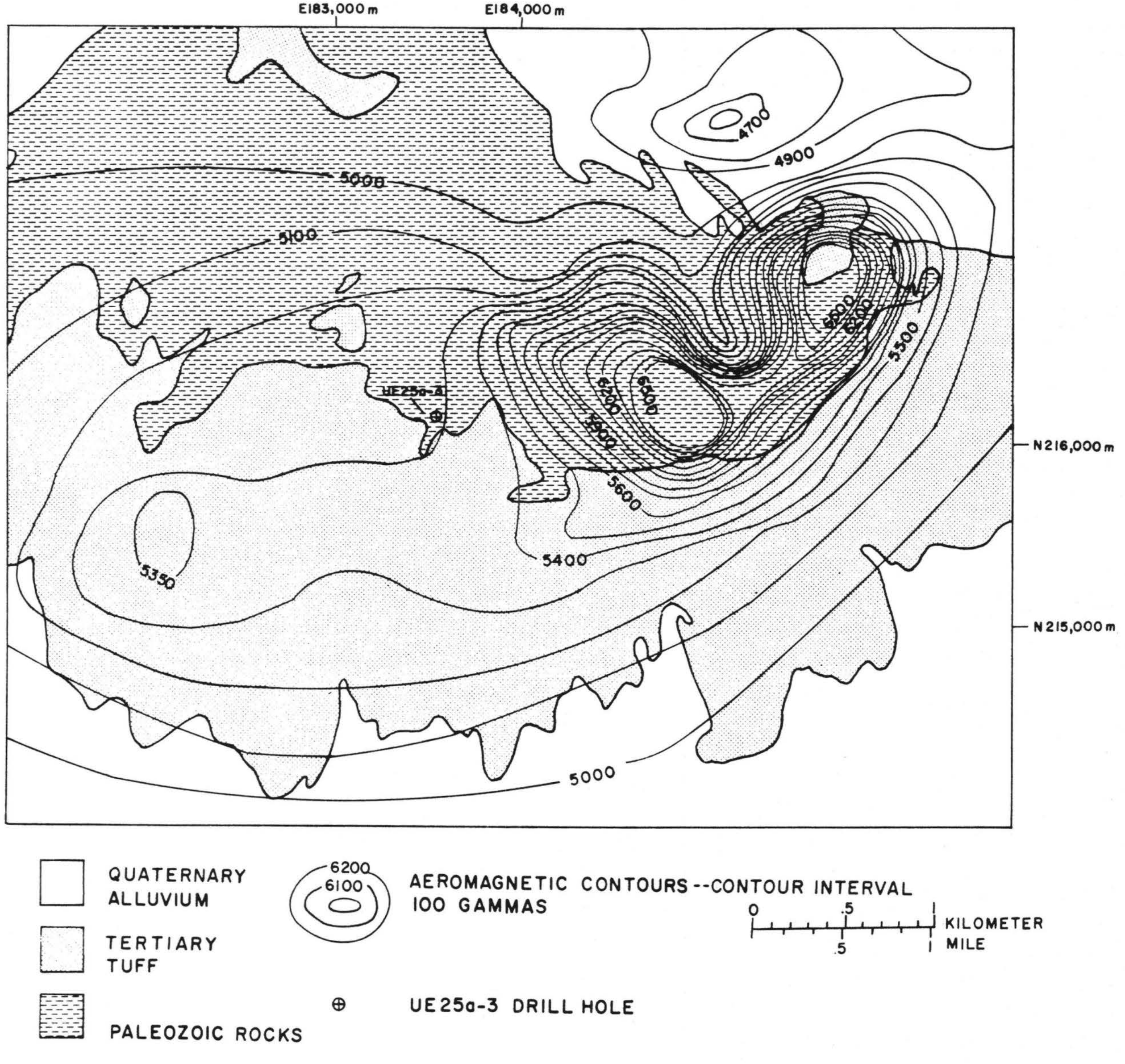

Figure 3.--Generalized geologic and aeromagnetic map of the Calico Hills area

Table 1.--Lithologic description of exploratory drill hole UE25a-3

Lithology and stratigraphy	Depth to base meters (feet)	Thickness meters (feet)
Eleana Formation		
Unit J		
Argillite subunit		
Argillite, dark-gray, grayish-black to black, very fine grained, laminated to thick bedded; intensely fractured, smooth polished surfaces very common; fractures filled with the following minerals in varying amounts: kaolinite, dickite, nacrite, pyrite, calcite, chlorite, quartz, montmorillonite-illite mixed layer, and hematite. Turbidity current structures occur in the following intervals: 63.1-71.5, 186.8-190.4, and 193.2-194.2 m (207.0-234.7, 613.0-624.5, and 633.7-637.1 ft). A quartzite bed is present at 59.8-60.1 m (196.3-197.3 ft), light gray, very fine grained, calcareous, and brecciated. Brecciated zones are very common (table 2) and possibly represent fault zones with no obvious fault planes. A fault plane at 404.7 m (1,327.6 ft) dips 45°. A thin recrystallized limestone bed containing fossil fragments, black to white, medium- to coarse-grained, occurs at 421.2-422.5 m (1,382-1,386 ft). Overlying the recrystallized limestone is 6.4 m (21 ft) of thermally altered argillite-------------------	422.5(1,386)	422.5(1,386)
Lower subunit		
Argillite, intercalated with thin-bedded quartzite and limestone beds in the upper part of subunit. Argillite, thermally altered, medium-dark-gray to dark-gray, very fine grained, thin- to thick-bedded, intensely fractured, fractures filled with calcite, chlorite, a red clay, and magnetite. Light and dark, thin argillite beds common at 422.7-452.7 m (1,386.7-1,485.2 ft). Thin recrystallized limestone bed at 431.3-431.9 m (1,415-1,417 ft). Quartzite, very fine grained, calcareous, occurs at 438.5-438.8 m (1,438.5-1,439.5 ft). Quartzite, very fine grained, noncalcareous, is present in the following intervals: 441.8-442.0 and 442.6-442.8 m (1,449.4-1,450.1 and 1,452.0-1,452.6 ft). Brecciated zones are common (table 2). A fault plane at 435.6 m (1,429.0 ft) dips 55°----------------------------------	452.6(1,485)	30.2(99)

Table 1.--Lithologic description of exploratory drill hole UE25a-3--Continued

Lithology and stratigraphy	Depth to base meters (feet)	Thickness meters (feet)
Eleana Formation--Continued		
Unit J--Continued		
Lower subunit--Continued		
Argillite, thermally altered, light-gray to greenish-gray, very fine grained, thin- to thick-bedded, alternating light and dark beds very common. Intensely fractured, fractures filled and commonly sealed with chlorite, calcite, magnetite, quartz, hematite, and some garnet (identified from X-ray analysis). The sealed fractures are commonly offset. A fault zone is present at 459.9-460.6 m (1,509-1,511 ft). A conglomerate bed occurs at the base of the interval, 489.8-490.4 m (1,607-1,609 ft), with rounded pebbles as large as 3.7 cm (1.5 in.)--	490.4(1,609)	37.8(124)
Argillite, intercalated with thin-bedded quartzites. Argillite, thermally altered, light-gray, greenish-gray to dark-greenish-gray, very fine grained, thin- to thick-bedded, alternating light and dark beds very common. The interval is intensely fractured and brecciated; fractures are filled with chlorite, calcite, magnetite, quartz, hematite, and some garnet (X-ray analysis). Limestone beds, white, at 498.4-498.7 and 521.7-522.1 m (1,635.2-1,636.3 and 1.711.7-1,712.8 ft); quartzites, very fine grained, at 500.0-500.5, 515.4-515.5, 591.4-591.8, and 613.0-613.3 m (1,640.5-1,642.0, 1,691.0-1,691.3, 1,940.4-1,941.5, and 2,011.3-2,012.0 ft). Meta-sandstone, argillaceous, medium-light-gray, fine-grained to very coarse grained, occurs at 634.1-639.9 m (2,080.5-2,099.5 ft). A thin conglomerate bed present at 648.7-648.9 m (2,128.4-2,129.0 ft). Brecciated zones are very common throughout interval (table 2). Fault planes were observed at the following intervals: 541.9 m (1,778.0 ft), 70°; 553.9 m (1,817.3 ft), 70°; 599.6 m (1,967.3 ft), 89°; 610.2 m (2,002.0 ft), 75°; 641.3 m (2,104.0 ft), vertical; 649.0 m (2,129.2 ft), 80°-------------------	677.0(2,221.0)	186.5(612.0)

Table 1.--Lithologic description of exploratory drill hole UE25a-3--Continued

Lithology and stratigraphy	Depth to base meters (feet)	Thickness meters (feet)
Eleana Formation--Continued		
Unit J--Continued		
Lower subunit--Continued		
Argillite, with intercalated limestone beds. Argillite, thermally altered, calcareous, dusky-yellow-green to dusky-green, very fine grained, thin-bedded; limestone beds marbleized and silicified, white to very light gray. Interval is intensely fractured and contains minor brecciated zones--------------------------------	681.2(2,235)	4.3(14)
Argillite, thermally altered, calcareous, grayish-olive, very fine grained, laminated, intensely fractured, fractures filled with calcite, chlorite, and quartz; minor brecciated zones--------------------------------	699.2(2,294)	18.0(59)
Argillite, thermally altered, medium-dark-gray, pale-olive to grayish-olive, very fine grained, laminated to thin-bedded, intensely fractured but fractures sealed or coated with calcite, chlorite, and quartz; minor brecciated zones--------------------------------	720.6(2,364)	21.3(70)
Unit I(?)		
Marble, white to grayish-orange-pink with occasional light-brown mudstone inclusions, dark-yellowish-orange clay (ferruginous) seams common. Silicified breccia present at 720.6-730.3 m (2,364-2,396 ft). Magnetite occurs along bedding planes and fractures at 752.3-754.4 m (2,468.3-2,475.0 ft). Fault at 746.2 m (2,448.3 ft) dipping 85°. Marbleized carbonate rocks 762.3-771.2 m (2,501.0-2,530.1 ft), laminated to thin-bedded, laminae consists of medium-gray to medium-light-gray beds alternating with white beds. Yellow-orange clay (ferruginous) seams common in interval 769.0-771.2 m (2,523.0-2,530.1 ft); intensely fractured--	771.2(2,530.1)	50.6(166.1)
Total depth---------	771.2(2,530.1)	

UE25a-3 site, because of numerous faults. Brecciated zones as shown on table 2 may possibly indicate fault zones.

The argillites of the argillite subunit are dark gray to black and contain quartz (30-40 percent), illite, and an illite-montmorillonite mixed layer, with lesser amounts of feldspars, chlorite, calcite, and siderite as determined from X-ray analysis. The fractures contain kaolinite, and its polymorphs; dickite, nacrite, and minor chlorite (identified by X-ray analysis). Also present in lesser amounts are pyrite, calcite, quartz, montmorillonite-illite mixed layer, and hematite. Kaolinite and its polymorphs occur throughout the argillite subunit. The bottom of a thin recrystallized limestone bed containing fossil fragments at 422.5 m (1,386 ft) was selected as the base of the argillite subunit. Overlying the fragmental limestone is 6.4 m (21 ft) of thermally altered argillite.

The next subunit penetrated is the lower subunit that occurs between 422.5 m (1,386 ft) and 720.6 m (2,364 ft), and is composed of argillite with minor intercalated quartzite, limestone, and conglomerate beds. Some of the argillites could be very fine grained siltstones. The argillites have been thermally altered as the result of contact metamorphism. The altered argillites have been thermally bleached to a lighter color and are light gray to dark greenish gray and contain quartz (50-70 percent), illite, montmorillonite-illite mixed layer, chlorite, feldspar, and calcite with lesser amounts of siderite and magnetite. The fractures contain calcite, chlorite, magnetite, some hematite, and trace amounts of garnet.

The basal part of the lower subunit consists of calcareous argillites that have been thermally altered and occur between 676.9 m (2,221 ft) and 720.6 m (2,364 ft). Thin limestone beds that have been marbleized and silicified occur in the upper part of the section. The section represents a transitional zone from argillaceous clastic sediments to carbonates. The calcareous altered argillites are medium dark gray, dusky green to grayish olive, and contain quartz (10-60 percent), corrensite (montmorillonite: chlorite; 1:1), montmorillonite, calcite, feldspars, and calcite. The fractures contain calcite, quartz, and trace amounts of magnetite.

Underlying the basal part of the lower subunit is a marble that represents the recrystallized carbonates of unit I(?). The marble is white to medium light gray, and consists of recrystallized calcite and brucite ($Mg(OH_2)$) with trace amounts of dolomite and serpentine(?) (X-ray analysis). The fractures contain calcite, ferruginous clay, and some magnetite, chlorite, and quartz. The presence and amount of brucite suggest the possibility that the recrystallized carbonate was probably a dolomite or a dolomitic limestone.

Metamorphism

The argillaceous clastic sediments of the Eleana Formation were exposed to low-grade regional metamorphism changing them to argillite. Superimposed on this low-grade regional metamorphism is thermal metamorphism (contact metamorphism) resulting mainly in bleaching of the argillites. The rocks penetrated by the drill hole have been broken down to stratigraphic subunits (argillite and lower); however, the alteration boundaries do not coincide with the stratigraphic subunits boundaries. For the purpose of discussion, the following intervals have been formed based on thermal alteration or the lack of: argillite 0-416.1-m

Table 2.--Brecciated zones, possibly indicative of fault zones, UE25a-3

Meters	Feet	Lithology
38.7- 42.3	126.8- 138.6	Argillite
49.2- 50.9	161.5- 167.0	Do.
56.4- 59.3	185.0- 194.4	Do.
61.2- 62.9	200.8- 206.5	Do.
78.9- 82.0	259.0- 269.0	Do.
103.0-103.6	338.0- 340.0	Do.
126.8-127.7	416.0- 419.0	Do.
131.1-131.8	430.0- 432.5	Do.
163.1-164.3	535.0- 539.0	Do.
200.0-200.7	656.0- 658.5	Do.
213.2-213.7	699.5- 701.0	Do.
252.7-253.3	829.0- 831.0	Do.
298.8-301.0	980.3- 987.4	Do.
355.2-357.0	1,165.5-1,171.3	Do.
372.0-372.7	1,220.6-1,222.6	Do.
384.1-387.1	1,260.1-1,270.0	Do.
404.3-405.7	1,326.4-1,331.0	Do.
413.3-419.2	1,356.0-1,375.2	Argillite and altered argillite
427.5-430.2	1,402.5-1,411.3	Altered argillite
505.7-514.6	1,659.0-1,688.4	Do.
523.7-524.3	1,718.0-1,720.0	Do.
525.1-537.3	1,722.7-1,762.7	Do.
539.3-555.4	1,769.3-1,822.0	Do.
563.6-572.4	1,849.0-1,878.0	Do.
573.3-634.0	1,881.0-2,080.0	Do.
639.9-648.7	2,099.5-2,128.4	Do.
658.7-666.9	2,161.0-2,188.0	Do.

(0-1,365-ft), altered argillite 416.1-676.9-m (1,365-2,221-ft), and calcareous altered argillite 676.9-720.6-m (2,221-2,364-ft) intervals. The argillite interval contains the argillite subunit, and the altered argillite and calcareous altered argillite intervals are part of the lower subunit. The upper part of the altered argillite interval extends 6.4 m (21 ft) upward into the argillite subunit.

The metamorphism of the rocks penetrated increases with depth. The argillite interval present in the upper half of the drill hole has not been visibly affected (bleached) by the thermal metamorphism; however, the presence of kaolinite and its polymorphs, nacrite, and dickite in fractures indicate that hydrothermal solutions migrated through the fractures depositing these minerals without appreciably altering the rock. The kaolinite and polymorphs are absent below the argillite-altered argillite contact that occurs at 416.1 m (1,365 ft).

The altered argillite and calcareous altered argillite intervals are composed of slightly thermally metamorphosed argillites that consist mainly of bleaching of the black argillite to a lighter color. The black colors in the argillites are due to the presence of organic carbon that averages about 1 percent (F. G. Poole, personal commun.). The organic carbon has been heated and driven off resulting in a lighter color.

The whole rock mineralogy of the argillites in the argillite, altered argillite, and calcareous altered argillite intervals is essentially similar, however, a change in clay mineralogy is present. The predominant clay in the argillite interval is illite. In the altered argillite interval illite is still the predominant clay; however, an increase in montmorillonite was noted. Corrensite is the predominant clay in the calcareous altered argillite interval. The presence of chlorite, calcite, magnetite, and trace amounts of garnet in fractures in the altered intervals and bleaching of the argillites indicates thermal metamorphism (contact metamorphism).

The marble present in the lower portion of the cored interval is the highest grade of metamorphism present in the cored rocks. The marble formed by thermal alteration or metamorphism of carbonates at high temperatures (300°-400°C?). The temperatures required for alteration of the rocks were probably generated by an intrusive body located deeper than the total depth of the drill hole.

Structure

The units penetrated by the drill hole have undergone several complex episodes of deformation that involve regional compression (thrust faulting), faulting related to doming, and possible high-angle faulting of Basin and Range age. Evidence for the deformation include fault planes, brecciated zones, intense fracturing, offset of sealed fractures (veins), and highly variable dips of beds.

The drill hole intersected numerous fault zones. Nine fault planes were observed with apparent dips ranging from 45° to 90°. These fault planes are listed on table 3 and plotted on plate 1 (in pocket). Some of the fault zones are characterized by brecciation even though no fault plane was observed. The brecciated zones are commonly present throughout the cored interval (table 2) and are probably related to the doming and possibly to thrust faulting.

Table 3.--Faults with measurable apparent dip, intersected by the UE25a-3 drill hole

Depth meters	Depth feet	Apparent dip
404.7	1,327.6	45°
435.6	1,429.0	55°
541.9	1,778.0	70°
553.9	1,817.3	70°
599.6	1,967.3	89°
610.2	2,002.0	75°
641.3	2,104.0	90°
649.0	2,129.2	80°
746.2	2,448.3	85°

The units cored are intensely fractured with fractures commonly sealed or coated with the following major minerals: kaolinite, nacrite, dickite, montmorillonite, quartz, calcite, chlorite, pyrite, hematite, magnetite, and a ferruginous clay.

The bedding planes in the thermally unaltered argillite interval are very obscure and are visible only by wetting the core. The dips range from 10° to 52° (plate 1). Bedding planes are more obvious in the thermally altered argillite zone and range from 18° to 50°; however, in the calcareous altered argillite interval the beds are essentially horizontal. The bedding planes in the marbleized interval range from 40° to 60°. The highly variable dips in the various units are due to the highly complex structure.

ENGINEERING GEOLOGY

Core Index

A core index (CI) was calculated for all the cores. A core index is a measure of relative rock competency (J. R. Ege and M. J. Cunningham, unpub. data, 1975) and is calculated by the following formula:

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

Broken core is defined as pieces less than 10 cm (0.4 in.) in length, core loss as core not recovered from cored interval, and fractures as natural breaks, excluding breaks in broken core interval. A CI greater than 50 indicates relatively incompetent rocks. In the Calico Hills area relatively incompetent rocks are generally due to faulting, jointing, brittleness, and intensity of alteration and brecciation.

The CI for all the cores for the entire hole has been plotted on plate 1. Approximately 67 percent of the entire cored interval (30.5-771.2 m) is relatively incompetent rock (fig. 4). Eighty-five percent of the argillite interval, 30.5-416.1 m (100-1,365 ft); 49 percent of the thermally altered argillite interval, 416.1-676.9 m (1,365-2,221 ft); 14 percent of the calcareous altered argillite interval, 676.9-720.6 m (2,221-2,364 ft); and 30 percent of the marble interval, 720.6-771.2 m (2,364-2,530.1 ft) represent relatively incompetent rock.

Fracture Analysis

In this analysis, fractures caused by drilling and (or) handling were not tabulated. Fractures were classified as open or closed (sealed). In this report, open fractures are defined as natural breaks with an aperture between the walls as they appear in the core box. The walls can be either clean or coated with some mineral material. Closed fractures are breaks whose walls are sealed or "glued" together by fracture filling material. Some of the tabulated open fractures could possibly be closed fractures that have been reopened during drilling and (or) handling.

The fracture analysis consisted of sampling a population of fractures because of the great number of fractures present in the core. A total of 2,430 fractures was tabulated representing approximately 30 percent of the total fractures. The sampling technique

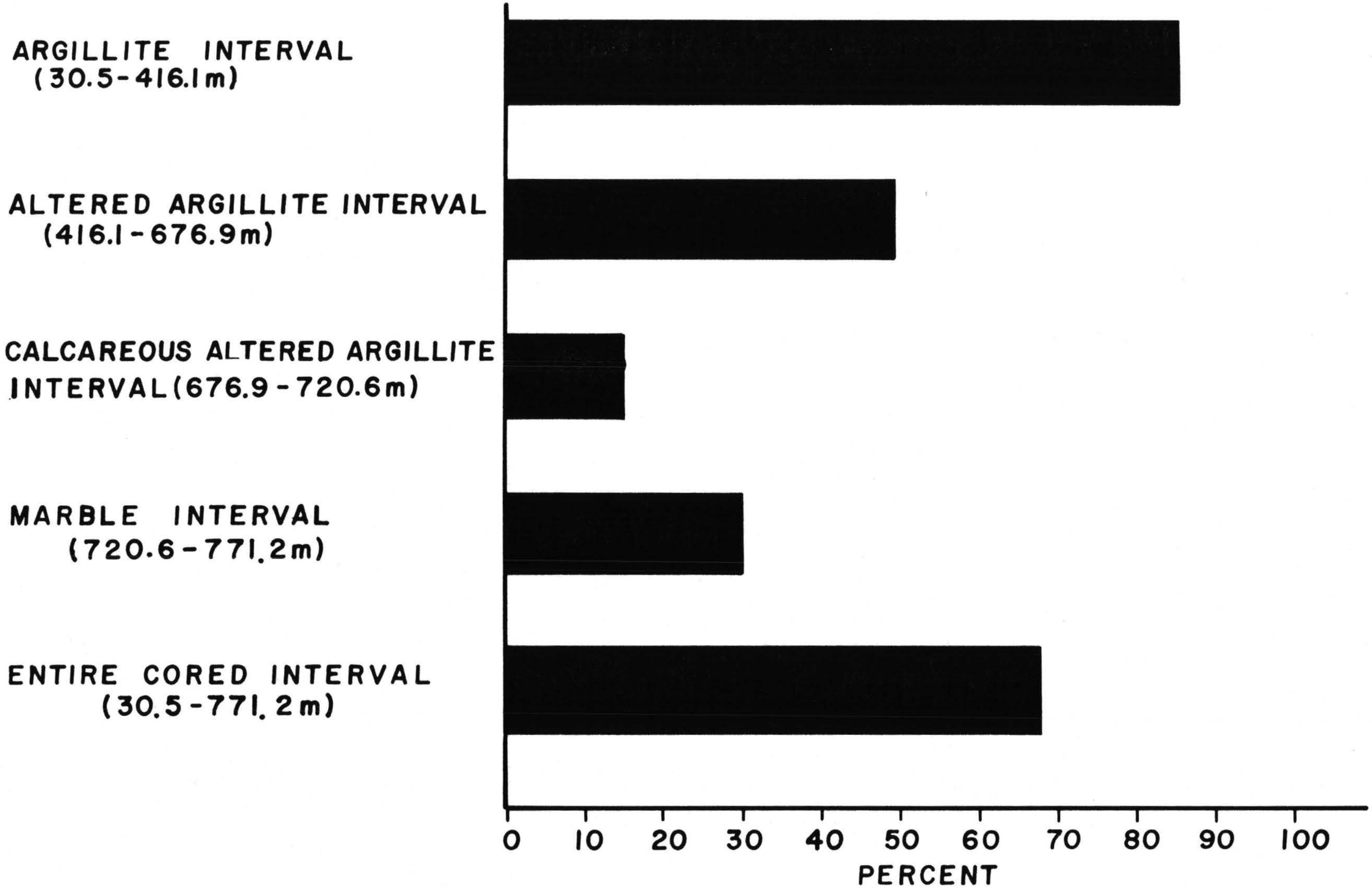

Figure 4.--Percentage of relatively incompetent rock of cored intervals, UE25a-3.

consisted of tabulating the first 10 fractures for every 3 m (10 ft) of core, so that the sampled fractures are representative of that 3-m (10-ft) interval. The entire cored interval was sampled in this manner. Number of fractures, dips of fractures, type of fracture filling, and open and closed fractures were tabulated from the sampled intervals and analyzed.

The fracture frequencies were obtained by sampling of 3-m (10-ft) intervals. The frequencies were determined by dividing 10 fractures by the interval where the first 10 fractures occurred within the sampled 3-m (10-ft) interval. The frequencies obtained from the sampled 3-m (10-ft) intervals were then summed and averaged for every 30.5 m (100 ft) of core (fig. 5). Next, the frequencies were again summed and averaged for the argillite, altered argillite, calcareous altered argillite and marble intervals (fig. 6). The sampled average fracture frequency for the above-mentioned intervals are as follows: argillite, 13.9; altered argillite, 13.7; calcareous altered argillite, 17.1; and marble, 7.9 fractures per meter. The sampled average fracture frequency for the entire cored interval is 13.5 fractures per meter.

Dips of the fractures were also tabulated per 10° dip interval, whether open or closed. Dips of fractures were grouped per 30.5 m (100 ft) (fig. 7) and per rock interval (fig. 8). Fifty percent of the fractures in the argillite interval are predominantly low angle or less than 45°. The low-angle fractures are probably related to the following: (1) low-angle thrust faulting; (2) doming of the Calico Hills area; (3) presence of low-angle bedding planes; (4) near-surface stress release; and (5) no appreciable thermal alteration in the argillite interval. Fractures in the thermally altered intervals are predominantly high angle or greater than 45°, with the greatest concentration in the 50°-80° range. The predominance of high-angle fractures in the thermally altered intervals is probably related to the alteration and doming.

Open and closed fractures were tabulated per 10° interval and compared per 30.5-m (100-ft) intervals (figs. 9 and 10). The number of open fractures versus closed fractures varied with depth. Of the 2,430 fractures tabulated, 66 percent of the fractures were closed, occurring mostly in the bottom half of the cored interval. In the argillite interval, 88 percent of the fractures were open, and 12 percent were closed (fig. 11); altered argillite, 46 percent open and 54 percent closed; calcareous altered argillite, 21 percent open and 78 percent closed; and the marble interval, 38 percent open and 62 percent closed. The closed fractures are more common in the altered intervals than in the argillite interval and are probably related to the type of fracture-filling minerals present, and the ability of those minerals to seal the fractures.

The fractures were sealed or coated by various minerals. In the argillite interval (fig. 12), the sealing or coating minerals consist predominantly of the following clay minerals: kaolinite, nacrite, dickite, and some chlorite with lesser amounts of pyrite and trace amounts of calcite and hematite. The fracture sealing or coating material in the altered argillite interval (fig. 13) consists of calcite and chlorite with lesser amounts of magnetite and trace amounts of quartz and hematite. Very small amounts of garnet were detected by X-ray analysis. In the calcareous altered argillite interval (fig. 14), calcite and chlorite are the major fracture sealing or coating minerals. In the marble interval

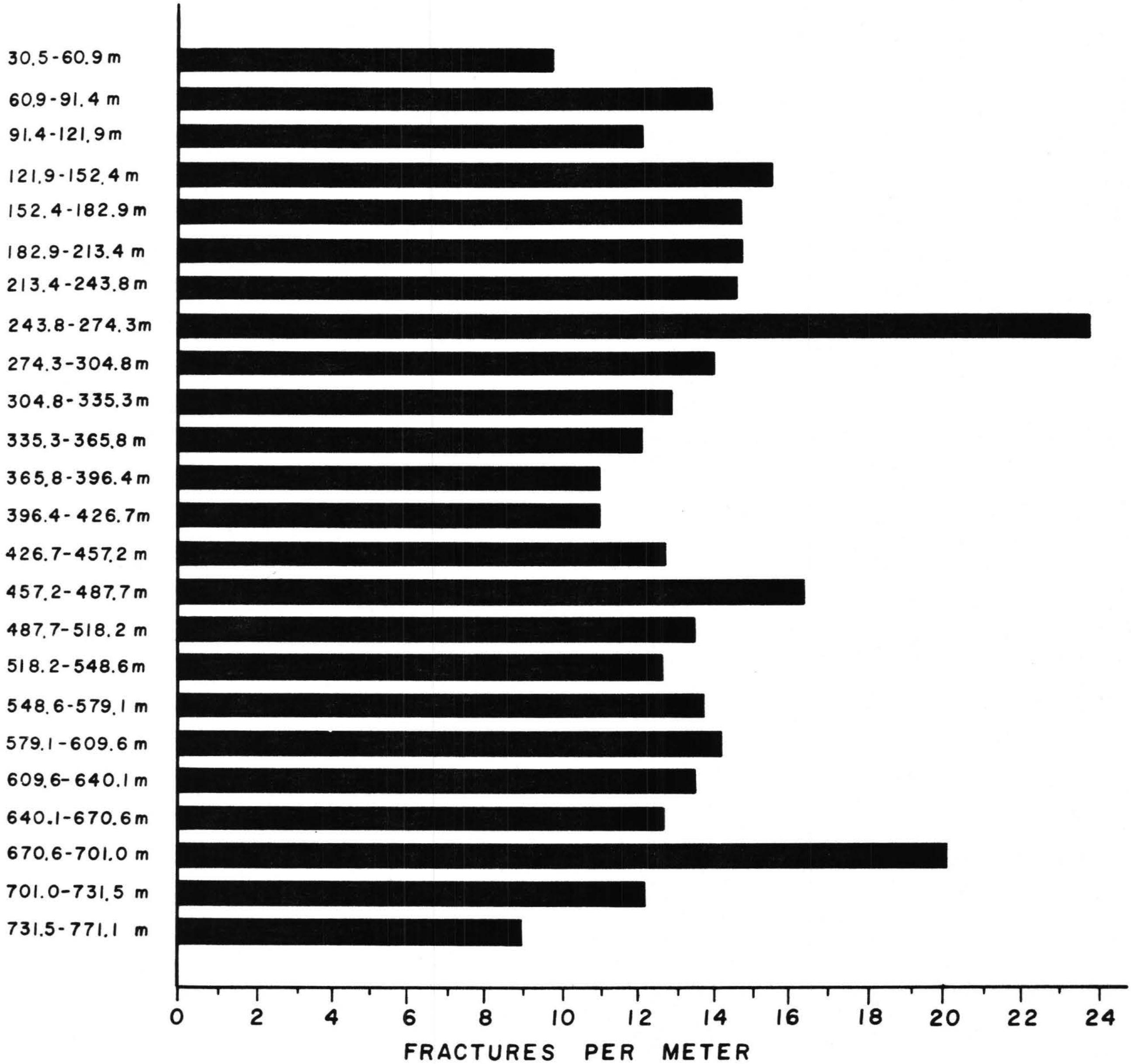

Figure 5.--Fracture frequencies per 30.5 m sampled interval, UE25a-3.

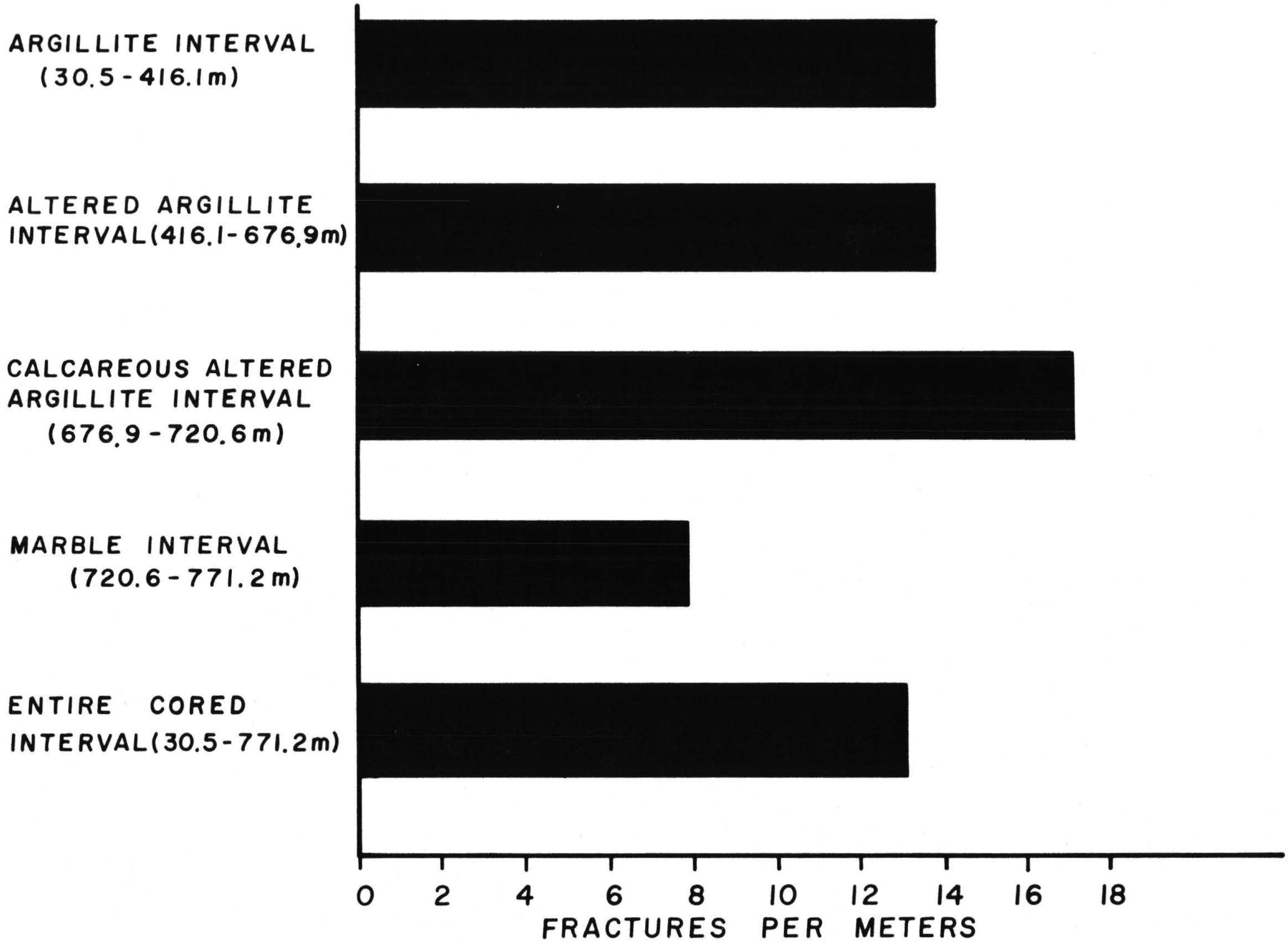

Figure 6.--Average fracture frequencies in the entire cored interval UE25a-3.

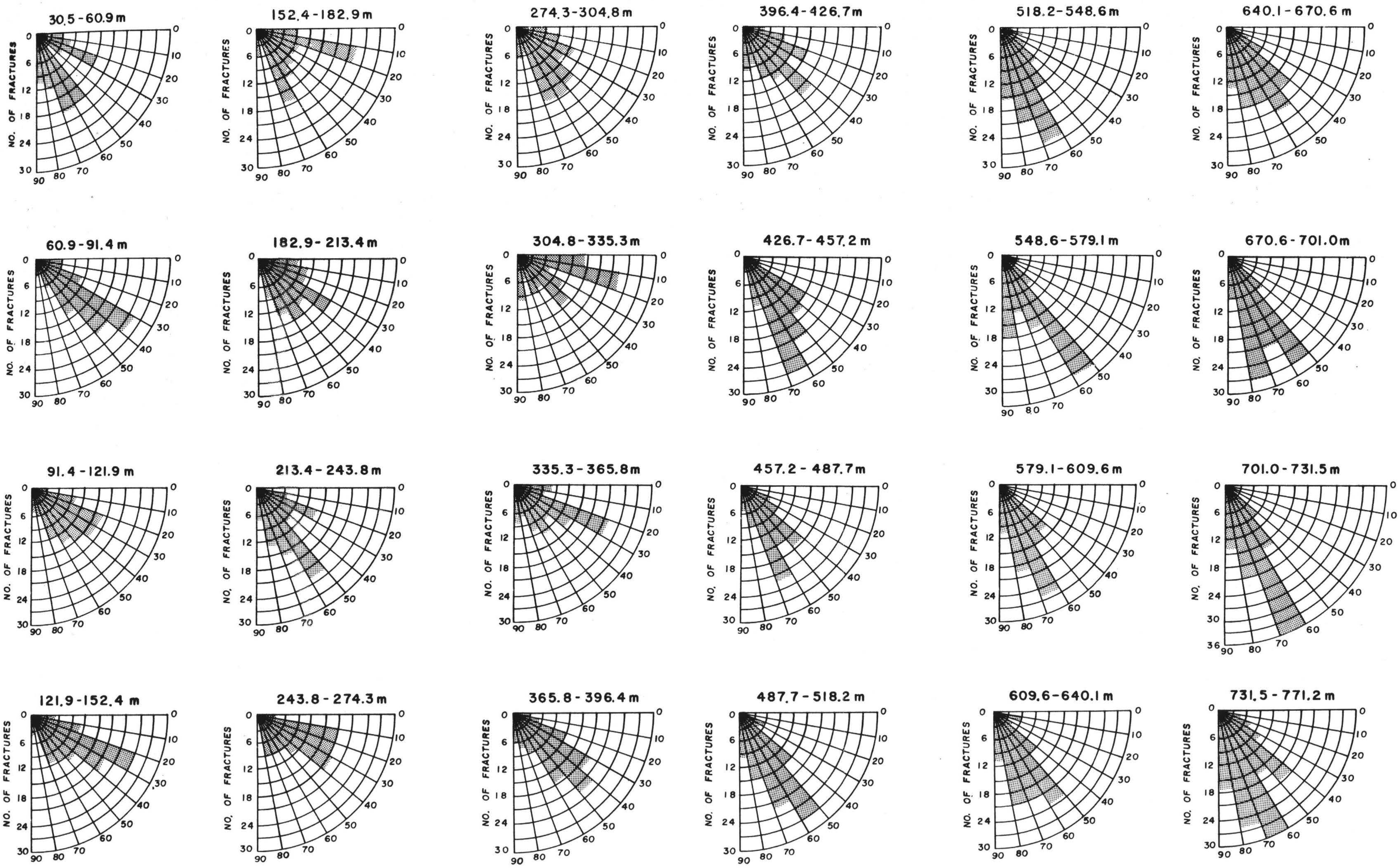

Figure 7.--Fractures per 10° dip interval for sampled interval 30.5 - 771.2 m, UE 25 a-3

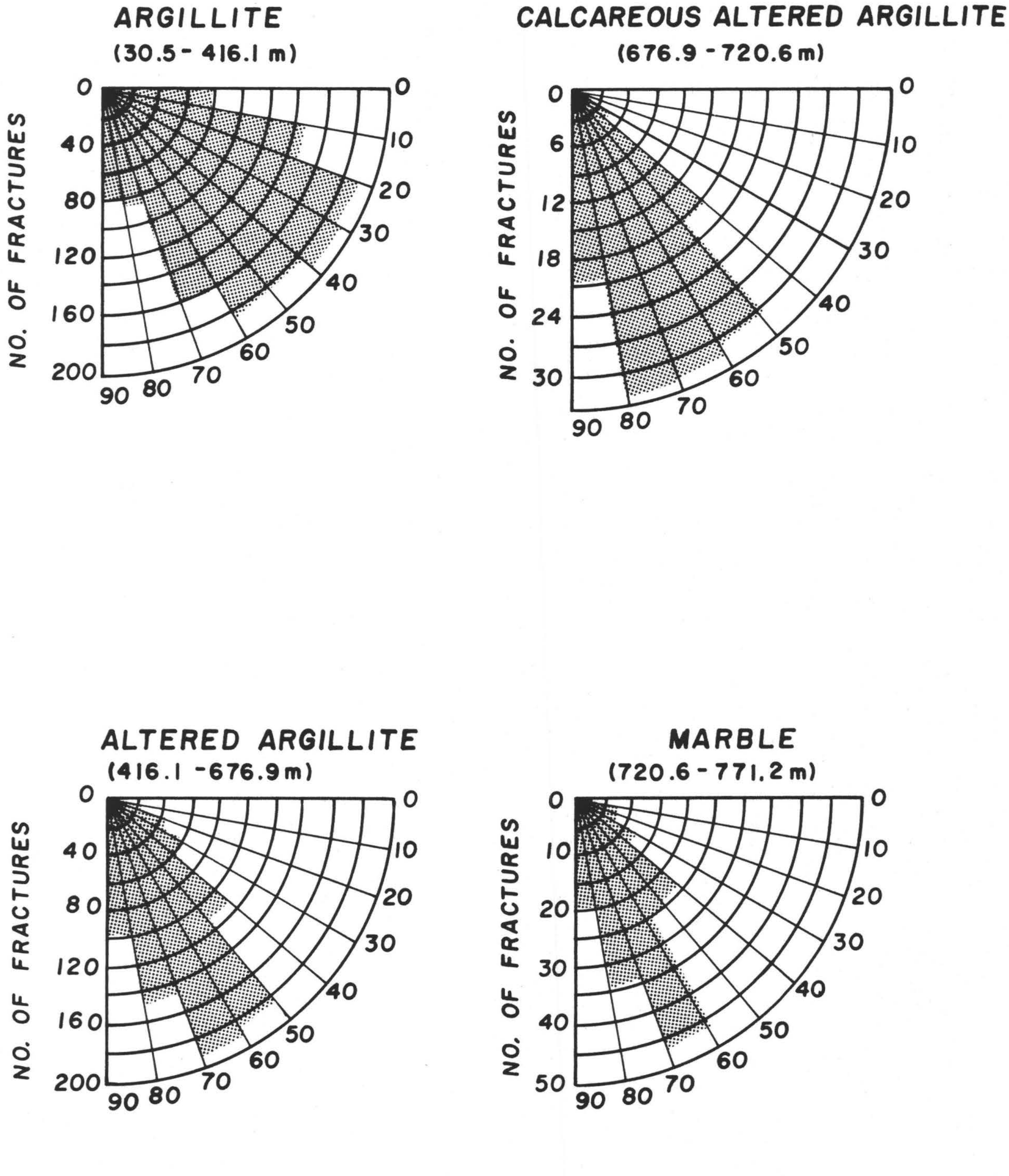

Figure 8.--Fractures per 10^{0} dip interval in the argillite, altered argillite, calcareous altered argillite, and marble intervals, UE25a-3.

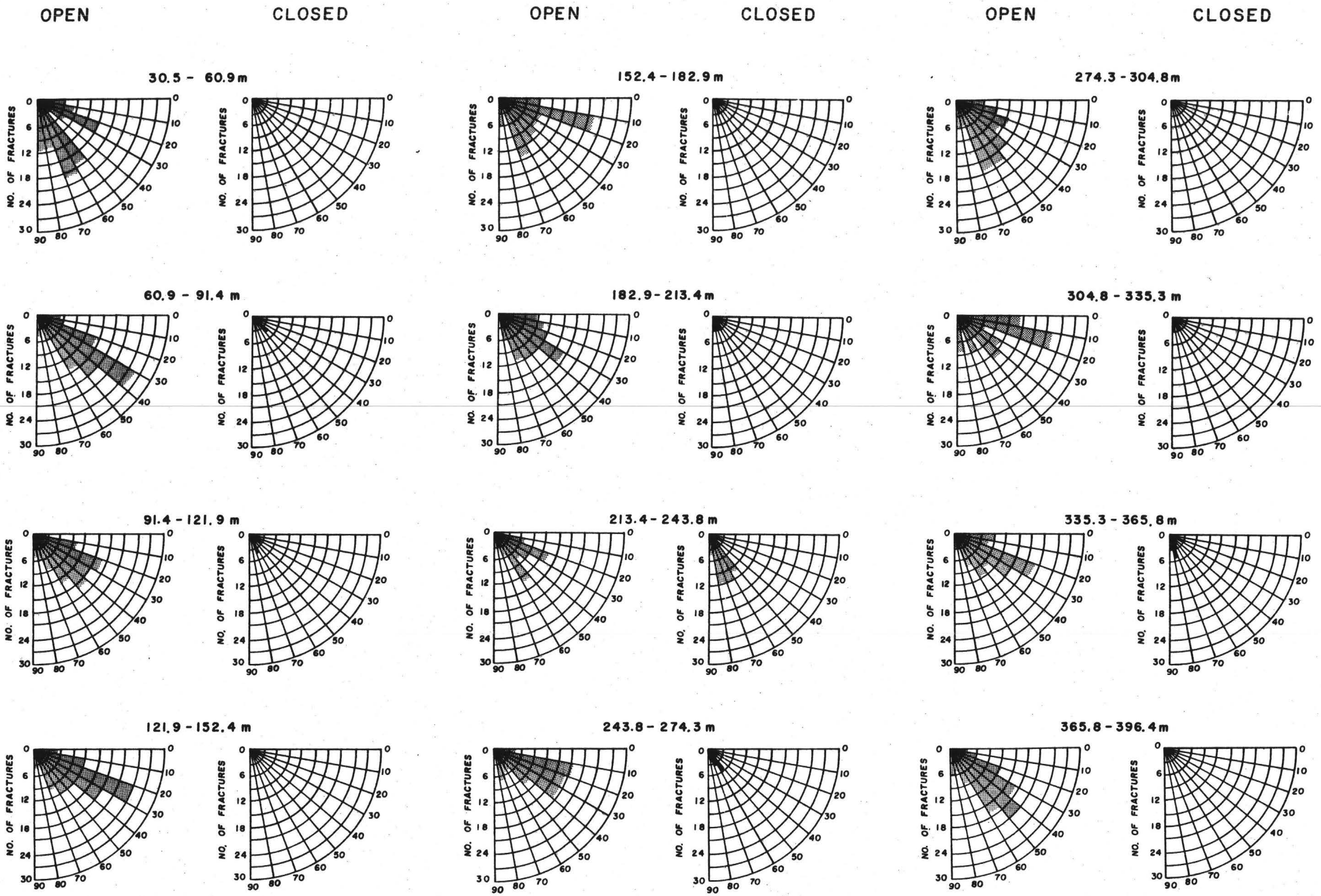

Figure 9.--Open and closed fractures per 10° interval for sampled interval, 30.5 - 396.4 m, UE25a-3

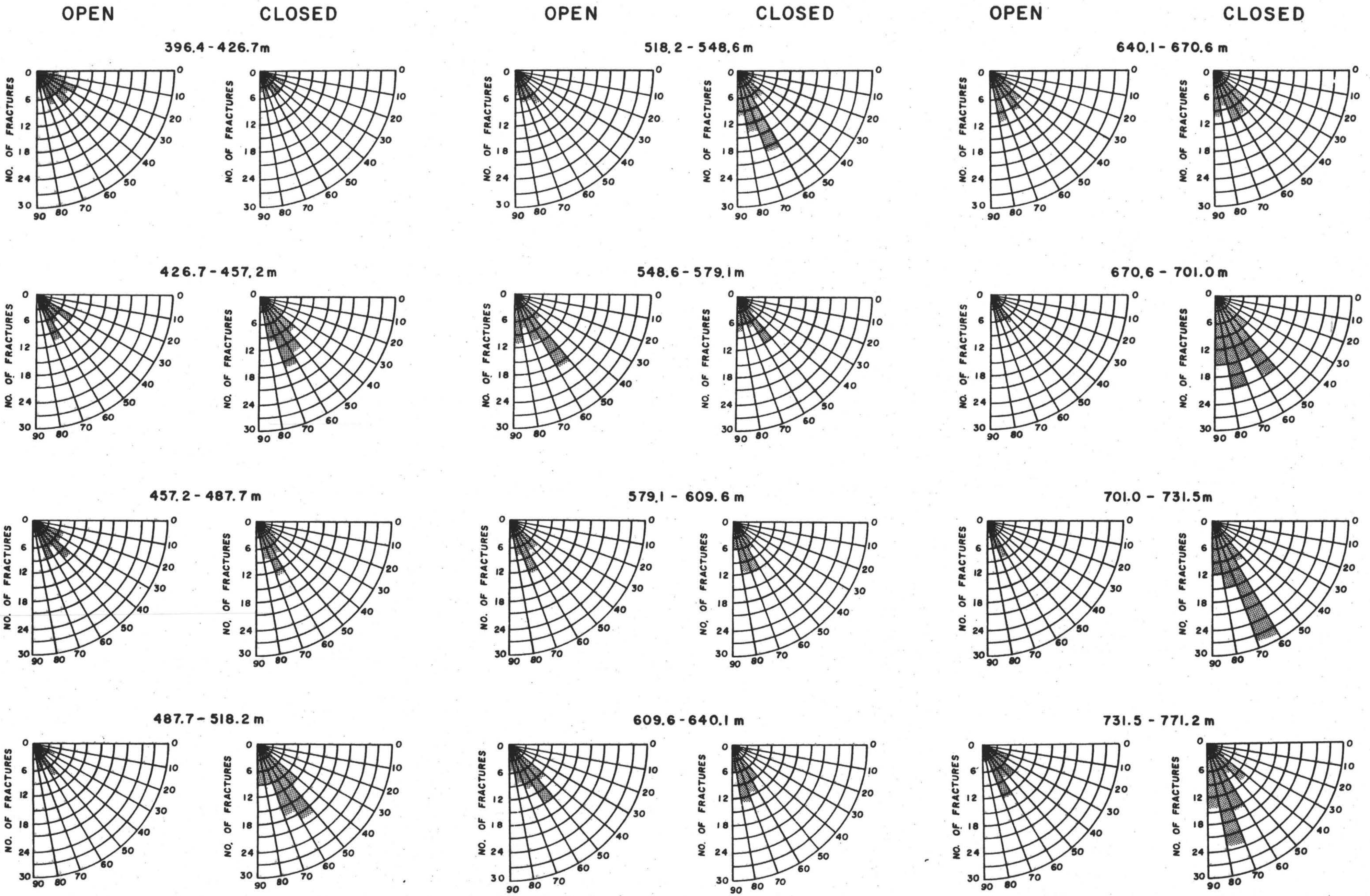

Figure 10.--Open and closed fractures per 10° interval for sampled interval, 396.4 - 771.2 m, UE25a-3

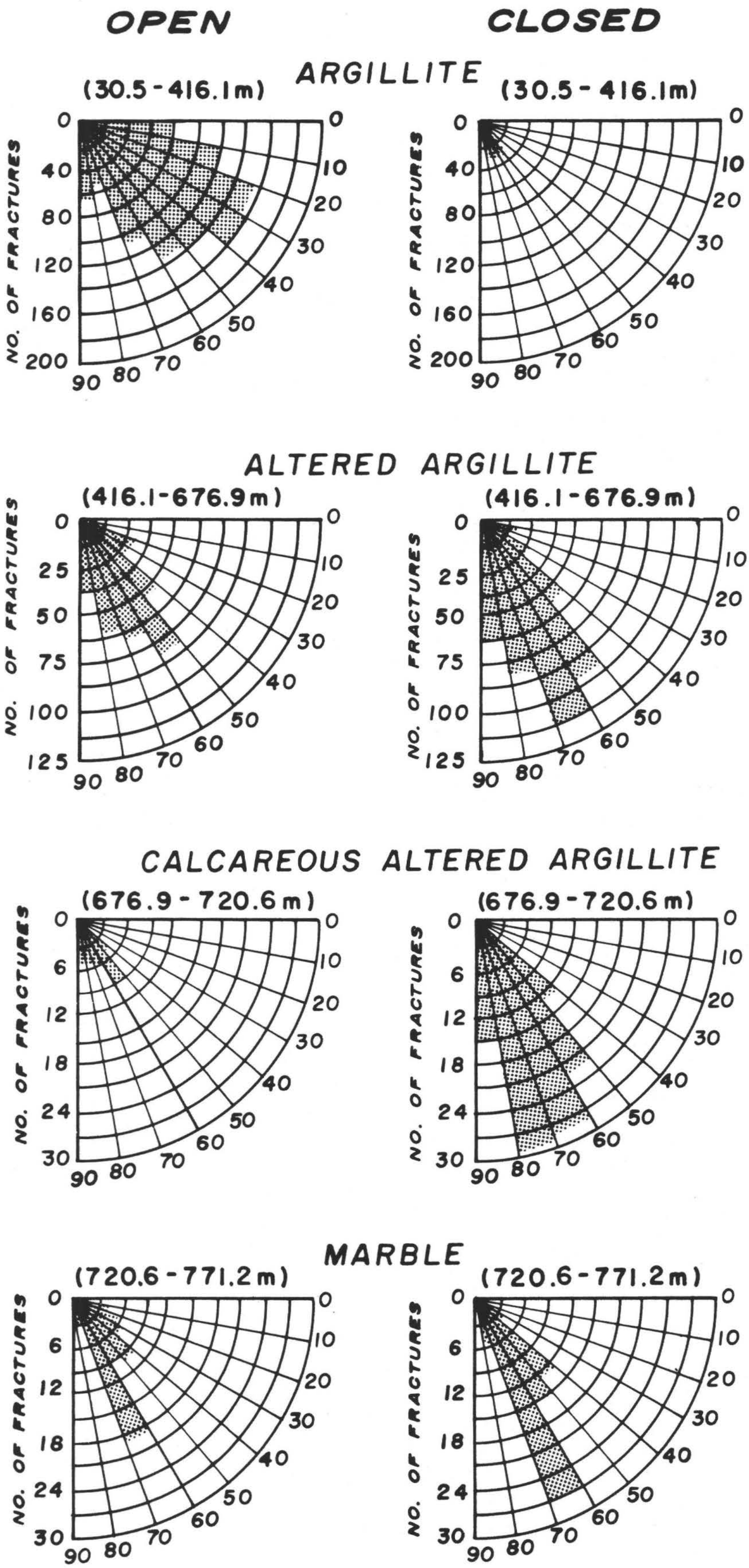

Figure 11.--Comparison of open and closed fractures per 10^0 dip interval, in the argillite, altered argillite, calcareous altered argillite, and marble intervals, UE25a-3.

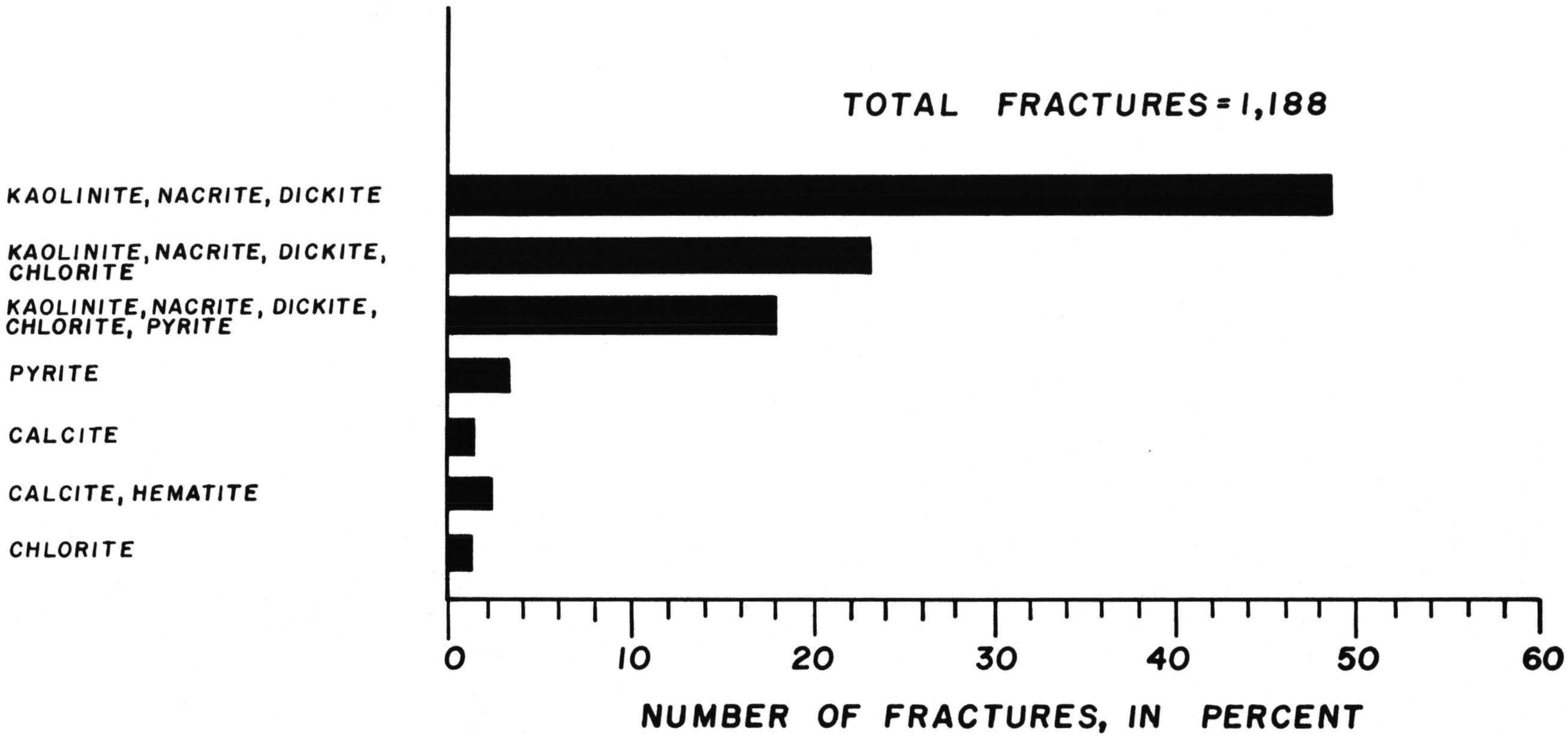

Figure 12.--Types of fracture sealing and coating, argillite interval (30.5-416.1 m) UE25a-3.

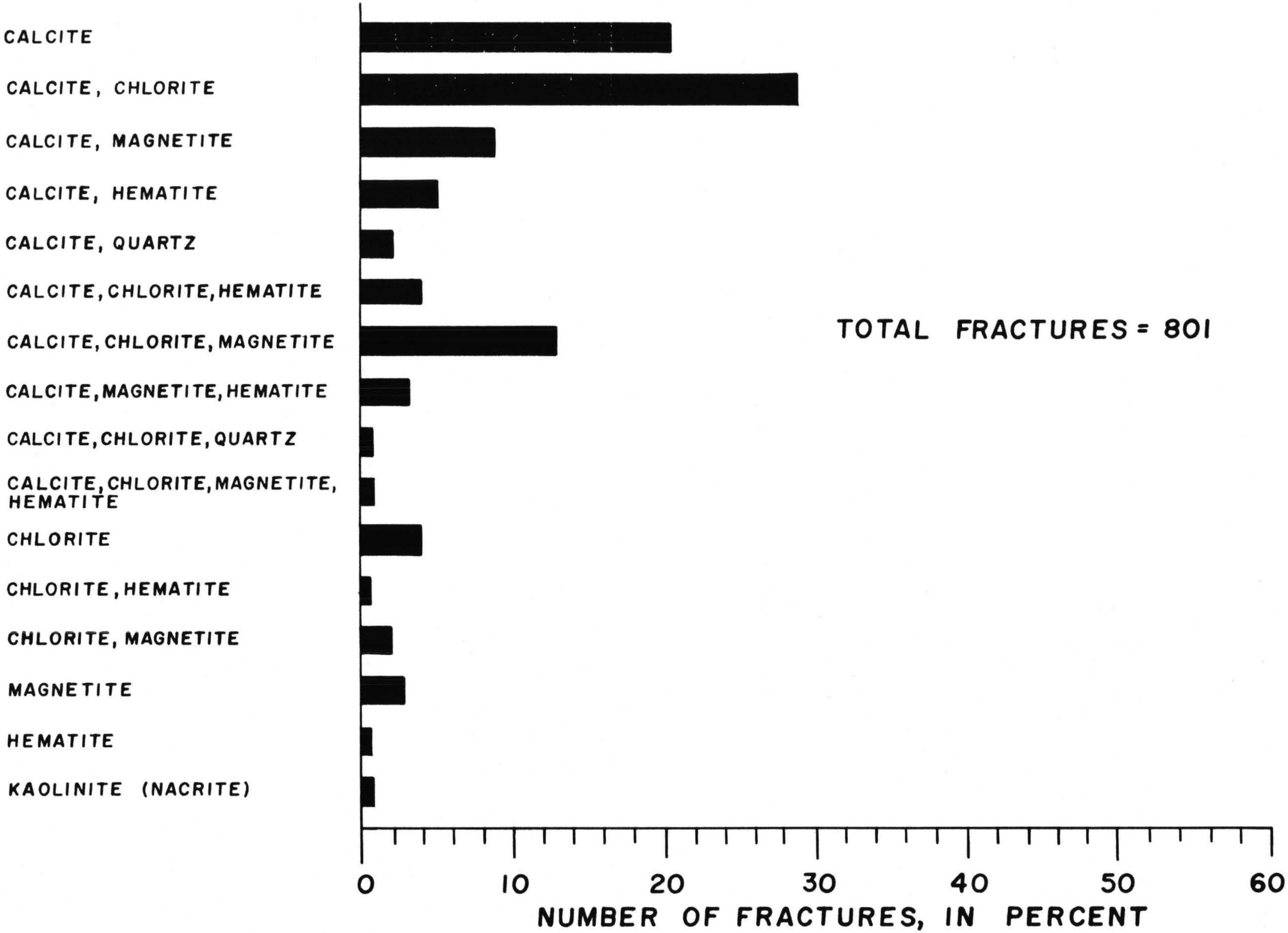

Figure 13.--Types of fracture sealing and coating, altered argillite interval (416.1-676.9 m) UE25a-3.

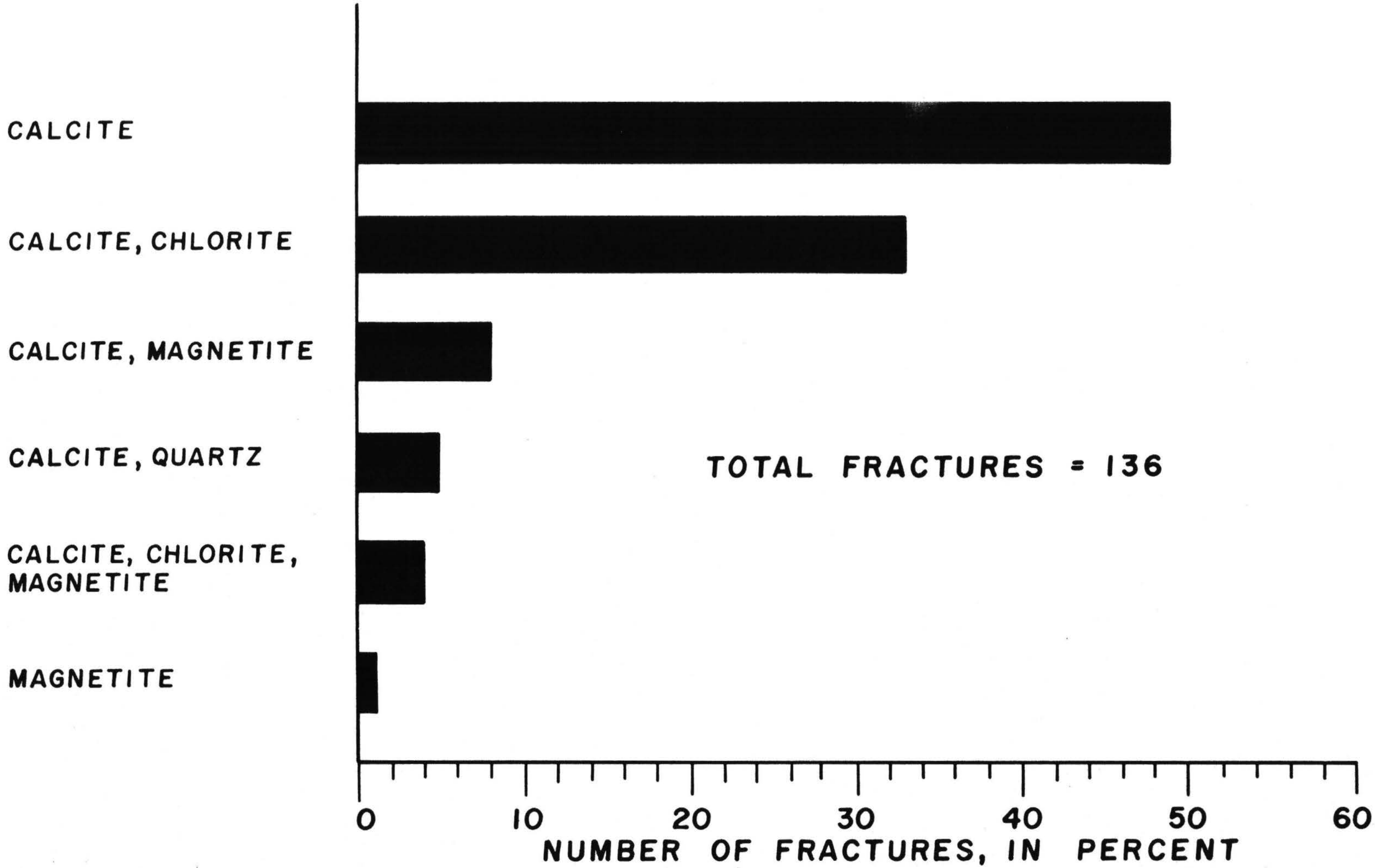

Figure 14.--Types of fracture sealing and coating, calcareous altered argillite interval (676.9-720.6 m) UE25a-3.

(fig. 15), calcite, ferroan dolomite, and a ferruginous (goethite) clay are predominant fracture sealing or coating with lesser amounts of quartz and magnetite.

Material Properties

Material properties that include axial stress at failure, modulus of elasticity, Poisson's ratio, and bulk and shear moduli were measured and calculated (table 4).

Natural-state density and porosity measurements were determined on 20 cores with results shown on table 5. In the argillite interval the densities range from 2.49 to 2.67 g/cm^3, and average 2.59 g/cm^3 with average porosity of 10.88 percent. In the altered argillite interval, the densities range from 2.46 to 2.60 g/cm^3 and average 2.54 g/cm^3 with average porosity of 6.71 percent. The average densities for both the argillites and altered argillites are essentially the same, however the porosity is lower in the altered argillite interval, possibly due to the thermal alteration.

BOREHOLE GEOPHYSICAL LOGS

General Statement

The geophysical logs plotted on plate 1 were run on UE25a-3 by the Birdwell Division of Seismograph Service Corp. to be used for geologic correlations and lithologic characterizations. These logs, which include caliper, density, resistivity, spontaneous potential, velocity, neutron and gamma logs, were digitized on 1.5-m (5-ft) intervals and are tabulated in table 6. Each of the above logs, plus Birdwell's inhole Vibroseis geophone survey and the deviation survey by Sperry Sun, Inc., will be addressed in this report. An experimental "hole to surface" electrical survey and geophysical logs were run by and are available from Jeffrey J. Daniels, U.S. Geological Survey, MS 964, Federal Center, Denver, CO 80225.

At the time of logging, the mud level was at a depth of 641.3 m (2,104 ft), which limited the coverage of logs that require fluid coupling to the formation. The Sperry Sun directional survey was run inside the drill string due to poor hole conditions and to protect the logging tool from hole collapse (fig. 16). The total horizontal displacement between the collar and the bottom of the hole is 42.5 m (139 ft) at N. 46°41' W. Most of the deviation occurs below 457 m (1,500 ft) in the altered argillite and marble intervals.

After Sperry Sun completed their survey, Birdwell logged the hole in three intervals: 771.2-598.5 m (2,530-1,964 ft), 598.5-304.8 m (1,964-1,000 ft), and 304.8-57.9 m (1,000-190 ft). During each interval of logging the drill rods were left just above the interval being logged to minimize the risk of hole collapse. After Birdwell completed their logging, the drill hole was cleaned and left open for the U.S. Geological Survey to log.

Caliper Log

The caliper tool is a 1 5/8-inch (4.13-cm) diameter three-arm device that measures average hole diameter. The tool is calibrated in rings of known diameters before and after logging the hole. The caliper log of the UE25a-3 drill hole shows that the hole is nearly in gage throughout its entire length (pl. 1). Hole enlargements tend to correlate either

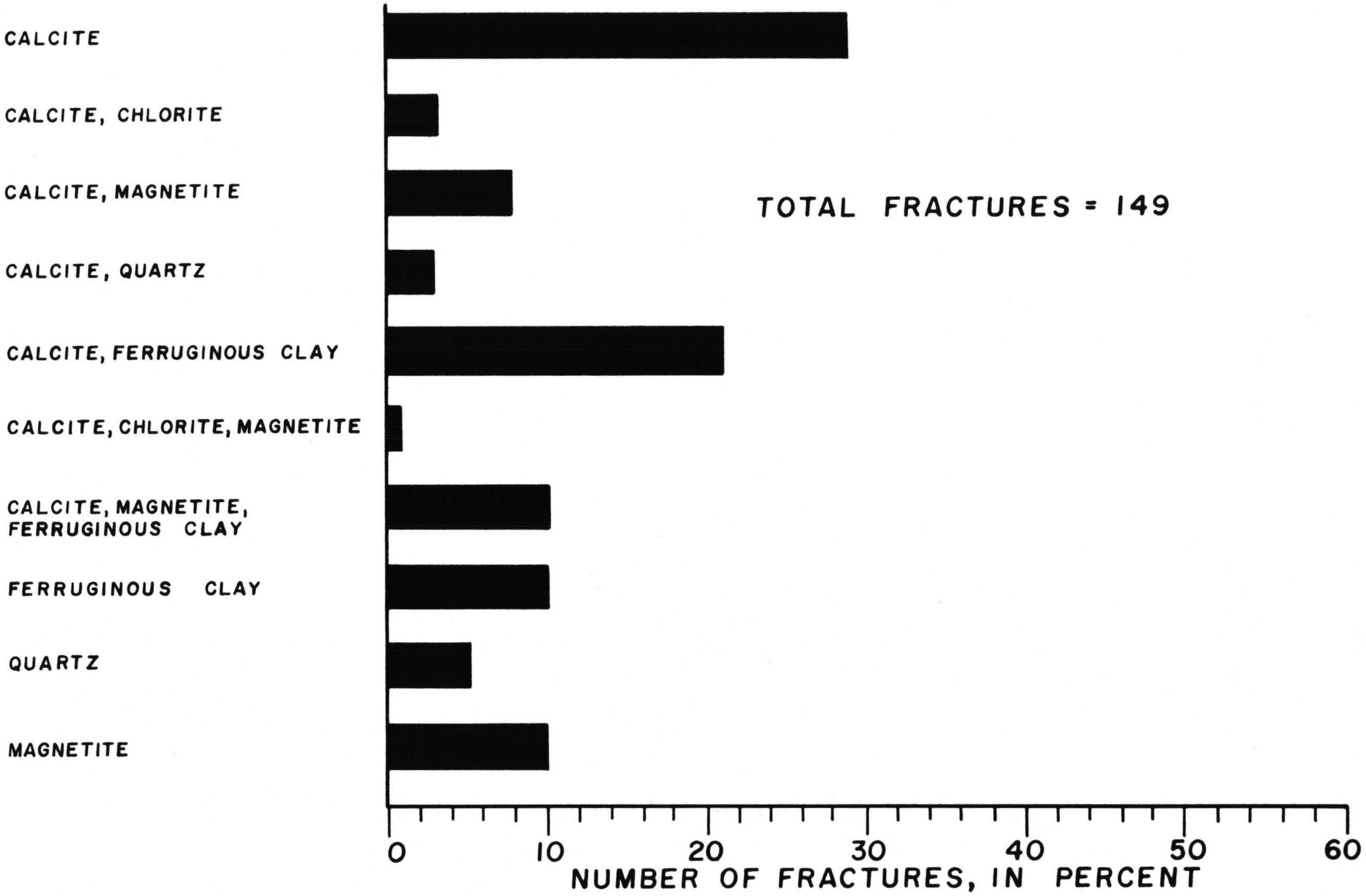

Figure 15.--Types of fracture sealing and coating, marble interval (720.6-771.2 m) UE25a-3.

Table 4.--Material properties determinations of cores from UE25a-3 drill hole

[Measurements by Holmes and Narver, Inc., Mercury, Nevada. Measured at zero confining pressure. Leaders (---) indicate no data]

Lithology number	Depth meters	Depth feet	Axial stress at failure MPa	Modulus of elasticity[1] X10^3 MPa	Poisson's ratio (ν)	Bulk modulus[2] X10^3 MPa	Shear modulus[3] X10^3 MPa	Lithology
2,177	293.2	962	12.55	9.79	0.31	8.63	3.74	Argillite
2,184	398.4	1,307	9.10	4.34	.15	2.08	1.88	Do.
2,185	425.2	1,395	37.50	46.40	.22	27.17	19.10	Altered argillite
2,186	441.9	1,450	15.40	4.36	.22	2.57	1.79	Do.
2,187	466.0	1,529	88.25	42.20	.15	19.93	18.41	Do.
2,188	505.1	1,657	23.99	29.37	.22	17.58	11.99	Do.
2,189	523.3	1,717	19.03	15.93	.22	9.31	6.56	Do.
2,191	591.3	1,940	67.91	43.44	.14	19.86	19.17	Do.
2,192	634.9	2,083	60.05	45.09	.19	23.86	19.03	Metasandstone
2,193	675.1	2,215	23.51	16.48	.13	7.38	7.31	Altered argillite
2,194	700.4	2,298	84.80	46.06	.33	45.99	17.31	Do.

[1]Elastic constants were calculated at 50 percent of failure stress.

[2]Bulk modulus equation $\frac{E}{3(1-2\nu)}$

[3]Shear modulus equation $\frac{E}{2(1+\nu)}$

E=modulus of elasticity

ν=Poisson's ratio

Table 5.--Density measurements and water content of cores from UE25a-3 drill hole

[Measurements and calculations by Holmes and Narver, Inc., Mercury, Nevada]

Laboratory number	Depth meters	Depth feet	Bulk density Natural state (g/cm^3)	Bulk density Dry (g/cm^3)	Grain density (g/cm^3)	Moisture content Natural state basis (percent)	Moisture content Dry basis (percent)	Porosity Calculated (percent)	Porosity Measured (percent)	Saturation (percent)	Lithology
2,175	260.3 260.5	854.0 854.8	2.62	2.58	2.76	1.6	1.7	6.7	6.4	63	Argillite
2,176	266.2 266.4	873.5 874.0	2.61	2.56	2.70	2.0	2.0	5.3	5.0	99	Do.
2,177	293.1 293.3	961.5 962.1	2.64	2.59	2.72	1.9	1.9	4.9	7.1	100	Do.
2,178	324.4 324.6	1,064.4 1,064.9	2.64	2.59	2.77	2.1	2.1	6.4	8.1	86	Do.
2,179	333.9 334.1	1,095.6 1,096.1	2.67	2.57	2.88	3.9	4.0	10.9	13.2	94	Do.
2,180	362.4 362.7	1,189.0 1,189.8	2.52	2.41	2.74	4.7	4.9	12.1	15.1	97	Do.
2,181	370.5 370.7	1,215.5 1,216.2	2.62	2.55	2.79	2.5	2.6	8.3	9.3	79	Do.
2,182	383.7 383.9	1,258.8 1,259.5	2.47	2.34	2.70	5.3	5.6	13.3	17.3	99	Do.
2,183	388.7 388.9	1,275.4 1,276.0	2.50	2.39	2.73	4.3	4.5	12.4	20.9	87	Do.
2,184	398.5 398.7	1,309.4 1,308.1	2.64	2.58	2.78	2.4	2.4	7.3	6.4	85	Do.
2,185	425.0 425.2	1,394.5 1,395.0	2.60	2.56	2.73	1.8	1.8	6.5	3.6	70	Altered argillite
2,186	441.9 442.1	1,450.1 1,450.6	2.46	2.36	2.69	3.9	4.1	12.2	12.5	79	Do.
2,187	466.3 466.5	1,529.7 1,530.4	2.58	2.53	2.71	1.9	2.0	6.7	1.1	74	Do.
2,188	505.0 505.2	1,656.9 1,657.5	2.56	2.52	2.68	1.5	1.6	5.9	3.0	67	Do.
2,189	523.3 523.7	1,717.0 1,718.0	2.56	2.48	2.71	3.1	3.2	8.4	6.5	94	Do.
2,190	552.7 552.8	1,813.2 1,813.7	2.48	2.36	2.69	4.9	5.2	12.4	11.7	98	Do.
2,191	591.4 591.7	1,940.4 1,941.1	2.60	2.52	2.76	2.9	3.0	8.7	5.5	88	Do.
2,192	634.8 634.9	2,082.5 2,083.2	2.54	2.48	2.70	2.0	2.1	8.1	5.8	64	Metasandstone
2,193	675.1 675.4	2,215.0 2,215.7	2.48	2.35	2.73	5.1	5.4	14.0	12.5	91	Altered argillite
2,194	700.5 700.7	2,298.3 2,298.9	2.55	2.51	2.68	1.4	1.4	6.1	4.0	59	Do.

Table 6.--Digitized values of Birdwell logs, UE25a-3

[Conversion factors: meter x 3.28=foot; centimeter x 0.3937=inch; leaders (---) indicate no data]

Depth (m)	Caliper (cm)	Density (Mg/m3)	Resistivity (ohm-meters) 16" normal	Resistivity (ohm-meters) 64" normal	Resistivity (ohm-meters) 18'8" lateral	Velocity (m/s)	Acoustic impedance (10^6 Rayls)	Neutron log (API units)	Gamma-ray log (API units)
.2440e 2	---	---	---	---	---	---	---	---	---
.2590e 2	---	---	---	---	---	---	---	---	---
.2740e 2	---	---	---	---	---	---	---	---	---
.2900e 2	---	---	---	---	---	---	---	---	---
.3050e 2	---	---	---	---	---	---	---	---	---
.3200e 2	---	---	---	---	---	---	---	---	---
.3350e 2	---	---	---	---	---	---	---	---	---
.3510e 2	---	---	---	---	---	---	---	---	---
.3660e 2	---	---	---	---	---	---	---	---	---
.3810e 2	---	---	---	---	---	---	---	---	---
.3960e 2	---	---	---	---	---	---	---	---	---
.4110e 2	---	---	---	---	---	---	---	---	---
.4270e 2	---	---	---	---	---	---	---	---	---
.4420e 2	---	---	---	---	---	---	---	---	---
.4570e 2	---	---	---	---	---	---	---	---	---
.4720e 2	---	---	---	---	---	---	---	---	---
.4880e 2	---	---	---	---	---	---	---	---	---
.5030e 2	---	---	---	---	---	---	---	---	---
.5180e 2	---	---	---	---	---	---	---	---	---
.5330e 2	---	---	---	---	---	---	---	---	---
.5490e 2	---	---	---	---	---	---	---	---	---
.5640e 2	---	---	---	---	---	---	---	---	---
.5790e 2	---	---	---	---	---	---	---	---	---
.5940e 2	---	---	---	---	---	---	---	---	---
.6100e 2	---	---	---	---	---	---	---	.3903e 4	.2039e 3
.6250e 2	---	---	---	---	---	---	---	.3612e 4	.2128e 3
.6400e 2	.9904e 1	.2510e 1	---	---	---	---	---	.2597e 4	.1836e 3
.6550e 2	.1005e 2	.2490e 1	---	---	---	---	---	.2532e 4	.2082e 3
.6710e 2	.9918e 1	.2520e 1	---	---	---	---	---	.3029e 4	.1611e 3
.6860e 2	.9996e 1	.2510e 1	---	---	---	---	---	.2348e 4	.1767e 3
.7010e 2	.9718e 1	.2470e 1	---	---	---	---	---	.2475e 4	.2035e 3
.7160e 2	.1008e 2	.2520e 1	---	---	---	---	---	.3007e 4	.1564e 3
.7320e 2	.1037e 2	.2300e 1	---	---	---	---	---	.2617e 4	.2124e 3
.7470e 2	.1401e 2	---	---	---	---	---	---	.3454e 4	.2034e 3
.7620e 2	.1089e 2	---	---	---	---	---	---	.2624e 4	.2056e 3
.7770e 2	.1132e 2	---	---	---	---	---	---	.2794e 4	.2122e 3
.7920e 2	.1104e 2	---	---	---	---	---	---	.2793e 4	.1930e 3
.8080e 2	.1347e 2	---	---	---	---	---	---	.3361e 4	.2031e 3
.8230e 2	.1049e 2	.2290e 1	---	---	---	---	---	.2590e 4	.1896e 3
.8380e 2	.1078e 2	---	---	---	---	---	---	.2828e 4	.1973e 3
.8530e 2	.1164e 2	---	---	---	---	---	---	.2821e 4	.1985e 3
.8690e 2	.1172e 2	---	---	---	---	---	---	.3105e 4	.1895e 3
.8840e 2	.1244e 2	---	---	---	---	---	---	.3282e 4	.1961e 3
.8990e 2	.1301e 2	---	---	---	---	---	---	.3403e 4	.1904e 3
.9140e 2	.1594e 2	---	---	---	---	---	---	.3658e 4	.2005e 3
.9300e 2	.1338e 2	---	---	---	---	---	---	.3239e 4	.2004e 3
.9450e 2	.1389e 2	---	---	---	---	---	---	.3693e 4	.2071e 3
.9600e 2	.1311e 2	---	---	---	---	---	---	.3693e 4	.1981e 3
.9750e 2	.1447e 2	---	---	---	---	---	---	.3913e 4	.2003e 3
.9910e 2	.1142e 2	---	---	---	---	---	---	.2834e 4	.2002e 3
.1006e 3	.1114e 2	---	---	---	---	---	---	.2500e 4	.1934e 3
.1021e 3	.1058e 2	.2370e 1	---	---	---	---	---	.2379e 4	.1979e 3
.1036e 3	.1229e 2	---	---	---	---	---	---	.2982e 4	.2001e 3
.1052e 3	.1408e 2	---	---	---	---	---	---	.3103e 4	.2045e 3
.1067e 3	.1032e 2	.2420e 1	---	---	---	---	---	.2357e 4	.1955e 3
.1082e 3	.1025e 2	.2440e 1	---	---	---	---	---	.2371e 4	.1999e 3
.1097e 3	.1047e 2	.2450e 1	---	---	---	---	---	.2414e 4	.1998e 3
.1113e 3	.1012e 2	.2460e 1	---	---	---	---	---	.2414e 4	.2110e 3
.1128e 3	.9989e 1	.2460e 1	---	---	---	---	---	.2435e 4	.1885e 3
.1143e 3	.1021e 2	.2470e 1	---	---	---	---	---	.2392e 4	.1952e 3
.1158e 3	.1022e 2	.2480e 1	---	---	---	---	---	.2378e 4	.1862e 3
.1173e 3	.1030e 2	.2470e 1	---	---	---	---	---	.2257e 4	.2040e 3
.1189e 3	.1037e 2	.2440e 1	---	---	---	---	---	.2384e 4	.1973e 3
.1204e 3	.1017e 2	.2480e 1	---	---	---	---	---	.2320e 4	.1905e 3
.1219e 3	.1096e 2	---	---	---	---	---	---	.2611e 4	.1949e 3
.1234e 3	.1025e 2	.2440e 1	---	---	---	---	---	.2348e 4	.1948e 3
.1250e 3	.1076e 2	---	---	---	---	---	---	.2455e 4	.1981e 3
.1265e 3	.1525e 2	---	---	---	---	---	---	.3753e 4	.1970e 3
.1280e 3	.1561e 2	---	---	---	---	---	---	.3611e 4	.1924e 3
.1295e 3	.1028e 2	.2400e 1	---	---	---	---	---	.2461e 4	.1969e 3
.1311e 3	.1029e 2	.2470e 1	---	---	---	---	---	.2298e 4	.1990e 3
.1326e 3	.1015e 2	.2470e 1	---	---	---	---	---	.2390e 4	.1967e 3
.1341e 3	.1009e 2	.2470e 1	---	---	---	---	---	.2383e 4	.1989e 3
.1356e 3	.1074e 2	---	---	---	---	---	---	.2311e 4	.2056e 3
.1372e 3	.1074e 2	---	---	---	---	---	---	.2375e 4	.1921e 3
.1387e 3	.1061e 2	.2440e 1	---	---	---	---	---	.2453e 4	.1898e 3
.1402e 3	.9975e 1	.2490e 1	---	---	---	---	---	.2190e 4	.1987e 3
.1417e 3	.1005e 2	.2470e 1	---	---	---	---	---	.2289e 4	.1987e 3
.1433e 3	.1013e 2	.2500e 1	---	---	---	---	---	.2268e 4	.1986e 3
.1448e 3	.1092e 2	---	---	---	---	---	---	.2523e 4	.2165e 3
.1463e 3	.1007e 2	.2500e 1	---	---	---	---	---	.2323e 4	.2075e 3
.1478e 3	.1022e 2	.2470e 1	---	---	---	---	---	.2343e 4	.2037e 3
.1494e 3	.9886e 1	.2490e 1	---	---	---	---	---	.2541e 4	.2052e 3
.1509e 3	.9959e 1	.2530e 1	---	---	---	---	---	.2292e 4	.2023e 3
.1524e 3	.9818e 1	.2500e 1	---	---	---	---	---	.2249e 4	.2106e 3
.1539e 3	.1010e 2	.2480e 1	---	---	---	---	---	.2334e 4	.2009e 3
.1554e 3	.1032e 2	.2440e 1	---	---	---	---	---	.2354e 4	.1891e 3
.1570e 3	.1046e 2	.2340e 1	---	---	---	---	---	.2588e 4	.1884e 3
.1585e 3	.1132e 2	---	---	---	---	---	---	.2332e 4	.2033e 3
.1600e 3	.9969e 1	.2510e 1	---	---	---	---	---	.2161e 4	.2005e 3
.1615e 3	.9971e 1	.2520e 1	---	---	---	---	---	.2132e 4	.2022e 3
.1631e 3	.1026e 2	.2430e 1	---	---	---	---	---	.2393e 4	.1980e 3
.1646e 3	.1211e 2	---	---	---	---	---	---	.3138e 4	.2031e 3

Table 6.--Digitized values of Birdwell logs, UE25a-3--Continued

[Conversion factors: meter x 3.28=foot; centimeter x 0.3937=inch; leaders (---) indicate no data]

Depth (m)	Caliper (cm)	Density (Mg/m^3)	Resistivity (ohm-meters) 16" normal	Resistivity (ohm-meters) 64" normal	Resistivity (ohm-meters) 18'8" lateral	Velocity (m/s)	Acoustic impedance (10^6 Rayls)	Neutron log (API units)	Gamma-ray log (API units)
.1661e 3	.1012e 2	.2470e 1	---	---	---	---	---	.2243e 4	.1955e 3
.1676e 3	.9978e 1	.2510e 1	---	---	---	---	---	.2682e 4	.1926e 3
.1692e 3	.9909e 1	.2530e 1	---	---	---	---	---	.2029e 4	.1953e 3
.1707e 3	.9932e 1	.2540e 1	---	---	---	---	---	.2206e 4	.2070e 3
.1722e 3	.9984e 1	.2540e 1	---	---	---	---	---	.2155e 4	.2019e 3
.1737e 3	.9914e 1	.2540e 1	---	---	---	---	---	.2162e 4	.2057e 3
.1753e 3	.9916e 1	.2530e 1	---	---	---	---	---	.2140e 4	.2005e 3
.1768e 3	.1006e 2	.2540e 1	---	---	---	---	---	.2167e 4	.2066e 3
.1783e 3	.1006e 2	.2540e 1	---	---	---	---	---	.2075e 4	.1992e 3
.1798e 3	.9921e 1	.2530e 1	---	---	---	---	---	.2190e 4	.1963e 3
.1814e 3	.9923e 1	.2520e 1	---	---	---	---	---	.2165e 4	.2001e 3
.1829e 3	.9854e 1	.2520e 1	---	---	---	---	---	.2179e 4	.2016e 3
.1844e 3	.1007e 2	.2530e 1	---	---	---	---	---	.2235e 4	.1988e 3
.1859e 3	.1007e 2	.2500e 1	---	---	---	---	---	.2767e 4	.1680e 3
.1875e 3	.9930e 1	.2540e 1	---	---	---	---	---	.2652e 4	.1481e 3
.1890e 3	.9932e 1	.2540e 1	---	---	---	---	---	.2247e 4	.1945e 3
.1905e 3	.1001e 2	.2500e 1	---	---	---	---	---	.2424e 4	.1937e 3
.1920e 3	.1001e 2	.2520e 1	---	---	---	---	---	.2274e 4	.2088e 3
.1935e 3	.1001e 2	.2550e 1	---	---	---	---	---	.3650e 4	.8718e 2
.1951e 3	.1001e 2	.2530e 1	---	---	---	---	---	.2521e 4	.1717e 3
.1966e 3	.1001e 2	.2530e 1	---	---	---	---	---	.2223e 4	.2315e 3
.1981e 3	.1001e 2	.2530e 1	---	---	---	---	---	.2208e 4	.2061e 3
.1996e 3	.1002e 2	.2510e 1	---	---	---	---	---	.2079e 4	.2166e 3
.2012e 3	.1002e 2	.2480e 1	---	---	---	---	---	.2128e 4	.1958e 3
.2027e 3	.1030e 2	.2500e 1	---	---	---	---	---	.2454e 4	.1750e 3
.2042e 3	.1023e 2	.2510e 1	---	---	---	---	---	.2361e 4	.1945e 3
.2057e 3	.1024e 2	.2520e 1	---	---	---	---	---	.2133e 4	.2229e 3
.2073e 3	.1102e 2	---	---	---	---	---	---	.2615e 4	.2043e 3
.2088e 3	.1017e 2	.2540e 1	---	---	---	---	---	.2004e 4	.2215e 3
.2103e 3	.1017e 2	.2530e 1	---	---	---	---	---	.1996e 4	.2164e 3
.2118e 3	.1024e 2	.2510e 1	---	---	---	---	---	.2038e 4	.2247e 3
.2134e 3	.1067e 2	---	---	---	---	---	---	.2079e 4	.2049e 3
.2149e 3	.1018e 2	.2520e 1	---	---	---	---	---	.2120e 4	.2049e 3
.2164e 3	.1018e 2	.2510e 1	---	---	---	---	---	.1998e 4	.2205e 3
.2179e 3	.1018e 2	.2530e 1	---	---	---	---	---	.2153e 4	.2136e 3
.2195e 3	.1025e 2	.2540e 1	---	---	---	---	---	.2109e 4	.2001e 3
.2210e 3	.1011e 2	.2540e 1	---	---	---	---	---	.1952e 4	.2067e 3
.2225e 3	.1011e 2	.2520e 1	---	---	---	---	---	.1894e 4	.2043e 3
.2240e 3	.1026e 2	.2490e 1	---	---	---	---	---	.1929e 4	.2042e 3
.2256e 3	.1005e 2	.2530e 1	---	---	---	---	---	.2019e 4	.1996e 3
.2271e 3	.1005e 2	.2530e 1	---	---	---	---	---	.1926e 4	.1973e 3
.2286e 3	.1012e 2	.2520e 1	---	---	---	---	---	.1939e 4	.1927e 3
.2301e 3	.1012e 2	.2540e 1	---	---	---	---	---	.1796e 4	.2038e 3
.2316e 3	.1012e 2	.2550e 1	---	---	---	---	---	.1745e 4	.2059e 3
.2332e 3	.1020e 2	.2540e 1	---	---	---	---	---	.1802e 4	.1968e 3
.2347e 3	.1001e 2	.2540e 1	---	---	---	---	---	.1948e 4	.2012e 3
.2362e 3	.1013e 2	.2520e 1	---	---	---	---	---	.1961e 4	.2033e 3
.2377e 3	.1004e 2	.2530e 1	---	---	---	---	---	.1819e 4	.2090e 3
.2393e 3	.1002e 2	.2500e 1	---	---	---	---	---	.1816e 4	.2120e 3
.2408e 3	.1028e 2	.2520e 1	---	---	---	---	---	.1908e 4	.2075e 3
.2423e 3	.9837e 1	.2540e 1	---	---	---	---	---	.1786e 4	.2029e 3
.2438e 3	.9960e 1	.2530e 1	---	---	---	---	---	.1799e 4	.2072e 3
.2454e 3	.1001e 2	.2530e 1	---	---	---	---	---	.2003e 4	.2026e 3
.2469e 3	.1006e 2	.2500e 1	---	---	---	---	---	.1952e 4	.1936e 3
.2484e 3	.9972e 1	.2520e 1	---	---	---	---	---	.2022e 4	.2024e 3
.2499e 3	.9953e 1	.2540e 1	---	---	---	---	---	.1964e 4	.1978e 3
.2515e 3	.1001e 2	.2530e 1	---	---	---	---	---	.1934e 4	.2022e 3
.2530e 3	.1020e 2	.2460e 1	---	---	---	---	---	.1997e 4	.1886e 3
.2545e 3	.1110e 2	---	---	---	---	---	---	.2230e 4	.1975e 3
.2560e 3	.1059e 2	.2470e 1	---	---	---	---	---	.2108e 4	.2175e 3
.2576e 3	.1021e 2	.2510e 1	---	---	---	---	---	.1958e 4	.2152e 3
.2591e 3	.1005e 2	.2500e 1	---	---	---	---	---	.2020e 4	.2128e 3
.2606e 3	.1017e 2	.2510e 1	---	---	---	---	---	.2033e 4	.2262e 3
.2621e 3	.1001e 2	.2530e 1	---	---	---	---	---	.2110e 4	.2261e 3
.2637e 3	.1006e 2	.2540e 1	---	---	---	---	---	.2151e 4	.2192e 3
.2652e 3	.1004e 2	.2530e 1	---	---	---	---	---	.2079e 4	.2214e 3
.2667e 3	.1002e 2	.2530e 1	---	---	---	---	---	.2064e 4	.2079e 3
.2682e 3	.1001e 2	.2510e 1	---	---	---	---	---	.2027e 4	.2189e 3
.2697e 3	.9910e 1	.2530e 1	---	---	---	---	---	.1941e 4	.2076e 3
.2713e 3	.9964e 1	.2510e 1	---	---	---	---	---	.2010e 4	.2074e 3
.2728e 3	.1009e 2	.2510e 1	---	---	---	---	---	.2073e 4	.2073e 3
.2743e 3	.1007e 2	.2500e 1	---	---	---	---	---	.1979e 4	.2072e 3
.2758e 3	.9906e 1	.2520e 1	---	---	---	---	---	.1978e 4	.2116e 3
.2774e 3	.9958e 1	.2520e 1	---	---	---	---	---	.1977e 4	.2115e 3
.2789e 3	.1008e 2	.2490e 1	---	---	---	---	---	.2004e 4	.2069e 3
.2804e 3	.9988e 1	.2470e 1	---	---	---	---	---	.2159e 4	.2113e 3
.2819e 3	.1004e 2	.2510e 1	---	---	---	---	---	.1987e 4	.2156e 3
.2835e 3	.1009e 2	.2480e 1	---	---	---	---	---	.1993e 4	.2043e 3
.2850e 3	.1007e 2	.2520e 1	---	---	---	---	---	.2262e 4	.2064e 3
.2865e 3	.1012e 2	.2510e 1	---	---	---	---	---	.2076e 4	.2220e 3
.2880e 3	.1018e 2	.2480e 1	---	---	---	---	---	.2025e 4	.2062e 3
.2896e 3	.1001e 2	.2510e 1	---	---	---	---	---	.1868e 4	.2195e 3
.2911e 3	.1014e 2	.2500e 1	---	---	---	---	---	.2058e 4	.2037e 3
.2926e 3	.1005e 2	.2520e 1	---	---	---	---	---	.2014e 4	.2148e 3
.2941e 3	.1010e 2	.2520e 1	---	---	---	---	---	.2041e 4	.2103e 3
.2957e 3	.1001e 2	.2520e 1	---	---	---	---	---	.2061e 4	.2169e 3
.2972e 3	.9985e 1	.2430e 1	---	---	---	---	---	.2145e 4	.2190e 3
.2987e 3	.1701e 2	---	---	---	---	---	---	.3024e 4	.2099e 3

Table 6.--Digitized values of Birdwell logs, UE25a-3--Continued

[Conversion factors: meter x 3.28=foot; centimeter x 0.3937=inch; leaders (---) indicate no data]

Depth (m)	Caliper (cm)	Density (Mg/m^3)	Resistivity (ohm-meters) 16" normal	64" normal	18'8" lateral	Velocity (m/s)	Acoustic impedance (10^6 Rayls)	Neutron log (API units)	Gamma-ray log (API units)
.3002e 3	.1016e 2	.2430e 1	---	---	---	---	---	.2187e 4	.2054e 3
.3018e 3	.9857e 1	.2510e 1	---	---	---	---	---	.2123e 4	.2278e 3
.3033e 3	.9979e 1	.2500e 1	---	---	---	---	---	.2003e 4	.2233e 3
.3048e 3	.9534e 1	.2540e 1	---	---	---	---	---	.2278e 4	.1927e 3
.3063e 3	.1096e 2	---	---	---	---	---	---	.2414e 4	.1993e 3
.3078e 3	.9612e 1	.2540e 1	---	---	---	---	---	.2272e 4	.1937e 3
.3094e 3	.1033e 2	.2500e 1	---	---	---	---	---	.2707e 4	.1937e 3
.3109e 3	.9690e 1	.2530e 1	---	---	---	---	---	.2573e 4	.2038e 3
.3124e 3	.9765e 1	.2490e 1	---	---	---	---	---	.2281e 4	.1869e 3
.3139e 3	.9769e 1	.2480e 1	---	---	---	---	---	.2267e 4	.1880e 3
.3155e 3	.9559e 1	.2530e 1	---	---	---	---	---	.2222e 4	.1969e 3
.3170e 3	.9420e 1	.2540e 1	---	---	---	---	---	.2313e 4	.1902e 3
.3185e 3	.1063e 2	.2430e 1	---	---	---	---	---	.2643e 4	.1924e 3
.3200e 3	.9640e 1	.2510e 1	---	---	---	---	---	.2194e 4	.1924e 3
.3216e 3	.9502e 1	.2520e 1	---	---	---	---	---	.2112e 4	.2002e 3
.3231e 3	.9577e 1	.2530e 1	---	---	---	---	---	.2090e 4	.1968e 3
.3246e 3	.9580e 1	.2540e 1	---	---	---	---	---	.2136e 4	.2069e 3
.3261e 3	.9655e 1	.2520e 1	---	---	---	---	---	.2196e 4	.2001e 3
.3277e 3	.9729e 1	.2500e 1	---	---	---	---	---	.2234e 4	.1866e 3
.3292e 3	.9662e 1	.2490e 1	---	---	---	---	---	.2183e 4	.2034e 3
.3307e 3	.9594e 1	.2490e 1	---	---	---	---	---	.2146e 4	.1922e 3
.3322e 3	.9811e 1	.2480e 1	---	---	---	---	---	.2236e 4	.2045e 3
.3338e 3	.1053e 2	.2390e 1	---	---	---	---	---	.2417e 4	.1854e 3
.3353e 3	.9676e 1	.2510e 1	---	---	---	---	---	.2230e 4	.1955e 3
.3368e 3	.9822e 1	.2480e 1	---	---	---	---	---	.2200e 4	.1954e 3
.3383e 3	.9612e 1	.2510e 1	---	---	---	---	---	.2156e 4	.1977e 3
.3399e 3	.9971e 1	.2520e 1	---	---	---	---	---	.2134e 4	.1965e 3
.3414e 3	.9975e 1	.2470e 1	---	---	---	---	---	.2307e 4	.1965e 3
.3429e 3	.9694e 1	.2530e 1	---	---	---	---	---	.2292e 4	.1830e 3
.3444e 3	.9697e 1	.2560e 1	---	---	---	---	---	.2360e 4	.1718e 3
.3459e 3	.9914e 1	.2520e 1	---	---	---	---	---	.2369e 4	.1942e 3
.3475e 3	.9847e 1	.2540e 1	---	---	---	---	---	.2159e 4	.1941e 3
.3490e 3	.9779e 1	.2520e 1	---	---	---	---	---	.2167e 4	.1862e 3
.3505e 3	.9711e 1	.2540e 1	---	---	---	---	---	.2265e 4	.1952e 3
.3520e 3	.9999e 1	.2480e 1	---	---	---	---	---	.2536e 4	.1761e 3
.3536e 3	.1136e 2	---	---	---	---	---	---	.2754e 4	.1839e 3
.3551e 3	.1015e 2	.2330e 1	---	---	---	---	---	.2612e 4	.1761e 3
.3566e 3	.9797e 1	.2450e 1	---	---	---	---	---	.2432e 4	.1940e 3
.3581e 3	.9729e 1	.2560e 1	---	---	---	---	---	.2321e 4	.1794e 3
.3597e 3	.9733e 1	.2560e 1	---	---	---	---	---	.2389e 4	.1726e 3
.3612e 3	.9808e 1	.2470e 1	---	---	---	---	---	.2209e 4	.1983e 3
.3627e 3	.9811e 1	.2510e 1	---	---	---	---	---	.2307e 4	.1770e 3
.3642e 3	.9815e 1	.2530e 1	---	---	---	---	---	.2120e 4	.1972e 3
.3658e 3	.9818e 1	.2510e 1	---	---	---	---	---	.2151e 4	.2027e 3
.3673e 3	.9822e 1	.2510e 1	---	---	---	---	---	.2242e 4	.2094e 3
.3698e 3	.9896e 1	.2510e 1	---	---	---	---	---	.2205e 4	.1903e 3
.3703e 3	.1011e 2	.2500e 1	---	---	---	---	---	.2193e 4	.2083e 3
.3719e 3	.9832e 1	.2500e 1	---	---	---	---	---	.2116e 4	.1936e 3
.3734e 3	.9836e 1	.2530e 1	---	---	---	---	---	.2011e 4	.1970e 3
.3749e 3	.9840e 1	.2510e 1	---	---	---	---	---	.2162e 4	.2015e 3
.3764e 3	.9914e 1	.2460e 1	---	---	---	---	---	.2305e 4	.1979e 3
.3780e 3	.9939e 1	.2550e 1	---	---	---	---	---	.2051e 4	.2002e 3
.3795e 3	.9993e 1	.2470e 1	---	---	---	---	---	.1929e 4	.1924e 3
.3810e 3	.9783e 1	.2560e 1	---	---	---	---	---	.1879e 4	.2002e 3
.3825e 3	.9715e 1	.2510e 1	---	---	---	---	---	.1895e 4	.1957e 3
.3840e 3	.9932e 1	.2450e 1	---	---	---	---	---	.1990e 4	.1979e 3
.3856e 3	.1079e 2	---	---	---	---	---	---	.2263e 4	.1899e 3
.3871e 3	.1001e 2	.2520e 1	---	---	---	---	---	.2279e 4	.1732e 3
.3886e 3	.1122e 2	---	---	---	---	---	---	.2737e 4	.1967e 3
.3901e 3	.9605e 1	.2570e 1	---	---	---	---	---	.1868e 4	.1826e 3
.3917e 3	.1003e 2	.2560e 1	---	---	---	---	---	.2033e 4	.1792e 3
.3932e 3	.9961e 1	.2580e 1	---	---	---	---	---	.1980e 4	.1803e 3
.3947e 3	.9961e 1	.2570e 1	---	---	---	---	---	.1792e 4	.1826e 3
.3962e 3	.1003e 2	.2580e 1	---	---	---	---	---	.1866e 4	.1770e 3
.3978e 3	.9889e 1	.2570e 1	---	---	---	---	---	.1881e 4	.1792e 3
.3993e 3	.9889e 1	.2560e 1	---	---	---	---	---	.1925e 4	.1703e 3
.4008e 3	.1003e 2	.2570e 1	---	---	---	---	---	.1737e 4	.1826e 3
.4023e 3	.1010e 2	.2530e 1	---	---	---	---	---	.2591e 4	.2140e 3
.4039e 3	.1060e 2	.2440e 1	---	---	---	---	---	.3400e 4	.1557e 3
.4054e 3	.1003e 2	.2510e 1	---	---	---	---	---	.4419e 4	.8179e 2
.4069e 3	.1003e 2	.2550e 1	---	---	---	---	---	.3691e 4	.1960e 3
.4084e 3	.1010e 2	.2540e 1	---	---	---	---	---	.3596e 4	.2330e 3
.4100e 3	.9961e 1	.2530e 1	---	---	---	---	---	.4292e 4	.2420e 3
.4115e 3	.1003e 2	.2530e 1	---	---	---	---	---	.3832e 4	.1781e 3
.4130e 3	.9961e 1	.2510e 1	---	---	---	---	---	.3607e 4	.2039e 3
.4145e 3	.1160e 2	---	---	---	---	---	---	.3614e 4	.1815e 3
.4161e 3	.9889e 1	.2540e 1	---	---	---	---	---	.4063e 4	.2072e 3
.4176e 3	.9961e 1	.2530e 1	---	---	---	---	---	.3980e 4	.1747e 3
.4191e 3	.9889e 1	.2510e 1	---	---	---	---	---	.3679e 4	.2330e 3
.4206e 3	.9889e 1	.2620e 1	---	---	---	---	---	.2967e 4	.1333e 3
.4221e 3	.9818e 1	.2610e 1	---	---	---	---	---	.2171e 4	.9299e 2
.4237e 3	.9818e 1	.2570e 1	---	---	---	---	---	.3977e 4	.1971e 3
.4252e 3	.9818e 1	.2570e 1	---	---	---	---	---	.4277e 4	.2296e 3
.4267e 3	.9889e 1	.2570e 1	---	---	---	---	---	.3474e 4	.1557e 3
.4282e 3	.1010e 2	.2530e 1	---	---	---	---	---	.3938e 4	.1848e 3
.4298e 3	.9747e 1	.2520e 1	---	---	---	---	---	.4065e 4	.1792e 3
.4313e 3	.9818e 1	.2620e 1	---	---	---	---	---	.2520e 4	.8963e 2
.4328e 3	.9889e 1	.2580e 1	---	---	---	---	---	.4581e 4	.1490e 3

Table 6.--Digitized values of Birdwell logs, UE25a-3--Continued

[Conversion factors: meter x 3.28=foot; centimeter x 0.3937=inch; leaders (---) indicate no data]

Depth (m)	Caliper (cm)	Density (Mg/m^3)	Resistivity (ohm-meters) 16" normal	Resistivity (ohm-meters) 64" normal	Resistivity (ohm-meters) 18'8" lateral	Velocity (m/s)	Acoustic impedance (10^6 Rayls)	Neutron log (API units)	Gamma-ray log (API units)
.4343e 3	.9889e 1	.2560e 1	---	---	---	---	---	.3936e 4	.1882e 3
.4359e 3	.9889e 1	.2540e 1	---	---	---	---	---	.4378e 4	.2453e 3
.4374e 3	.9818e 1	.2510e 1	---	---	---	---	---	.4535e 4	.2375e 3
.4389e 3	.9818e 1	.2580e 1	---	---	---	---	---	.4504e 4	.2464e 3
.4404e 3	.9747e 1	.2570e 1	---	---	---	---	---	.4301e 4	.2285e 3
.4420e 3	.9676e 1	.2540e 1	---	---	---	---	---	.4443e 4	.3081e 3
.4435e 3	.9818e 1	.2570e 1	---	---	---	---	---	.4023e 4	.1960e 3
.4450e 3	.9889e 1	.2550e 1	---	---	---	---	---	.4269e 4	.2655e 3
.4465e 3	.9747e 1	.2570e 1	---	---	---	---	---	.4081e 4	.1501e 3
.4481e 3	.9818e 1	.2570e 1	---	---	---	---	---	.3924e 4	.2162e 3
.4496e 3	.9818e 1	.2550e 1	---	---	---	---	---	.4523e 4	.2745e 3
.4511e 3	.1046e 2	.2420e 1	---	---	---	---	---	.4709e 4	.2028e 3
.4526e 3	.9818e 1	.2510e 1	---	---	---	---	---	.4304e 4	.2285e 3
.4542e 3	.9818e 1	.2580e 1	---	---	---	---	---	.3719e 4	.2084e 3
.4557e 3	.9747e 1	.2560e 1	---	---	---	---	---	.4056e 4	.1826e 3
.4572e 3	.1003e 2	.2590e 1	---	---	---	---	---	.4250e 4	.2352e 3
.4587e 3	.1010e 2	.2540e 1	---	---	---	---	---	.4534e 4	.1355e 3
.4602e 3	.9961e 1	.2570e 1	---	---	---	---	---	.4106e 4	.2050e 3
.4618e 3	.1017e 2	.2570e 1	---	---	---	---	---	.4098e 4	.1848e 3
.4633e 3	.9961e 1	.2590e 1	---	---	---	---	---	.3903e 4	.1602e 3
.4648e 3	.1003e 2	.2590e 1	---	---	---	---	---	.4315e 4	.1501e 3
.4663e 3	.1025e 2	.2590e 1	---	---	---	---	---	.4119e 4	.1983e 3
.4679e 3	.1032e 2	.2510e 1	---	---	---	---	---	.3964e 4	.1624e 3
.4694e 3	.1103e 2	---	---	---	---	---	---	.4350e 4	.1298e 3
.4709e 3	.1010e 2	.2570e 1	---	---	---	---	---	.3990e 4	.1568e 3
.4724e 3	.1010e 2	.2590e 1	---	---	---	---	---	.4229e 4	.2151e 3
.4740e 3	.1003e 2	.2590e 1	---	---	---	---	---	.4574e 4	.1602e 3
.4755e 3	.9918e 1	.2590e 1	---	---	---	---	---	.4153e 4	.1702e 3
.4770e 3	.1035e 2	.2570e 1	---	---	---	---	---	.4545e 4	.1432e 3
.4785e 3	.1014e 2	.2520e 1	---	---	---	---	---	.4612e 4	.1196e 3
.4801e 3	.9721e 1	.2570e 1	---	---	---	---	---	.4747e 4	.1508e 3
.4816e 3	.9867e 1	.2610e 1	---	---	---	---	---	.4889e 4	.1204e 3
.4831e 3	.9802e 1	.2590e 1	---	---	---	---	---	.4603e 4	.7772e 2
.4846e 3	.9808e 1	.2570e 1	---	---	---	---	---	.4393e 4	.8880e 2
.4862e 3	.9741e 1	.2530e 1	---	---	---	---	---	.4685e 4	.7746e 2
.4877e 3	.9747e 1	.2540e 1	---	---	---	---	---	.4827e 4	.9636e 2
.4892e 3	.9895e 1	.2580e 1	---	---	---	---	---	.4722e 4	.1599e 3
.4907e 3	.9901e 1	.2590e 1	---	---	---	---	---	.4587e 4	.1453e 3
.4923e 3	.9977e 1	.2580e 1	---	---	---	---	---	.4391e 4	.1441e 3
.4938e 3	.9911e 1	.2580e 1	---	---	---	---	---	.4159e 4	.1663e 3
.4953e 3	.9844e 1	.2590e 1	---	---	---	---	---	.4316e 4	.1483e 3
.4968e 3	.9921e 1	.2590e 1	---	---	---	---	---	.4188e 4	.1437e 3
.4983e 3	.9785e 1	.2550e 1	---	---	---	---	---	.2523e 4	.1065e 3
.4999e 3	.9861e 1	.2570e 1	---	---	---	---	---	.4802e 4	.1322e 3
.5014e 3	.9866e 1	.2570e 1	---	---	---	---	---	.4899e 4	.1376e 3
.5029e 3	.9659e 1	.2560e 1	---	---	---	---	---	.4898e 4	.1353e 3
.5044e 3	.9735e 1	.2570e 1	---	---	---	---	---	.4658e 4	.1320e 3
.5060e 3	.9669e 1	.2580e 1	---	---	---	---	---	.4493e 4	.1417e 3
.5075e 3	.9604e 1	.2550e 1	---	---	---	---	---	.4635e 4	.1304e 3
.5090e 3	.9538e 1	.2550e 1	---	---	---	---	---	.4522e 4	.1302e 3
.5105e 3	.9543e 1	.2560e 1	---	---	---	---	---	.4724e 4	.1133e 3
.5121e 3	.9619e 1	.2560e 1	---	---	---	---	---	.4814e 4	.1142e 3
.5136e 3	.9554e 1	.2560e 1	---	---	---	---	---	.4633e 4	.1219e 3
.5151e 3	.9559e 1	.2590e 1	---	---	---	---	---	.4843e 4	.1364e 3
.5166e 3	.9920e 1	.2580e 1	---	---	---	---	---	.4250e 4	.1519e 3
.5182e 3	.1270e 2	---	---	---	---	---	---	.4722e 4	.1518e 3
.5197e 3	.9717e 1	.2580e 1	---	---	---	---	---	.4602e 4	.1729e 3
.5212e 3	.9509e 1	.2590e 1	---	---	---	---	---	.3170e 4	.1313e 3
.5227e 3	.9657e 1	.2600e 1	---	---	---	---	---	.4654e 4	.1536e 3
.5243e 3	.9661e 1	.2570e 1	---	---	---	---	---	.4706e 4	.1333e 3
.5258e 3	.9738e 1	.2550e 1	---	---	---	---	---	.4638e 4	.1130e 3
.5273e 3	.9815e 1	.2570e 1	---	---	---	---	---	.4383e 4	.1252e 3
.5288e 3	.9678e 1	.2560e 1	---	---	---	---	---	.4525e 4	.1553e 3
.5304e 3	.9825e 1	.2560e 1	---	---	---	---	---	.4629e 4	.1182e 3
.5319e 3	.9689e 1	.2560e 1	---	---	---	---	---	.4576e 4	.1359e 3
.5334e 3	.9694e 1	.2600e 1	---	---	---	---	---	.4186e 4	.1526e 3
.5349e 3	.9771e 1	.2580e 1	---	---	---	---	---	.4373e 4	.1379e 3
.5364e 3	.9847e 1	.2570e 1	---	---	---	---	---	.4658e 4	.1478e 3
.5380e 3	.9781e 1	.2560e 1	---	---	---	---	---	.4732e 4	.1242e 3
.5395e 3	.9786e 1	.2540e 1	---	---	---	---	---	.4680e 4	.1285e 3
.5410e 3	.9792e 1	.2540e 1	---	---	---	---	---	.4619e 4	.1239e 3
.5425e 3	.9797e 1	.2560e 1	---	---	---	---	---	.4566e 4	.1170e 3
.5441e 3	.9660e 1	.2560e 1	---	---	---	---	---	.4678e 4	.1135e 3
.5456e 3	.9879e 1	.2550e 1	---	---	---	---	---	.4333e 4	.1224e 3
.5471e 3	.9813e 1	.2560e 1	---	---	---	---	---	.4415e 4	.1368e 3
.5486e 3	.9747e 1	.2560e 1	---	---	---	---	---	.4467e 4	.1355e 3
.5502e 3	.9824e 1	.2550e 1	---	---	---	---	---	.4280e 4	.1399e 3
.5517e 3	.9758e 1	.2540e 1	---	---	---	---	---	.4137e 4	.1229e 3
.5532e 3	.9764e 1	.2570e 1	---	---	---	---	---	.4339e 4	.1295e 3
.5547e 3	.9769e 1	.2540e 1	---	---	---	---	---	.4286e 4	.1451e 3
.5563e 3	.9846e 1	.2560e 1	---	---	---	---	---	.4301e 4	.1438e 3
.5578e 3	.9851e 1	.2550e 1	---	---	---	---	---	.4458e 4	.1548e 3
.5593e 3	.9785e 1	.2560e 1	---	---	---	---	---	.4547e 4	.1591e 3
.5608e 3	.9619e 1	.2580e 1	---	---	---	---	---	.4375e 4	.1555e 3
.5624e 3	.9612e 1	.2560e 1	---	---	---	---	---	.4509e 4	.1543e 3
.5639e 3	.9605e 1	.2540e 1	---	---	---	---	---	.4494e 4	.1442e 3
.5654e 3	.9313e 1	.2510e 1	---	---	---	---	---	.4763e 4	.1296e 3
.5669e 3	.9236e 1	.2560e 1	---	---	---	---	---	.4365e 4	.1498e 3

Table 6.—Digitized values of Birdwell logs, UE25a-3—Continued

[Conversion factors: meter x 3.28=foot; centimeter x 0.3937=inch; leaders (---) indicate no data]

Depth (m)	Caliper (cm)	Density (Mg/m³)	Resistivity (ohm-meters) 16" normal	Resistivity (ohm-meters) 64" normal	Resistivity (ohm-meters) 18'8" lateral	Velocity (m/s)	Acoustic impedance (10⁶ Rayls)	Neutron log (API units)	Gamma-ray log (API units)
.5685e 3	.9512e 1	.2540e 1	---	---	---	---	---	.4515e 4	.1296e 3
.5700e 3	.9576e 1	.2490e 1	---	---	---	---	---	.4687e 4	.1407e 3
.5715e 3	.9285e 1	.2470e 1	---	---	---	---	---	.4910e 4	.1194e 3
.5730e 3	.9989e 1	.2530e 1	---	---	---	---	---	.4724e 4	.1228e 3
.5745e 3	.1397e 2	---	---	---	---	---	---	.3209e 4	.1104e 3
.5761e 3	.1097e 2	---	---	---	---	---	---	.4678e 4	.1330e 3
.5776e 3	.9683e 1	.2530e 1	---	---	---	---	---	.4940e 4	.1215e 3
.5791e 3	.9392e 1	.2580e 1	---	---	---	---	---	.4812e 4	.1430e 3
.5806e 3	.9312e 1	.2600e 1	---	---	---	---	---	.4827e 4	.1060e 3
.5822e 3	.9520e 1	.2570e 1	---	---	---	---	---	.4924e 4	.9910e 2
.5837e 3	.9512e 1	.2570e 1	---	---	---	---	---	.4376e 4	.6546e 2
.5852e 3	.9577e 1	.2580e 1	---	---	---	---	---	.4676e 4	.1382e 3
.5867e 3	.9427e 1	.2630e 1	---	---	---	---	---	.4556e 4	.1068e 3
.5883e 3	.9562e 1	.2600e 1	---	---	---	---	---	.4743e 4	.1247e 3
.5898e 3	.9484e 1	.2630e 1	---	---	---	---	---	.4525e 4	.1112e 3
.5913e 3	.9476e 1	.2610e 1	---	---	---	---	---	.4592e 4	.1269e 3
.5928e 3	.9612e 1	.2620e 1	---	---	---	---	---	.4599e 4	.1224e 3
.5944e 3	.9320e 1	.2600e 1	---	---	---	---	---	.4651e 4	.1336e 3
.5959e 3	.9028e 1	.2590e 1	---	---	---	---	---	.4051e 4	.1503e 3
.5974e 3	.9164e 1	.2650e 1	---	---	---	---	---	.4291e 4	.1055e 3
.5989e 3	.7663e 1	.2620e 1	---	---	---	---	---	.3773e 4	.9655e 2
.6005e 3	.9078e 1	.2350e 1	---	---	---	---	---	.3563e 4	.1155e 3
.6020e 3	.9489e 1	.2400e 1	---	---	---	---	---	.4094e 4	.1536e 3
.6035e 3	.9413e 1	.2320e 1	---	---	---	---	---	.4109e 4	.1412e 3
.6050e 3	.8620e 1	.2470e 1	---	---	---	---	---	.4083e 4	.1469e 3
.6066e 3	.7756e 1	.2510e 1	---	---	---	---	---	.3475e 4	.1511e 3
.6081e 3	.8183e 1	.2470e 1	---	---	---	---	---	.3460e 4	.1261e 3
.6096e 3	.7677e 1	.2630e 1	---	---	---	---	---	.3918e 4	.1213e 3
.6111e 3	.7817e 1	.2630e 1	---	---	---	---	---	.4188e 4	.1300e 3
.6126e 3	.7742e 1	.2620e 1	---	---	---	---	---	.3663e 4	.1275e 3
.6142e 3	.8313e 1	.2490e 1	---	---	---	---	---	.3603e 4	.1137e 3
.6157e 3	.7735e 1	.2540e 1	---	---	---	---	---	.3573e 4	.1157e 3
.6172e 3	.7659e 1	.2620e 1	---	---	---	---	---	.3670e 4	.1221e 3
.6187e 3	.7871e 1	.2650e 1	---	---	---	---	---	.3475e 4	.1331e 3
.6203e 3	.7867e 1	.2550e 1	---	---	---	---	---	.3715e 4	.1216e 3
.6218e 3	.1088e 2	---	---	---	---	---	---	.4151e 4	.1168e 3
.6233e 3	.7645e 1	---	---	---	---	---	---	.1839e 4	.1278e 3
.6248e 3	.1309e 2	---	---	---	---	---	---	.3715e 4	.1252e 3
.6264e 3	.7925e 1	.2670e 1	---	---	---	---	---	.3573e 4	.1294e 3
.6279e 3	.7706e 1	.2590e 1	---	---	---	---	---	.2770e 4	.1359e 3
.6294e 3	.8420e 1	---	---	---	---	---	---	.4053e 4	.1154e 3
.6309e 3	.7699e 1	.2480e 1	---	---	---	---	---	.3625e 4	.1151e 3
.6325e 3	.7839e 1	.2600e 1	---	---	---	---	---	.4601e 4	.1036e 3
.6340e 3	.7620e 1	.2570e 1	---	---	---	---	---	.4031e 4	.1033e 3
.6355e 3	.7688e 1	.2650e 1	---	---	---	---	---	.4789e 4	.1053e 3
.6370e 3	.7541e 1	.2670e 1	---	---	---	---	---	.4534e 4	.1095e 3
.6386e 3	.7466e 1	.2700e 1	---	---	---	---	---	.2582e 4	.9130e 2
.6401e 3	.7534e 1	.2730e 1	---	---	---	---	---	.2056e 4	.1269e 3
.6416e 3	.7602e 1	.2750e 1	---	---	---	---	---	.2064e 4	.1289e 3
.6431e 3	.7526e 1	.2730e 1	.3028e 3	.1743e 3	.1782e 2	---	---	.1914e 4	.1264e 3
.6447e 3	.7595e 1	.2530e 1	.2816e 3	.1688e 3	.8309e 2	---	---	.1869e 4	.1171e 3
.6462e 3	.7519e 1	.2530e 1	.2463e 3	.1702e 3	.4146e 2	---	---	.1411e 4	.9662e 2
.6477e 3	.7731e 1	.2430e 1	.2840e 3	.1479e 3	.5955e 2	---	---	.1629e 4	.9634e 2
.6492e 3	.7871e 1	.2460e 1	.1969e 3	.1619e 3	.4847e 2	---	---	.1839e 4	.1208e 3
.6507e 3	.7652e 1	.2570e 1	.2317e 3	.1745e 3	.4851e 2	---	---	.1831e 4	.1160e 3
.6523e 3	.7577e 1	.2550e 1	.2805e 3	.1745e 3	.1660e 2	.5116e 4	.1279e 2	.2101e 4	.1224e 3
.6538e 3	.7645e 1	.2600e 1	.3303e 3	.2262e 3	.6802e 2	.4970e 4	.1272e 2	.1869e 4	.1244e 3
.6553e 3	.7642e 1	.2540e 1	.3739e 3	.2249e 3	.1014e 3	.4968e 4	.1237e 2	.1914e 4	.1308e 3
.6568e 3	.7566e 1	.2570e 1	.3303e 3	.2458e 3	.8615e 2	.4827e 4	.1216e 2	.1651e 4	.1306e 3
.6584e 3	.7706e 1	.2500e 1	.3707e 3	.2529e 3	.8757e 2	.4645e 4	.1133e 2	.1621e 4	.1101e 3
.6599e 3	.7703e 1	.2530e 1	.2486e 3	.2208e 3	.7927e 2	.4277e 4	.1061e 2	.1816e 4	.1143e 3
.6614e 3	.7699e 1	.2510e 1	.2891e 3	.2320e 3	.9042e 2	.4363e 4	.1069e 2	.1824e 4	.1387e 3
.6629e 3	.7695e 1	.2500e 1	.3603e 3	.3116e 3	.1474e 3	.4563e 4	.1113e 2	.1711e 4	.1294e 3
.6645e 3	.7763e 1	.2500e 1	.4175e 3	.3117e 3	.1922e 3	.4447e 4	.1090e 2	.1846e 4	.1404e 3
.6660e 3	.7616e 1	.2550e 1	.2996e 3	.2838e 3	.1475e 3	.4398e 4	.1099e 2	.1696e 4	.1693e 3
.6675e 3	.7613e 1	.2540e 1	.3610e 3	.2684e 3	.1898e 3	.4535e 4	.1125e 2	.1674e 4	.1286e 3
.6690e 3	.7681e 1	.2520e 1	.2782e 3	.2489e 3	.1725e 3	.4307e 4	.1060e 2	.1749e 4	.1283e 3
.6706e 3	.7821e 1	.2480e 1	.2794e 3	.2015e 3	.1698e 3	.4348e 4	.1052e 2	.1186e 4	.1280e 3
.6721e 3	.1313e 2	---	.2148e 3	.1652e 3	.1240e 3	.4057e 4	.1014e 2	.1659e 4	.1323e 3
.6736e 3	.7742e 1	.2570e 1	.1095e 3	.1736e 3	.9069e 2	.4180e 4	.1053e 2	.1659e 4	.1297e 3
.6751e 3	.7666e 1	.2490e 1	.2634e 3	.1736e 3	.1310e 3	.4177e 4	.1015e 2	.2041e 4	.1205e 3
.6767e 3	.7591e 1	.2590e 1	.2113e 3	.1779e 3	.1102e 3	.4213e 4	.1074e 2	.2192e 4	.7977e 2
.6782e 3	.7659e 1	.2780e 1	.1915e 3	.1988e 3	.1255e 3	.5742e 4	.1579e 2	.2424e 4	.7274e 2
.6797e 3	.7584e 1	.2740e 1	.4985e 3	.4698e 3	.1769e 3	.5742e 4	.1556e 2	.2462e 4	.5222e 2
.6812e 3	.7580e 1	.2620e 1	.8605e 3	.8858e 3	.3910e 3	.5892e 4	.1520e 2	.2777e 4	.5421e 2
.6828e 3	.7649e 1	.2580e 1	.5082e 3	.4336e 3	.3330e 3	.4923e 4	.1246e 2	.2619e 4	.7413e 2
.6843e 3	.7645e 1	.2520e 1	.1290e 3	.1026e 3	.4520e 2	.4867e 4	.1197e 2	.2244e 4	.8734e 2
.6858e 3	.7642e 1	.2570e 1	.2213e 3	.7473e 2	.6875e 2	.4919e 4	.1240e 2	.2447e 4	.9603e 2
.6873e 3	.7581e 1	.2600e 1	.6981e 2	.5520e 2	.6045e 2	.5054e 4	.1289e 2	.2409e 4	.9128e 2
.6888e 3	.7520e 1	.2630e 1	.6260e 2	.5105e 2	.4937e 2	.4750e 4	.1226e 2	.2582e 4	.1022e 3
.6904e 3	.7673e 1	.2590e 1	.9881e 2	.4968e 2	.4941e 2	.4750e 4	.1206e 2	.2416e 4	.1177e 3
.6919e 3	.7613e 1	.2590e 1	.1420e 3	.6229e 2	.4667e 2	.4800e 4	.1219e 2	.2055e 4	.2150e 3
.6934e 3	.7696e 1	.2540e 1	.1894e 3	.7629e 2	.6337e 2	.4616e 4	.1149e 2	.1951e 4	.2511e 3
.6949e 3	.7563e 1	.2510e 1	.1276e 3	.9728e 2	.3979e 2	.4340e 4	.1068e 2	.1163e 4	.2512e 3
.6965e 3	.7574e 1	.2520e 1	.1442e 3	.8614e 2	.4538e 2	.4315e 4	.1062e 2	.1516e 4	.1120e 3
.6980e 3	.7943e 1	.2540e 1	.4174e 2	.6243e 2	.2042e 2	.4355e 4	.1084e 2	.2777e 4	.1323e 3
.6995e 3	.7524e 1	.2540e 1	.4993e 2	.7504e 2	.1767e 2	.4564e 4	.1136e 2	.3370e 4	.2942e 3
.7010e 3	.7606e 1	.2530e 1	.2416e 3	.9742e 2	.8160e 2	.4658e 4	.1150e 2	.2762e 4	.2943e 3

Table 6.--Digitized values of Birdwell logs, UE25a-3--Continued

[Conversion factors: meter x 3.28=foot; centimeter x 0.3937=inch; leaders (---) indicate no data]

Depth (m)	Caliper (cm)	Density (Mg/m³)	Resistivity (ohm-meters) 16" normal	Resistivity (ohm-meters) 64" normal	Resistivity (ohm-meters) 18'8" lateral	Velocity (m/s)	Acoustic impedance (10^6 Rayls)	Neutron log (API units)	Gamma-ray log (API units)
.7026e 3	.7545e 1	.2430e 1	.3940e 3	.2958e 3	.1039e 3	.4268e 4	.1011e 2	.3378e 4	.2607e 3
.7041e 3	.7484e 1	.2520e 1	.3084e 3	.3056e 3	.6500e 2	.4752e 4	.1169e 2	.3221e 4	.2451e 3
.7056e 3	.7710e 1	.2530e 1	.3348e 3	.3266e 3	.7754e 2	.4779e 4	.1185e 2	.3423e 4	.2767e 3
.7071e 3	.7577e 1	.2580e 1	.3500e 3	.3168e 3	.1734e 3	.4909e 4	.1242e 2	.2673e 4	.3442e 3
.7087e 3	.7659e 1	.2480e 1	.3344e 3	.3197e 3	.1721e 3	.4596e 4	.1112e 2	.3994e 4	.3241e 3
.7102e 3	.7598e 1	.2530e 1	.2810e 3	.3630e 3	.1415e 3	.4795e 4	.1189e 2	.3844e 4	.1669e 3
.7117e 3	.7610e 1	.2550e 1	.4402e 3	.4971e 3	.2610e 3	.5046e 4	.1261e 2	.4220e 4	.2322e 3
.7132e 3	.7548e 1	.2500e 1	.5924e 3	.7116e 3	.3722e 3	.5385e 4	.1319e 2	.3567e 4	.2008e 3
.7148e 3	.7631e 1	.2540e 1	.5483e 3	.7399e 3	.3347e 3	.5129e 4	.1277e 2	.3267e 4	.2706e 3
.7163e 3	.7642e 1	.2570e 1	.4622e 3	.6704e 3	.3139e 3	.5064e 4	.1276e 2	.2772e 4	.2955e 3
.7178e 3	.7582e 1	.2570e 1	.4073e 3	.6289e 3	.3486e 3	.5091e 4	.1288e 2	.2607e 4	.2304e 3
.7193e 3	.7591e 1	.2590e 1	.4743e 3	.6152e 3	.3056e 3	.5178e 4	.1315e 2	.3027e 3	.2103e 3
.7209e 3	.7602e 1	.2670e 1	.4111e 3	.5039e 3	.5288e 3	.5087e 4	.1338e 2	.8809e 3	.3517e 2
.7224e 3	.7756e 1	.2780e 1	.2891e 3	.2976e 3	.1099e 4	.6030e 4	.1658e 2	.6934e 3	.2853e 2
.7239e 3	.7696e 1	.2660e 1	.5914e 3	.6861e 3	.2780e 3	.6199e 4	.1624e 2	.2131e 3	.3539e 2
.7254e 3	.7562e 1	.2610e 1	.4189e 3	.5328e 3	.1808e 3	.5454e 4	.1402e 2	.3560e 3	.4674e 2
.7269e 3	.7645e 1	.2740e 1	.2702e 3	.3508e 3	.1489e 3	.4794e 4	.1299e 2	.1099e 4	.4910e 2
.7285e 3	.7656e 1	.3040e 1	.1836e 3	.3831e 3	.1586e 3	.6150e 4	.1870e 2	.1039e 4	.4921e 2
.7300e 3	.7596e 1	.2870e 1	.5787e 3	.3044e 3	.9396e 3	.6142e 4	.1750e 2	.3866e 3	.8302e 2
.7315e 3	.7534e 1	.2670e 1	.2024e 3	.5665e 3	.8946e 2	.6133e 4	.1619e 2	.9648e 3	.1573e 2
.7330e 3	.7545e 1	.2720e 1	.9331e 3	.1554e 4	.2530e 3	.6595e 4	.1774e 2	.2406e 4	.2258e 2
.7346e 3	.7699e 1	.2750e 1	.1623e 4	.3044e 4	.1124e 3	.6352e 4	.1728e 2	.1730e 4	.9216e 1
.7361e 3	.7710e 1	.2690e 1	.1190e 4	.2774e 4	.7872e 3	.6256e 4	.1658e 2	.1100e 4	.1381e 2
.7376e 3	.7650e 1	.2650e 1	.1542e 4	.2993e 4	.3673e 3	.6080e 4	.1587e 2	.1753e 4	.1843e 2
.7391e 3	.7588e 1	.2580e 1	.1405e 4	.2876e 4	.4573e 4	.6129e 4	.1551e 2	.1093e 4	.1180e 2
.7407e 3	.7742e 1	.2200e 1	.8475e 3	.1028e 4	.4458e 4	.5811e 4	.1226e 2	.1258e 4	.2314e 2
.7422e 3	.7610e 1	.2460e 1	.1956e 3	.7161e 3	.1136e 4	---	---	.7634e 3	.9068e 2
.7437e 3	.7908e 1	---	.3821e 3	.5162e 3	.1160e 4	---	---	.4708e 3	.5483e 2
.7452e 3	.1703e 2	---	.7841e 2	.3879e 3	.2073e 3	---	---	.1004e 4	.2573e 2
.7468e 3	.1317e 2	---	.7874e 2	.3818e 3	.2920e 3	---	---	.1199e 4	.4832e 2
.7483e 3	.9037e 1	.2420e 1	.1518e 3	.3925e 3	.3304e 3	---	---	.1665e 4	.1697e 2
.7498e 3	.7878e 1	.2580e 1	.1578e 3	.4242e 3	.2010e 3	---	---	.1455e 4	.5845e 1
.7513e 3	.7532e 1	.2600e 1	.2420e 3	.4502e 3	.2590e 3	---	---	.1124e 4	.1046e 2
.7529e 3	.7541e 1	.2670e 1	.5744e 3	.7954e 3	.2830e 3	.6392e 4	.1681e 2	.7798e 3	.5101e 2
.7544e 3	.7481e 1	.2600e 1	.1780e 4	.2929e 4	---	.6401e 4	.1639e 2	.1147e 4	.6908e 2
.7559e 3	.7490e 1	.2680e 1	.1882e 4	.4084e 4	---	.6412e 4	.1699e 2	.1996e 4	.5122e 2
.7574e 3	.7574e 1	.2640e 1	.1674e 4	.3451e 4	---	.6023e 4	.1566e 2	.9680e 3	.3561e 2
.7590e 3	.7513e 1	.2620e 1	.1213e 4	.2650e 4	.3712e 4	.5989e 4	.1545e 2	.1291e 4	.4696e 2
.7605e 3	.7451e 1	.2630e 1	.1229e 4	.2729e 4	.4570e 4	.6039e 4	.1564e 2	.9984e 3	.4483e 2
.7620e 3	.7391e 1	.2620e 1	.1022e 4	.2459e 4	.4345e 4	.5843e 4	.1502e 2	.9085e 3	.4270e 2
.7635e 3	.7546e 1	.2590e 1	.9821e 3	.2119e 4	.2911e 4	.6365e 4	.1617e 2	.8186e 3	.5180e 2
.7650e 3	.7556e 1	.2600e 1	.1084e 4	.2715e 4	.1505e 4	.6375e 4	.1632e 2	.5711e 3	.4966e 2
.7666e 3	.7566e 1	.2570e 1	.1604e 4	.3954e 4	.2480e 4	.6114e 4	.1541e 2	.8490e 3	.3405e 2
.7681e 3	.7505e 1	.2470e 1	.1690e 4	.4145e 4	.2790e 4	.6392e 4	.1534e 2	.1164e 4	.3191e 2
.7696e 3	.7588e 1	.2500e 1	.1468e 4	.3848e 4	.3850e 4	---	---	.1187e 4	---
.7711e 3	.7742e 1	.2490e 1	---	---	---	---	---	---	---

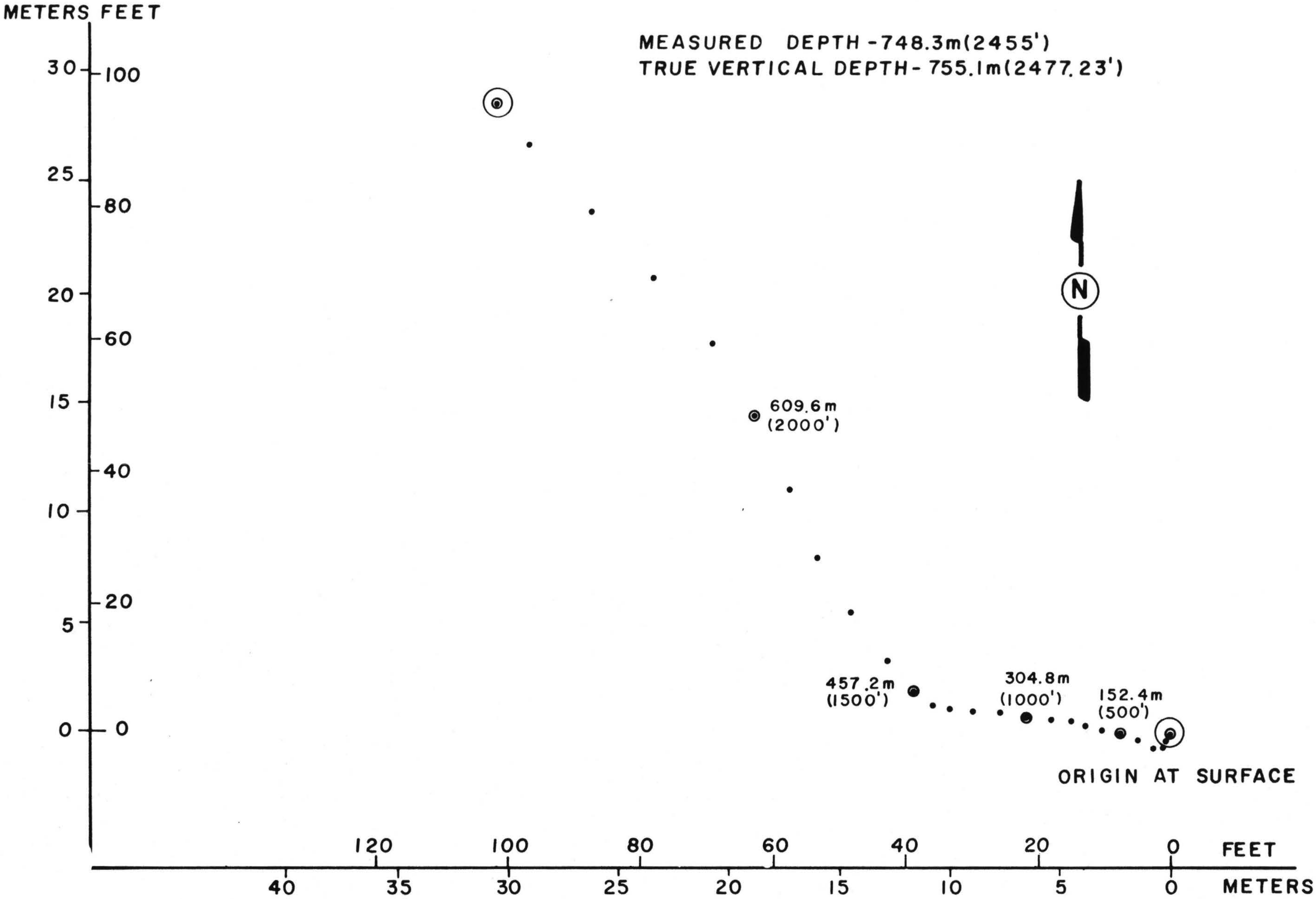

Figure 16.--Plot of Sperry Sun directional survey data, UE25a-3

with faults, brecciation, clay zones, intervals where the CI is greater than 50, or combinations of these parameters.

Density Log

The densities were obtained with two different tools. The section of drill hole below 598.3 m (1,964 ft) was logged with a decentralized tool. This tool is calibrated before and after logging in aluminum and magnesium blocks. The response of the tool in these blocks is plotted versus the block densities for that particular hole diameter to obtain a calibration curve which is used to convert the log response to density.

Because the decentralized tool was damaged, an omnidirectional tool was used in the lower portion of the drill hole. Birdwell does not have density calibration curves for this tool. However, core data can be used for calibration when available, or as in this case, data from the decentralized tool was used in an interval logged by both tools to calibrate the omnidirectional tool. Densities from the decentralized tool were plotted versus the omnidirectional tool response in the lower portion of the hole. The resulting calibration curves were used to compute densities above 598.3 m (1,964 ft) in the drill hole.

Subsequent to the calibration of the omnidirectional density log, density values measured on 20 core samples were obtained. In the altered argillite interval, the average core density (2.54 g/cm^3) and average log density (2.56 g/cm^3) are in excellent agreement. However, in the argillite interval the average core density is 2.59 g/cm^3 and the average log density is 2.50 g/cm^3. Taken separately, the core indicates the argillite interval is denser than the altered argillite interval, and the converse is indicated by the density log. Assuming the core densities are correct, new calibration curves for the density log can be constructed using count rates from the density log and the core densities. These calibration curves would be in violation of the principles of Compton scattering and attenuation of gamma rays which are the basis for gamma-gamma density logging. A more viable assumption is that the density log is correct. In the altered argillite interval the CI (pl. 1) is low as a result of fractures being sealed and filled with secondary mineralization during hydrothermal alteration. As a result, the cores selected in the altered argillite interval are representative of the total interval, and are in agreement with the density log. In the argillite interval the CI (pl. 1) is high as a result of open fractures. The cores selected for density measurements in this interval were unfractured, so the core densities do not reflect the fracture porosity which lowers the in situ densities measured by the density log. Densities from the density log should therefore be considered valid estimates of in situ density.

The densities are quite uniform throughout the argillite and altered argillite intervals. Variations in density in these intervals tend to correlate with structure and thin interbedded beds of limestone and quartzite. The marble in the lower portion of the section exhibits considerable variation in density which correlates with faulting, fracturing, and changes in porosity. The silicified breccia at 720.6-730.3 m (2,364-2,396 ft) exhibits anomalously high density which is not explained by the mineralogy.

Electric Logs

Birdwell's electric log tool measures three different apparent resistivities, depending on the electrode configuration: a short normal, a long normal, and a lateral. The electric log requires fluid coupling to the formation which limited the logged interval to below 641.3 m (2,104 ft).

The electric logs record an apparent resistivity which is based on a geometric factor calculated from the electrode spacing. All of the spacings give apparent resistivities higher than true resistivity, but the short normal reading is nearly true resistivity when it is less than about 100Ω-m.

The resistivities in the marble interval are, in general, much higher than they are in the altered argillite interval; the resistivities of altered argillites are less than 1,000Ω-m. The low resistivities in the marble interval correspond to a fracture zone with low densities at 746.2 m (2,448 ft).

Spontaneous Potential Log

Because of the fresh formation water and fresh muds used in drilling, the spontaneous potential log is not useful at NTS. It is included in plate 1 because it was run as a standard item with the electric log. The only expression of note shown on the log trace is a positive excursion through the brecciated zone at the top of the marble interval 720.6-730.3 m (2,364-2,396 ft).

Velocity Logs

Two velocity surveys were made: one with a 3-D tool and the other with a downhole geophone and a surface Vibroseis system. The 3-D log is Birdwell's continuous-trace sonic log which is recorded at 0.9- and 1.8-m (3- and 6-ft) spacings. The first arrivals from both spacings are digitized and velocity is computed from the difference in spacing divided by the difference in time. The advantage of the continuous trace is that the shear-wave velocity can sometimes be picked and used to calculate the dynamic moduli. However, the shear-wave arrival is not readily apparent on the logs in this hole.

The Vibroseis survey was accomplished with a surface Vibroseis unit that generated seismic energy and a clamping geophone that recorded the seismic signal downhole at different levels. The average velocity trace on the velocity log is the average velocity from the recording depths to the surface. The interval velocity trace is the velocity between recording levels. The velocity is computed from the time of arrival of the signal at the geophone and the geophone depth (table 7).

Subsequent to the survey, the data was reprocessed to obtain reflections in an attempt to define structure. However, as the spacings lower in the hole were greater than 7.6 m (25 ft), no interpretable data were obtained.

Because the Vibroseis survey is made on discrete intervals of 7.6 m (25 ft) or greater, a detailed correlation with other logs and with stratigraphy cannot be made. Much of the variability in computed interval velocity for short intervals is the result of uncertainty

Table 7.--Vibroseis geophone survey data, UE25a-3

[Conversion factors: meter x 3.28=foot; meter/second x 3.28=foot/second]

Depth (m)	Average velocity (m/s)	Interval velocity (m/s)
0.0		
		2,019
61.0	2,019	
		2,822
68.6	2,085	
		2,177
76.2	2,093	
		3,048
83.8	2,155	
		3,175
91.4	2,214	
		3,313
99.1	2,272	
		3,313
106.7	2,324	
		3,313
114.3	2,371	
		2,381
121.9	2,372	
		2,458
129.5	2,377	
		3,464
137.2	2,419	
		3,629
144.8	2,462	
		2,458
152.4	2,462	
		2,458
160.0	2,462	
		3,464
167.6	2,495	
		3,629
175.3	2,592	
		2,540
182.9	2,529	
		3,629
190.5	2,560	
		2,458
198.1	2,556	
		3,810
205.7	2,588	
		3,629
213.4	2,615	
		3,629
221.0	2,640	
		3,810
228.6	2,667	
		3,629
236.2	2,690	
		2,540
243.8	2,685	
		2,540
251.5	2,681	
		3,629
259.1	2,702	
		2,540
266.7	2,697	
		3,810
274.3	2,719	
		3,629
281.9	2,737	
		3,810
289.6	2,758	
		3,629
297.2	2,775	
		3,810
304.8	2,794	
		3,048
320.0	2,805	
		3,717
335.3	2,837	
		3,810
350.5	2,868	
		3,717
365.8	2,896	
		3,048
381.0	2,902	
		3,048
396.2	2,907	
		3,717
411.5	2,931	
		3,810
426.7	2,955	
		3,810
442.0	2,978	
		5,080
457.2	3,020	
		3,717
472.4	3,038	
		3,810
487.7	3,058	
		3,810
502.9	3,076	
		5,080
518.2	3,112	
		5,080
533.4	3,147	
		3,810
548.6	3,162	
		2,988
563.9	3,577	
		3,810
579.1	3,172	
		3,810
594.4	3,185	
		3,810
609.6	3,198	
		3,810
640.1	3,223	
		4,997
670.6	3,276	
		4,354
701.0	3,311	
		4,354
731.5	3,345	
		5,080
762.0	3,391	

in the time of arrival. For intervals greater than 60 m (200 ft) the uncertainty in time-of-arrival can be considered negligible (Muller and Brethauer, 1978).

The Vibroseis survey shows a velocity of 2,000 m/sec (6,560 ft/sec) for the upper 61 m (200 ft) of argillite. The average interval velocity in the argillite below 61 m (200 ft) is 3,200 m/sec (10,500 ft/sec) ranging from 2,200 to 3,800 m/sec (7,220 to 12,470 ft/sec). In the altered argillite interval the average interval velocity is 4,100 m/sec (13,450 ft/sec) ranging from 3,000 to 5,100 m/sec (9,840 to 16,730 ft/sec). The single interval velocity recorded in the marble is 5,100 m/sec (16,730 ft/sec).

The 3-D velocity log requires fluid coupling to the formation, which limits the coverage to below 641.3 m (2,104 ft). The velocities derived from the 3-D log are generally greater than those derived from the Vibroseis survey. One apparent reason for this difference is that the 3-D log is only affected by a small volume of formation around the borehole surface over a 0.9-m (3-ft) interval. Thus, the effect of thin low-velocity fracture zones is minimized, and the velocities obtained are representative of the more competent, less fractured rock. The Vibroseis method, on the other hand, integrates the effects of fracturing into the velocities obtained, because the Vibroseis method responds to the total bulk effects of the rock around the borehole.

The interval 741-752 m (2,431-2,467 ft) is highly fractured and the signal from the 3-D tool could not be transmitted through this interval. The low velocity at 725 m (2,379 ft) near the top of the marble is the result of a breccia zone. The high velocity "spike" at 677 m (2,221 ft) coincides with a high density and resistivity in the thin bedded limestones (pl. 1).

Acoustic Impedance

The acoustic impedance log is computed using data from the density and 3-D velocity logs. It indicates an acoustic boundary at the thin-bedded limestone beds at 677 m (2,221 ft). The bed, however, is probably too thin and too deep to be detected by either reflection or refraction seismic methods. The acoustic boundary at the top of the marble, on the other hand, could probably be detected by reflection or refraction seismic methods.

Neutron Log

The neutron log is a thermal neutron type and the tool is centralized. Some of the variation in the neutron response correlates with hole enlargements as shown by comparison with the caliper log. A major boundary is indicated by this log trace at 403 m (1,322 ft), which is the boundary of alteration effects on porosity. The change in count rate at 641.3 m (2,104 ft) is the top of the borehole fluid. The calcareous altered argillite interval is manifested by an increase in count and the marble is evident as a decrease in count. The inference can be made, since neutrons are effected primarily by hydrogen in water, that the greatest water content is in the marble, the least is in the altered argillite with the argillite being intermediate in water content.

Gamma Log

The gamma log is a measure of the natural gamma radiation in the formation. The gamma log trace is very "quiet" in the argillite interval. The activity level increases at the boundary indicated by the neutron log as the upper boundary of hydrothermal alteration effects. Natural radioactivity is greatest in the calcareous altered argillite interval and it is very low in the marble interval at the bottom of the hole.

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