

## 7. SITE 472: BAJA CALIFORNIA SEAMOUNT PROVINCE<sup>1</sup>

### Shipboard Scientific Party<sup>2</sup>

#### HOLES 472, 472A

**Date occupied:** 18 November 1978 (472); 20 November 1978 (472A)

**Date departed:** 20 November 1978 (472, 472A)

**Position:** 23°00.35' N, 113°59.71' W (472, 472A)

**Water depth (sea level; corrected m, echo-sounding):** 3831 (472, 472A)

**Bottom felt (m, drill pipe):** 3847.5 (472, 472A)

**Penetration (m):** 137.5 (472); 94.5 (472A)

**Number of cores:** 16 (472); 1 (472A)

**Total length of cored section (m):** 137.5 (472); 0.2 (472A)

**Total core recovered (m):** 65.11 (472); 0.2 (472A)

**Core recovery (%):** 47 (472); 100 (472A)

**Oldest sediment cored (472):**

Depth sub-bottom (m): 112

Nature: Nannofossil ooze

Chronostratigraphy: Middle Miocene (15 ± 0.5 m.y.)

**Basement (472):**

Depth sub-bottom (m): 112

Nature: Pillow basalt

**Principal results:** Unit 1, moderate yellowish brown pelagic clay deposited from the early Quaternary to late Miocene, was recovered from the mudline to sub-bottom depth of 24.5 meters. This unit is underlain by upper and middle Miocene greenish gray clayey diatomaceous ooze and pelagic clay to 91 meters (Unit 2). Unit 3 is composed of diatomaceous nannofossil ooze with minor vitric ash; metalliferous, dolomitic nannofossil ooze occurs at the base (at 112 m). The oldest sediment above basalt was deposited in the middle Miocene 15 ± 0.5 m.y. ago and is assigned to the *Sphenolithus heteromorphus* Zone. Unit 1 is almost barren of fossils and grades into Unit 2, indicated by the increase in siliceous microfossils. The absence of calcareous microfossils in these two units suggests deposition below the carbonate compensation depth (CCD). Sediment accumulation rates are about 5 m/m.y. in sediments younger than about 7 m.y., and 8 m/m.y. in older sediments. One heat-flow measurement at 88 meters was 14.3°C; sediment density is 1.5 g/cm<sup>3</sup> and velocity 1.5 km/s.

Basement is olivine-plagioclase basalt with well-developed quench texture; 11 different cooling units (pillows) were recog-

nized. Rare intercalations of middle Miocene limestone were found in Core 15.

At Hole 472A the drill pipe was raised above the mudline and washed down to obtain a second heat-flow reading below 100 meters. Unfortunately, basalt was reached at 94.5 meters, 17.5 meters shallower than in the original hole. A 20-cm basalt core was recovered.

#### BACKGROUND AND OBJECTIVES

Site 472 was proposed at about 23°N and 114°W to obtain a pelagic upper Neogene record at this latitude free from terrigenous influences, such as those affecting Site 471 (Figs. 1 and 2). This goal was especially important in view of the fragmentary paleontological record obtained at Site 471. The proposed site was expected to yield a well-preserved siliceous and calcareous microfauna and -flora for most of the upper Neogene beyond the influence of the eastern boundary current and possible terrestrial input. It was selected to complement Site 471 and to complete a north-south latitudinal transect in various climatic and circulatory regions.

Site 471 was thought to be located on oceanic crust about 11 m.y. of age, according to a projection of striped magnetic anomalies described by Chase et al. (1970) (Fig. 3). The low amplitude of north-south magnetic stripes at this low latitude, however, makes magnetic correlations somewhat speculative in this area. On the basis of paleontological data, the crust at this site should be much older, about 15 m.y. of age; thus the tectonics west of southern Baja California may be more complex than previously believed.

South of the Clarion fracture zone, the Mathematician Ridge represents a fossil rise crest abandoned about 5 m.y. ago for the present East Pacific Rise crest farther east (Sclater et al., 1971; Fig. 4). North of the Clarion, the area around Site 472 has relatively high heat flow for a site so far west of the present rise crest (Fig. 4). The anomalous bulge in the western flank of the East Pacific Rise in the area of the Suitcase seamounts (Fig. 2) may represent a northern continuation of the abandoned Mathematician rise crest, and the rugged topography and offset of the 2100-fathom contour may indicate a fracture zone between those of the Clarion and the Molokai. We anticipated that the basement age at Site 472 would shed light on the interpretation of these features.

We planned to sail about 100 miles west of Site 471 across an existing *Challenger* Leg 54 reflection profile. Our strategy was to locate a site a short distance west of the *Challenger* Leg 54 line on fairly flat abyssal-hill topography with about 200 meters of sediments. The proposed location would put us on a magnetic anomaly

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<sup>2</sup> Robert S. Yeats (Co-Chief Scientist), Department of Geology, Oregon State University, Corvallis, Oregon; Bilal U. Haq (Co-Chief Scientist), Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; John A. Barron, U.S. Geological Survey, Menlo Park, California; David Bukry, U.S. Geological Survey, La Jolla, California; James K. Crouch, U.S. Geological Survey, Menlo Park, California (present address: Sohio Petroleum Co., San Francisco, California); Charles Denham, Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; A. G. Douglas, Department of Geology, The University, Newcastle-upon-Tyne, United Kingdom; Vladimir I. Grechin, Geological Institute of the Academy of Sciences of the U.S.S.R., Moscow, U.S.S.R.; Margaret Leinen, Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island; Alan R. Niem, Department of Geology, Oregon State University, Corvallis, Oregon; Surendra Pal, Instituto de Geofísica, Universidad Nacional Autónoma de México, México 20, D.F.; Kenneth A. Pisciotto, Deep Sea Drilling Project, Scripps Institution of Oceanography, La Jolla, California; Richard Z. Poore, U.S. Geological Survey, Menlo Park, California; Tsugio Shibata, Department of Earth Sciences, Okayama University, Tushima, Okayama, Japan; and Reinhard Wolfart, Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Federal Republic of Germany.

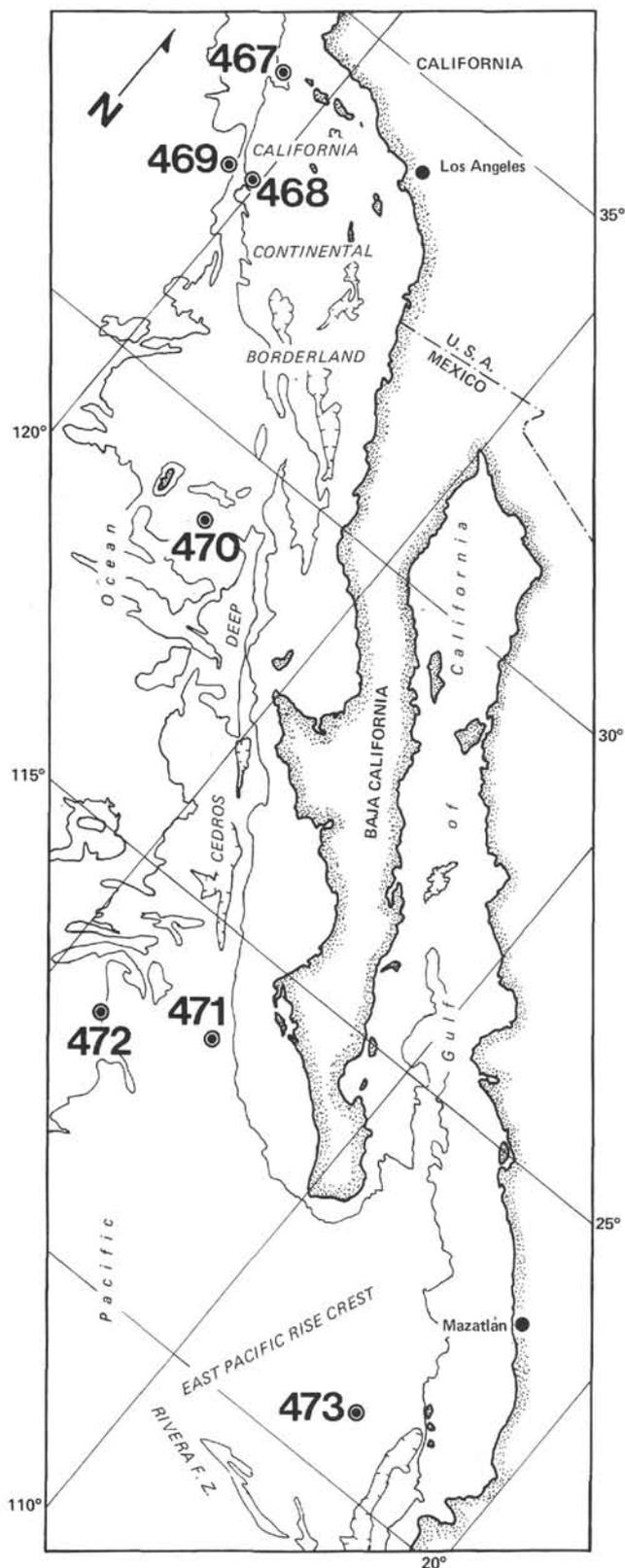


Figure 1. Location of Leg 63 sites.

with a crustal age of 14 m.y. (Fig. 3), according to paleomagnetic interpretations of Chase et al. (1970).

### OPERATIONS

We steamed west from Site 471 to examine a normal, low-latitude pelagic sediment section on crust with reliable magnetics. Near  $23^{\circ}\text{N}$ ,  $114^{\circ}\text{W}$ , we found a small plateau on our westward pass, and we returned about a mile to the north to get a mirror image of our westward track. We then turned west again on our old track and dropped the beacon at 0056 hours,<sup>3</sup> 18 November 1978 (Fig. 5).

We ran into difficulty when the bumper subs jarred several hundred meters above precision depth recorder (PDR) bottom on the way into the hole. A stand of pipe was being picked up at the time the bumper subs took weight. We then continued running pipe and spudded the hole close to PDR depth.

Coring was routine (Table 1), except for operational problems: the vertical reference gyro was switched because of erratic positioning, and the bottom blew out of the starboard Bowen hydraulic pump, requiring replacement with a spare unit. We took a heat-flow measurement at 88 meters and planned another one at around 115 meters, but instead encountered fresh basalt at 112 meters. Basalt was cored to 137.5 meters, with low core recovery and intermittent pipe sticking.

In hopes of getting a second heat-flow measurement at 105 meters, we raised the pipe above the mudline and washed down Hole 472A. However, basalt was encountered at 94.5 meters, 17.5 meters shallower than in the Hole 472, so we abandoned the site.

### LITHOLOGY

#### Sediments and Sedimentary Rocks

Site 472 is dominated by biogenic sediments and consists mainly of diatomaceous and siliceous clay, diatomaceous and nannofossil ooze, clay, and minor metaliferous sediment. These sediments are divided into three lithologic units (Fig. 6; Table 2).

#### Unit 1: Clay (0–24.5 m)

Unit 1 consists of firm to compact clay with trace amounts of siliceous microfossils. The clay is yellowish brown and mottled with scattered grayish brown to olive gray patches and vertical streaks. The darker colors are probably the result of higher proportions of finely disseminated opaque aggregates. Thin layers of greenish gray clay are present as a minor lithology in this unit (Samples 472-2-5, 50–70 cm; Sample 472-3-3, 30–70 cm). These layers have sharp contacts with overlying and underlying yellowish brown clay that has been disturbed by drilling.

<sup>3</sup> Times specified in the text are local times in hours; those in seismic-section figures are Zulu (Z) times.

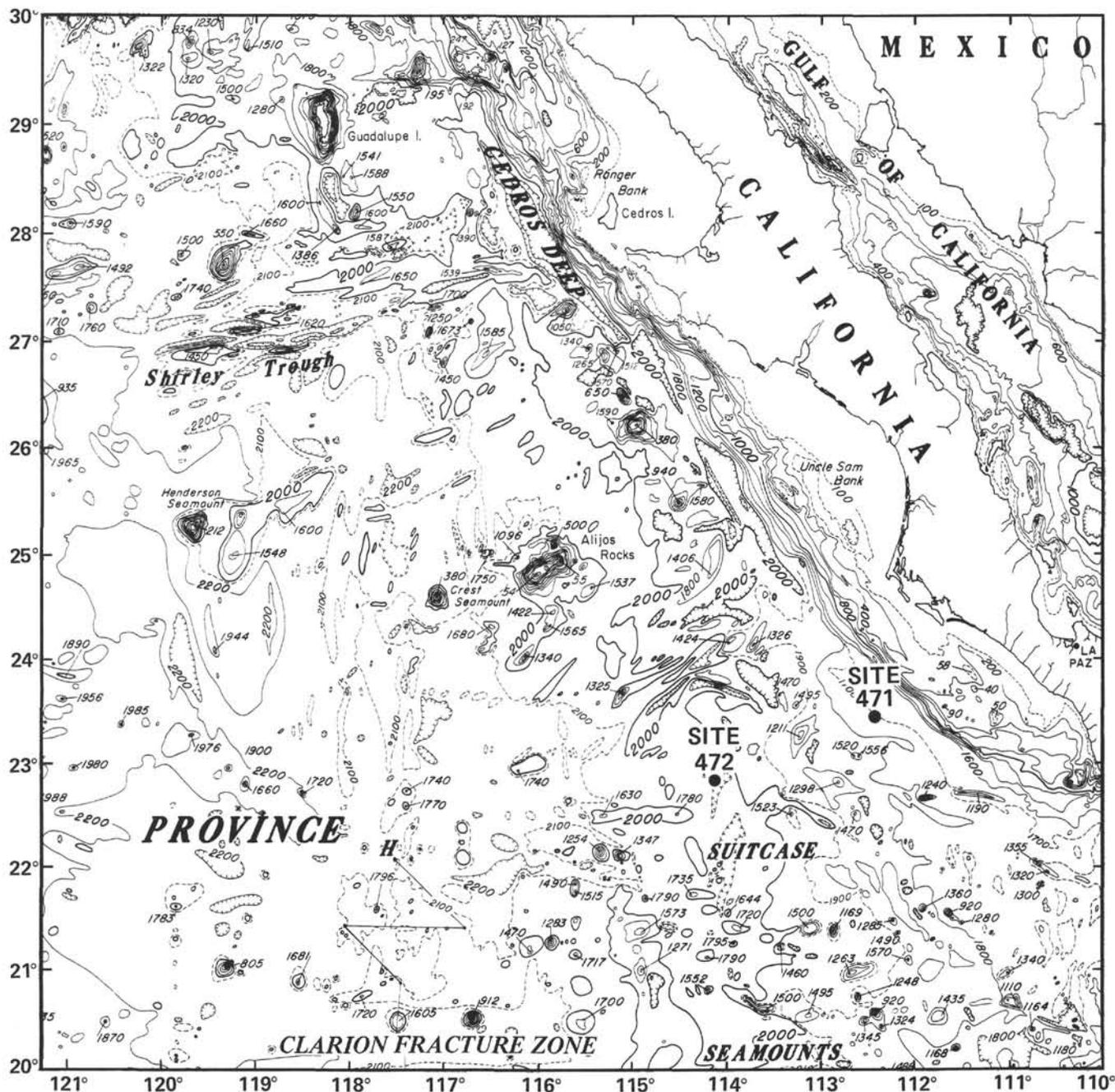


Figure 2. Bathymetric map showing location of Sites 471 and 472 off southern Baja California (Chase et al., 1974).

Unit 1 is composed of about 95% clay minerals. Silt-size angular quartz, feldspar, micas, brown volcanic glass, and opaque aggregates and pyrite are present as accessory constituents. A few diatoms, sponge spicules, radiolarians, and silicoflagellates also occur.

#### Unit 2: Diatomaceous Ooze and Clay (24.5–91 m)

This unit forms the thickest sedimentary interval (66.5 m) at this site. Greenish gray clayey diatomaceous ooze and light olive gray diatomaceous clay are the dominant lithologies. Minor lithologies include clay, diatomaceous ooze, and siliceous clay. These minor lithologies are more abundant in the lower and upper-

most parts of the unit. Unit 2 contains many reduction streaks and patches of grayish purple manganese oxide or finely disseminated pyrite that have been distorted by drilling. Small scattered patches and streaks of grayish yellow green to pale olive vitric ash also occur in Cores 9 and 10.

The upper contact of this unit is defined by an abrupt color change from yellowish brown (Core 3) to greenish gray (Core 4) as well as by a dramatic increase of siliceous microfossils in Cores 4 and 5. In Core 4, the clay is dominant, but it decreases sharply in Core 5 where diatoms (circa 5–70%), radiolarians 3–15%), silicoflagellates (up to 10%), and sponge spicules (up to 5%)

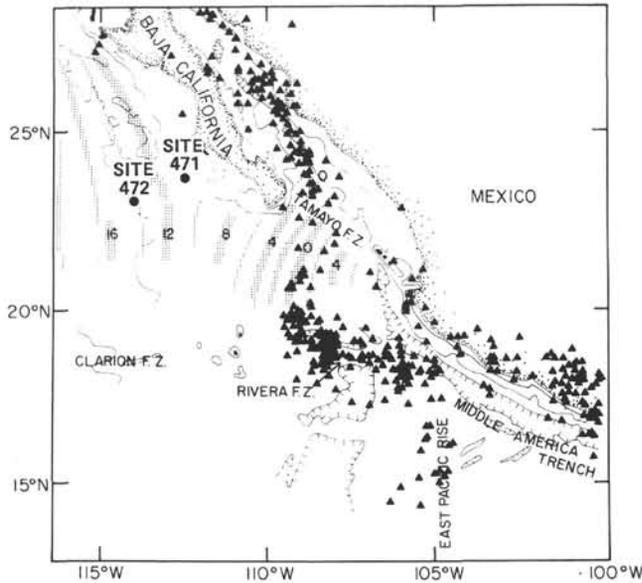


Figure 3. Earthquake epicenters and sea-floor age at the mouth of the Gulf of California (after Atwater [1970] and Chase et al. [1970]). (The magnetic-anomaly age at Site 472 is about 14 m.y. old.)

become the major sedimentary components. Nannofossils and foraminifers are almost absent in this unit. Near the base of the unit (Cores 9 and 10), clay again becomes the dominant component. Accessory components include quartz, feldspar, volcanic glass, mica, glauconite, and heavy minerals (including pyrite). The lower contact of Unit 2 is gradational. It occurs at the top of Core 11 where nannofossil abundance increases sharply.

**Unit 3: Nannofossil Ooze and Diatomaceous Clay (91–112 m)**

Unit 3 consists of greenish gray to light gray diatom-nannofossil ooze, dark greenish gray nannofossil-diatomaceous clay, and grayish green siliceous-nannofossil clay. The ooze and clay contain up to 5% silt-size quartz and volcanic glass as well as traces of mica, pyrite, feldspar, and glauconite.

Minor lithologies in Unit 3 include greenish gray siliceous, clayey nannofossil ooze and yellowish brown to grayish orange clay. Small scattered patches and streaks of pale yellowish brown vitric ash and grayish blue green, glauconitic siliceous clay also occur. There is a small patch of nannofossil clay containing 3% glauco-

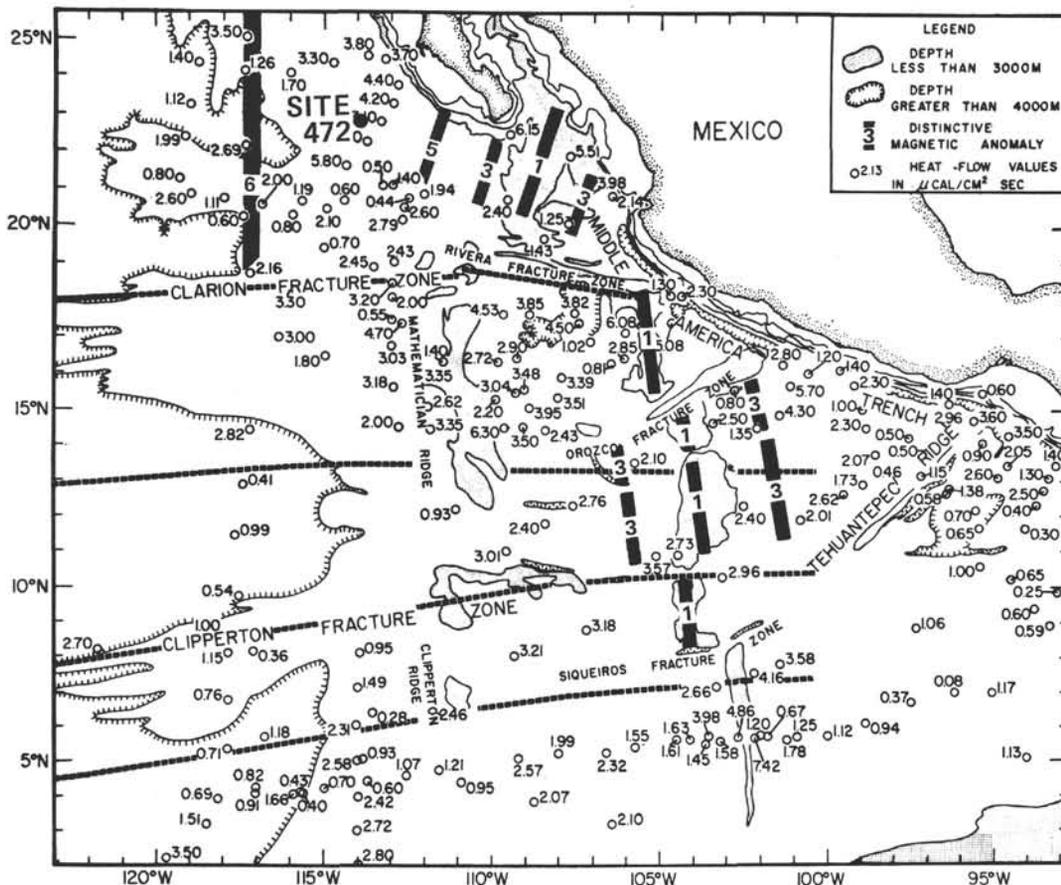


Figure 4. Heat-flow map of the eastern Pacific (after Sclater et al., 1971). (The Mathematician Ridge is an abandoned crest of the East Pacific Rise. Note high heat-flow values at Site 472.)

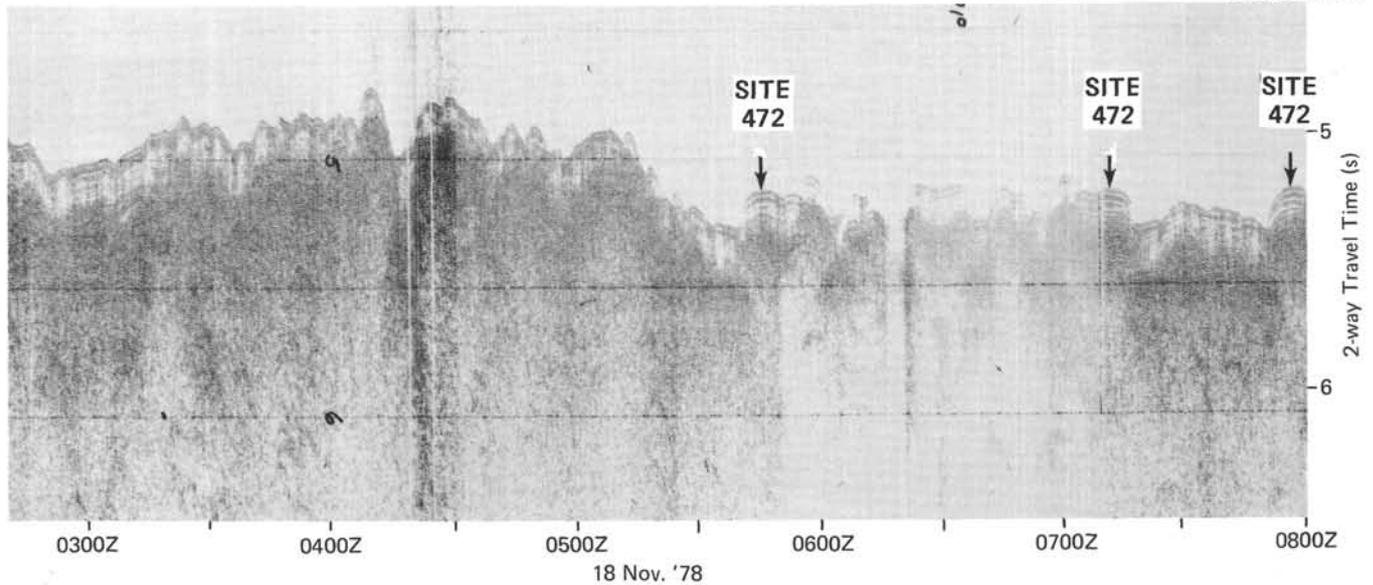


Figure 5. Challenger seismic profile approaching Site 472.

Table 1. Coring summary, Site 472.

Core No.	Date (Nov. 1978)	Time	Depth from Drill Floor (m)	Depth below Sea Floor (m)	Length Cored (m)	Length Recovered (m)	Core Recovered (%)
Hole 472							
1	18	1240	3847.5-3853.0	0.0-5.5	5.5	5.33	97
2	18	1336	3853.0-3862.5	5.5-15.0	9.5	7.37	78
3	18	1443	3862.5-3872.0	15.0-24.5	9.5	4.48	47
4	18	1546	3872.0-3881.5	24.5-34.0	9.5	2.03	21
5	18	1652	3881.5-3891.0	34.0-43.5	9.5	2.85	30
6	18	1756	3891.0-3900.5	43.5-53.0	9.5	6.65	70
7	18	1908	3900.5-3910.0	53.0-62.5	9.5	6.80	72
8	18	2013	3910.0-3919.5	62.5-72.0	9.5	4.81	51
9	19	0112	3919.5-3929.0	72.0-81.5	9.5	5.82	61
10	19	0445	3929.0-3938.5	81.5-91.0	9.5	2.71	29
11	19	0557	3938.5-3948.0	91.0-100.5	9.5	5.86	62
12	19	1030	3948.0-3957.5	100.5-110.0	9.5	4.32	45
13	19	1205	3957.5-3959.5	110.0-112.0	2.0	0.05	3
14	19	1526	3959.5-3967.0	112.0-119.5	7.5	1.66	22
15	19	1843	3967.0-3976.0	119.5-128.5	9.0	2.51	28
16	20	0015	3976.0-3985.0	128.5-137.5	9.0	1.86	21
Total					137.5	65.11	47
Hole 472A							
1	20	1145	3941.8-3942.0	94.3-94.5	0.2	0.20	100
Total					0.2	0.20	100

nite and 5% pyrite in Core 11. A few pebbles (~1-8 cm long) of manganese-oxide-coated olive gray silty claystone are present within the oozes in Cores 11 and 13. Another salient feature of Unit 3 is the presence of two thin layers (6-9 cm thick) of grayish brown dolomitic nannofossil ooze near the base of this unit (Core 12). This sediment contains up to 25% dolomite rhombs.

Pillow basalt was encountered below the dolomitic ooze at 112 meters. A few thin yellowish green limestone interbeds (<8 cm thick) and siliceous sedimentary fragments are present within the basalt sequence (in Core 15). These sedimentary rock fragments contain scattered, altered basaltic glass fragments presumably derived from the fragmentation of the adjacent pillows.

### Igneous Rocks

Basaltic basement rocks encountered at Site 472 include hyaloclastitic breccias, slightly altered basaltic pillow lavas, and basalt pebbles. We define 11 cooling units in Cores 14, 15, and 16; each of these units is separated by glassy chilled margins or intercalated thin sediments (Fig. 7). Because of the poor recovery and the many pebble-size, unoriented fragments, these subdivisions of the basalt sequence are necessarily arbitrary and are not meant to carry any genetic implications, although each of the units in Core 15 could correspond fairly well to single basalt pillows. The top 80 cm of the basalt sequence at Site 472 are characterized by hyaloclastic breccia made up of angular basaltic glass and pillow margin fragments cemented with very light gray cryptocrystalline material (clay plus silica?). The rest of the basalt sequence is mainly basaltic pillow lavas and basaltic pebbles, with two sediment intercalations at 119.6 and 120 meters below the sea floor.

The basaltic pillow lavas and basaltic fragments are gray to dark gray and become brownish gray along fractures and the glassy chilled margins. Vesicles in these basalts are not abundant (<2-3%), are generally small in size (<0.5 mm), and are commonly filled with calcite and clay minerals. The pillow basalts and pebble-size basaltic fragments are mostly massive and aphanitic, and no phenocrystic mineral is visible macroscopically. Viewed through a microscope, these basalts vary in texture from aphyric to porphyritic and glomeroporphyritic, with plagioclase and occasional olivine microphe-nocrysts. These microphe-nocrysts are generally euhedral and range in size from 0.2 to 1 mm. The plagioclase microphe-nocrysts are normally zoned or have an optically homogeneous core of labradoritic composition with a thin rim of more sodic plagioclase. The ground-

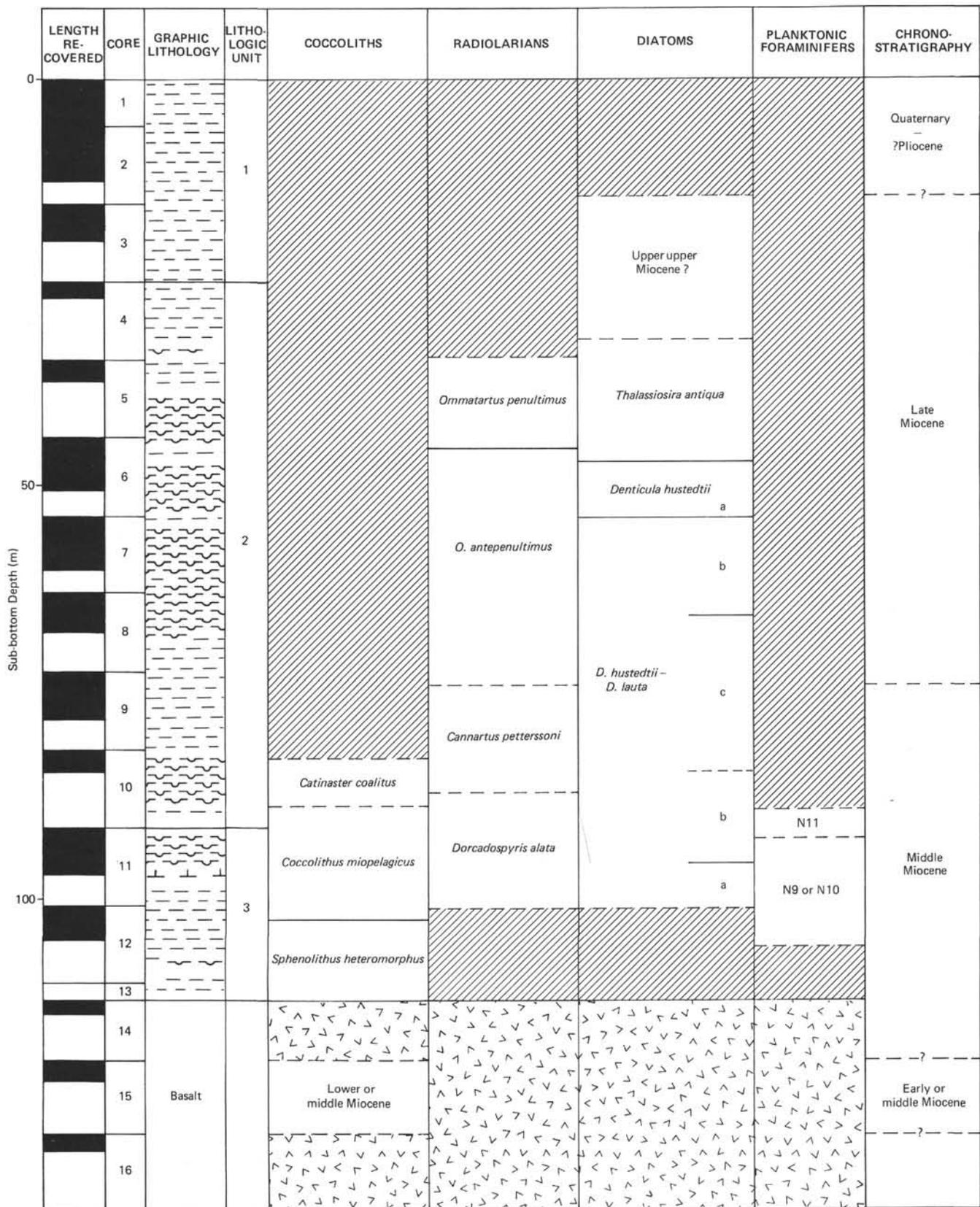


Figure 6. Lithologic and biostratigraphic summary, Site 472.

Table 2. Summary of lithologic units, Site 472.

Unit	Core Number	Depth below Sea Floor (m)	Chronostratigraphy	Lithology
1	1-3	0.0-24.5	lower Quaternary- upper Miocene	Clay.
2	4-10	24.5-91.0	upper Miocene middle Miocene	Diatomaceous ooze and clay.
3	11-13	91.0-112.0	middle Miocene	Diatom-nannofossil ooze, nannofossil diatomaceous clay, and dolomitic nannofossil ooze.

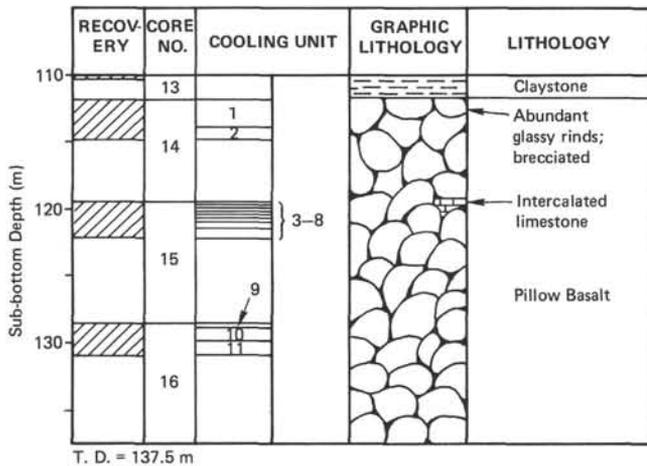


Figure 7. Igneous rock sequence at Site 472.

mass textures of specimens sampled from pillow margins vary from holohyaline to subvariolic, and locally to hyalopilitic. The pillow interiors usually show an intergranular texture with minute mesostasis between plagioclase laths and equant clinopyroxenes. The specimens sampled from pillow margins are characterized by skeletal microlites of plagioclase and feathery clinopyroxene with well-developed quench morphology.

The glassy fragments found in the hyaloclastic breccia are mostly fresh and clear brown, though some are partly devitrified. They are angular and range in grain size from 1 mm to 5 cm. Scattered euhedral plagioclase (<2%) occurs commonly as a microphenocryst phase in these glassy fragments.

### BIOSTRATIGRAPHY

At Site 472, lower Quaternary to (?)Pliocene red clay overlies upper upper Miocene diatomaceous clay, lower upper Miocene to upper middle Miocene diatomaceous ooze, and lower middle Miocene nannofossil-diatomaceous ooze. Figure 8 portrays microfossil abundances in Hole 472. Microfossil age control in the red clay is limited to the top of the hole (Sample 472-1-1, 1-2 cm), where Quaternary radiolarians are present. Rare to few diatoms and silicoflagellates in the core catchers of Cores 3 and 4 of Hole 472 are similar to those found in the upper upper Miocene at nearby Site 471. Abundant siliceous microfossils begin downhole in the lower part

of Section 1 of Core 5, where upper Miocene diatoms and radiolarians are present. The middle Miocene/upper Miocene boundary lies within Core 9 at the boundary between the *Ommatartus antepenultimus* and *Cannartus petterssoni* (radiolarian) Zones. Calcareous nannofossils in Sample 472-10,CC and planktonic foraminifers in Sample 472-11,CC indicate deposition above the CCD. *Sphenolithus heteromorphus* Zone coccoliths in Cores 12 and 13 above the basalt suggest a basement age of about 16 m.y. Figure 6 summarizes zone assignments for Site 472.

### Coccoliths

Cores 1 to 9 of Hole 472 and Core 1 of Hole 472A are barren of coccoliths. Middle Miocene coccolith assemblages, however, are common to abundant and moderately well preserved, ranging from the *Sphenolithus heteromorphus* Zone just above basalt in Core 13 (110-112 m) to the *Catinaster coalitus* Zone in Core 10 (81.5-91 m). A limestone from Hole 472, Section 15-1, is the only coccolith-bearing sediment recovered from the basalt interval at either hole. The low-diversity assemblage is dominated by *Cyclicargolithus floridanus* (Roth and Hay) and represents a residuum of durable species that probably belongs to the overlying *S. heteromorphus* Zone. A *S. heteromorphus* Zone assemblage occurs in a black manganese-oxide fragment in the core-catcher sample of Core 13. The zone extends as high as Section 12-2 within dark brown clay beds.

The overlying *Coccolithus miopelagicus* Subzone ranges upsection from Core 12 (100.5 m) to Sample 472-11-1, 10 cm (91 m). *Cyclicargolithus floridanus* is common throughout the subzone, suggesting that the top was not sampled. *Catinaster coalitus* Martini and Bramlette occurs in Sample 472-10,CC with *Coccolithus* sp. aff. *C. miopelagicus* Bukry, indicating the upper middle Miocene *Catinaster coalitus* Zone. Owing to poor recovery in Cores 10 and 11 or to a hiatus, the intervening *Discoaster kugleri* Subzone is missing.

### Silicoflagellates

In Hole 472, silicoflagellates are sparse to common and well preserved in Miocene Cores 3 to 12. The low-diversity assemblages of the *Dictyochoa fibula* Zone in Cores 3 to 5 (correlative with Cores 10 to 17 at Site 471) probably are upper Miocene on the basis of radiolarian dates at Site 471 (upper upper Miocene *Stichocorys peregrina* Zone). The assemblages are dominated by *Dictyochoa fibula* Ehrenberg, *D. brevispina* (Lemmermann), and *Distephanus speculum* (Ehrenberg). Older *Dictyochoa pulchella* Bukry is common in Cores 6 to 12. Mid-latitude guide *Distephanus pseudofibula* (Schultz) occurs in Core 6; elsewhere low-latitude assemblages prevail. Panicoid and elongate opal phytoliths (microfossils from terrestrial grasses) also occur in Core 6.

### Radiolarians

Rare to common, poorly preserved, nondiagnostic radiolarians were recovered from Section 1-1 through

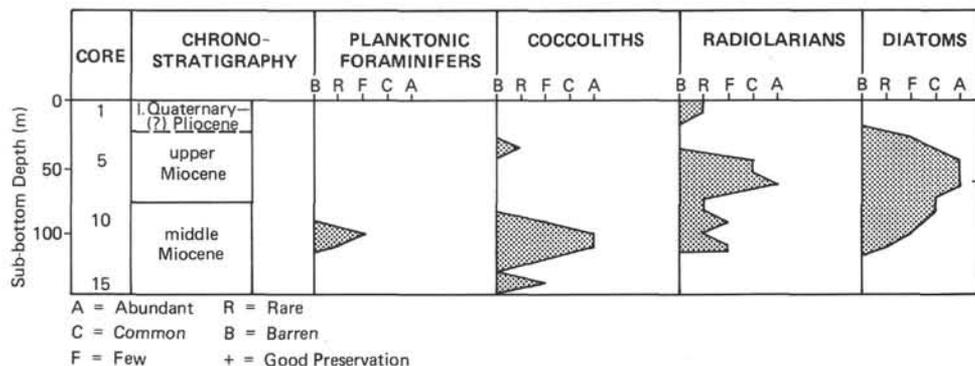


Figure 8. Plots of abundances of planktonic microfossils at Site 472.

Sample 1, CC. Cores 2 through 3 are barren; Cores 5 through 12 contain rare to abundant, poorly to well preserved radiolarian assemblages deposited in the late through middle middle Miocene. Sample 472-13, CC consists only of downhole contaminants.

The early Quaternary (? through late Pliocene) Sample 472-1-1, 1-2 cm contains a typical equatorial radiolarian assemblage (*Amphirhopalum ypsilon*, *Ommatartus tetrathalamus*, *Pterocanium praetextum*, *P. prismatum*, *Theocorythium trachelium*, *T. vetulum*, etc.), which lacks only the usually more frequent equatorial species *Spongaster tetras*.

The Miocene radiolarian assemblages are also composed of warm-water species. Section 4-1 yielded few, nondiagnostic radiolarians. Section 5-1 through Section 6-1, which contain *Ommatartus penultimus*, *O. antepenultimus*, *O. hughesi*, *Stichocorys peregrina*, *S. delmontensis*, and *S. wolffii*, can be assigned to the *O. penultimus* Zone. Because Riedel and Sanfilippo (1978) placed the boundary between *O. penultimus* and *O. antepenultimus* Zones immediately above the last occurrence of *O. hughesi*, the *O. penultimus* Zone would only include Section 5-1 at Site 472. Alternatively, this boundary can be drawn below the first appearance of *O. penultimus*. The lower upper Miocene (*O. antepenultimus* Zone) is indicated by the rare to common presence of *O. antepenultimus*, *O. hughesi*, rare to abundant occurrences of *S. delmontensis* and *S. wolffii* (Section 6-3 through Section 9-1), and by the absence of *O. penultimus* and *S. peregrina*. The boundary between middle and upper Miocene (i.e., the boundary between the *Cannartus petterssoni* and *O. antepenultimus* Zones) can either be drawn just below the first appearances of *O. hughesi* and *O. antepenultimus* (below Section 9-1) or above the last appearance of *C. petterssoni* (Section 8-1).

Upper middle Miocene (*C. petterssoni* Zone) is suggested for Section 9-3 (or Section 8-3) through Section 10-1, because of the presence of *C. petterssoni* and *C. laticonus* as well as less diagnostic species such as *S. delmontensis*, *S. wolffii*, and *Cyrtocapsella japonica*.

The deepest part of the succession at Site 472, below Section 10-1, possibly belongs to the *Dorcadospyrus alata* Zone, because it contains *C. laticonus* and lacks *C. petterssoni* and various species of *Cyrtocapsella*.

## Diatoms

Diatoms are common to abundant in the upper and middle Miocene sediments at Site 472. Cores 3 and 4 of Hole 472 contain relatively sparse assemblages that are similar to upper upper Miocene assemblages recovered at nearby Site 471, as revealed by the presence of *Denticula hustedtii*, *Thalassiosira antiqua*, and *Cussia* species. Diatoms increase in abundance downhole in Core 5 and are generally common to abundant through Core 11. Diagenesis removed all but the robust diatoms from Cores 12 and 13.

Samples 472-5-1, 120-122 cm through 472-6-2, 130-132 cm are assigned to the upper Miocene *Thalassiosira antiqua* Zone. The presence of *Nitzschia porteri* without *N. miocenica* in Sample 472-5-1, 140 cm indicates an age older than the upper part of paleomagnetic Epoch 7 and therefore older than Core 17 at nearby Site 471.

The interval from Sample 472-6-3, 130-132 cm through Sample 472-7-1, 10-12 cm is correlated with Subzone a of the *Denticula hustedtii* Zone. A possible short hiatus between Samples 472-6-4, 20-22 cm and 472-6-5, 10-12 cm is indicated by the presence of *Thalassiosira burckliana* in the former sample and the presence of *Coscinodiscus temperei* and *Rhizosolenia miocenica* in the latter sample. In middle latitudes of the North Pacific the first occurrence of *T. burckliana* is very high in Subzone a of the *D. hustedtii* Zone, whereas the last occurrences of *C. temperei* and *R. miocenica* are quite low in that subzone. Sample 472-6-5, 10-12 cm contains abundant, well preserved diatoms including common *Denticula hustedtii*. Sample 472-6-4, 20-22 cm, however, displays poor diatom preservation with rare *D. hustedtii*. This apparent hiatus corresponds with a hiatus recognized at Site 469 and may reflect a regional paleoceanographic event such as a dissolution cycle or erosion associated with increased bottom currents.

Sample 472-7-1, 77-79 cm through Sample 472-12-1, 21-23 cm are assigned to the *Denticula hustedtii-D. lauta* Zone. This interval is further subdivided into the following subzones: Subzone d—Samples 472-7-1, 77-79 cm through 472-8-2, 120-122 cm; Subzone c—Samples 472-8-3, 30-32 cm through 472-10-2, 80-82 cm; Subzone b—Samples 474-11-1, 35-37 cm through

472-11-3, 35–37 cm; and Subzone a—Samples 472-11-4, 28–30 cm through 472-12-1, 21–23 cm. The middle Miocene/upper Miocene boundary is placed in the upper part of Subzone c, in the lower part of Core 8. Because preservation is poor in the lower part of the hole, the correlation of Subzone a is tentative.

Although the middle- to high-latitude diatom zonation was employed at this site, low-latitude diatoms are a consistent component of the assemblage.

### Foraminifers

Foraminifers are sparse and moderately well preserved in Cores 11 and 12 of Hole 472. Planktonic taxa encountered include *Globigerinoides sacculifer*, *Globigerina bulloides*, *G. obesa*, *Globoquadrina altispira*, and *Orbulina universa*. The occurrence of *Globorotalia praefohsi* in Section 11-1, indicates at least part of Core 11 is referable to Zone N11.

### SEDIMENT ACCUMULATION RATES

Selected coccolith (C), radiolarian (R), diatom (D), and planktonic foraminiferal (F) events are used to construct the sediment accumulation rate curve (Fig. 9) for Site 472. The plot indicates rates of about 5 m/m.y. for the Quaternary through latest Miocene (Cores 1–4) and about 8 m/m.y. for most of the late Miocene and the middle Miocene. No significant stratigraphic gaps are indicated.

### GEOCHEMICAL MEASUREMENTS

#### Interstitial Water

The salinity, chlorinity, alkalinity, and calcium and magnesium concentrations of the pore waters from

three samples were determined on board. These samples span the entire sediment thickness at Site 472. The sedimentary column at the site is very thin, and the pore water chemistry shows only very minor changes from sea water. There is a slight increase in calcium and decrease in magnesium in the pore waters (Fig. 10).

### Calcium Carbonate Content

Calcium carbonate contents of samples from Hole 472 determined by the carbonate-bomb technique are included with the core descriptions in this chapter and plotted in Figure 11. Like Site 471, this site is dominated by noncalcareous pelagic and biogenic sediments; all but three samples from Site 472 are noncalcareous. Unit 3 contains some siliceous nannofossil clays and oozes, which contain up to 50% CaCO<sub>3</sub>.

### PHYSICAL PROPERTIES

Figure 11 summarizes the physical-properties data at Site 472. Although we recognize three lithologic units in the sedimentary section, density and velocity profiles do not show corresponding breaks. On the contrary, both density and velocity remain constant throughout the sedimentary section (1.47 g/cm<sup>3</sup> and 1.50 km/s, respectively) and increase abruptly only at the top of the basalt at 112 meters. The average density and velocity of the basalt are 2.79 g/cm<sup>3</sup> and 5.51 km/s, respectively. The impedance contrast for the boundary between sediment and basalt is 0.75.

We made one run with the U/K heat-flow probe, stopping at 88 meters in the sediment for 20 minutes, then raising the probe to the mudline and holding for 10 minutes to get a bottom-water temperature. Figure 12 displays the results. The bottom-water temperature was

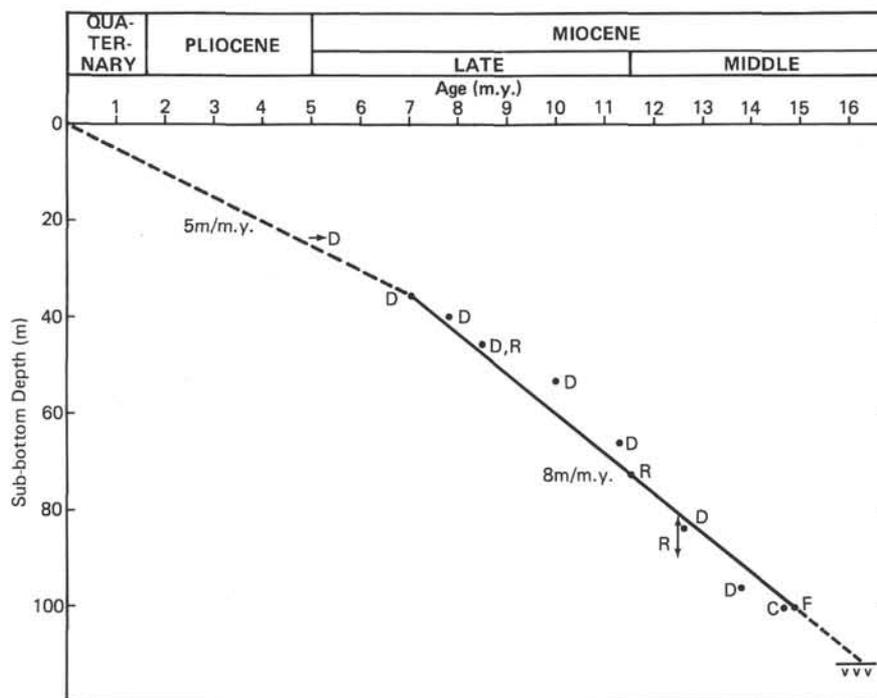


Figure 9. Sediment accumulation rates, Site 472.

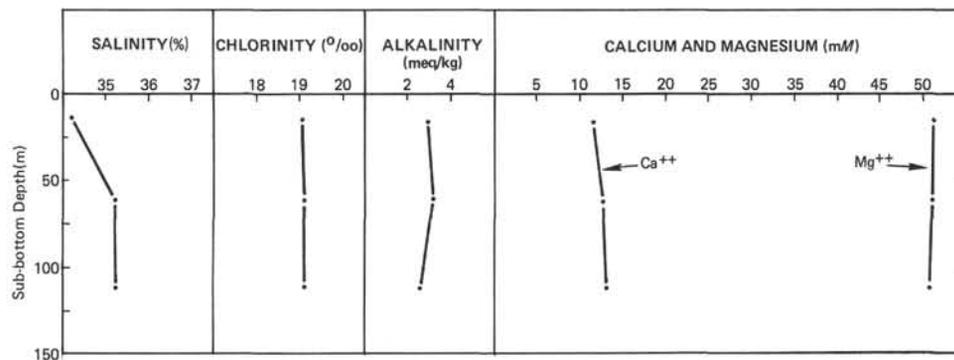


Figure 10. Interstitial water profiles, Site 472.

slightly variable, averaging about 1.9°C. The sediment temperature at a depth of 88 meters increased slightly from 14°C to 14.3°C during the measurement. The computed geothermal gradient is 141°C/km. The approximate heat flow, assuming a value of 1.9 kcal/cm s °C for the thermal conductivity of the sediment is 2.7 HFU (heat-flow units).

#### CORRELATION OF REFLECTION PROFILE WITH DRILLING RESULTS

Correlation of the reflection profile obtained by the *Glomar Challenger* approaching Site 472 (Fig. 5) and the drilling results are shown in Figure 13. The upper units of Quaternary to Miocene clay and clayey diatomaceous ooze appear as the light upper layer on the profile. The diatomaceous oozes and diatom-rich interbeds within this clay-rich part of the section probably produce the several sets of strong paired reflectors within this upper acoustic unit. The underlying acoustic unit, which includes the lower part of Lithologic Unit 2 and all of Unit 3, appears as a darker, more closely spaced, and more continuous sequence of reflectors. In this sequence, the number of diatomaceous and nannofossil interbeds increases, which probably accounts for the increased number of strong reflectors. Although basaltic basement at 0.15 s sub-bottom shows only a weak contrast with the overlying sedimentary layers, it can be distinguished by its irregular relief.

#### CONCLUSIONS

1. Site 472 provides a biostratigraphic reference section for middle and lower upper Miocene siliceous microfossils at the southern, distal end of the California

Current. The section contains a mixture of high- and low-latitude siliceous assemblages.

2. The oldest sediments contain microfossils of this *Sphenolithus heteromorphus* Zone,  $16 \pm 0.5$  m.y. old; this age is also indicated by magnetic anomalies at the site. The oldest sediments at this site are about the same age as those at Site 471. The sediments are underlain by fresh, olivine-bearing pillow basalt, brecciated in the upper part.

3. The transition downsection from unfossiliferous red clay in Core 3 to highly siliceous ooze in Core 5 occurred in the latest Miocene, about 7 to 5 m.y. ago. This transition is attributed to either a narrowing of upwelling areas in the northeastern Pacific about 7 m.y. ago or to tectonic translation of Site 472 from a high- to low-productivity region at this time. The transition that took place at this site 7 to 5 m.y. ago occurred in the same time interval as did the hiatus in the biostratigraphic record at Site 470. The upper part of the siliceous sequence at Site 472 is the same age as the base of the siliceous sequence at Site 471.

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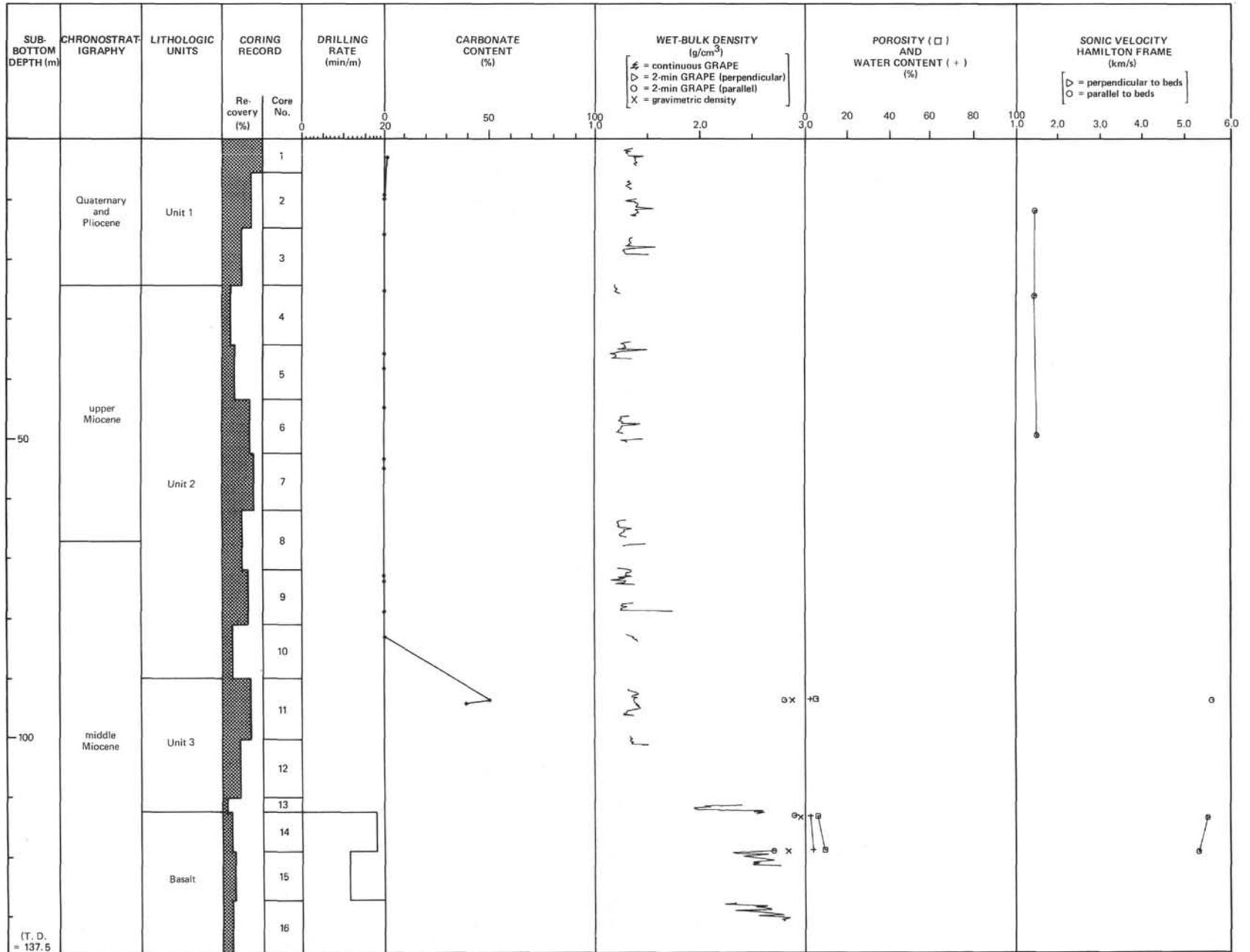


Figure 11. Summary of physical properties at Site 472.

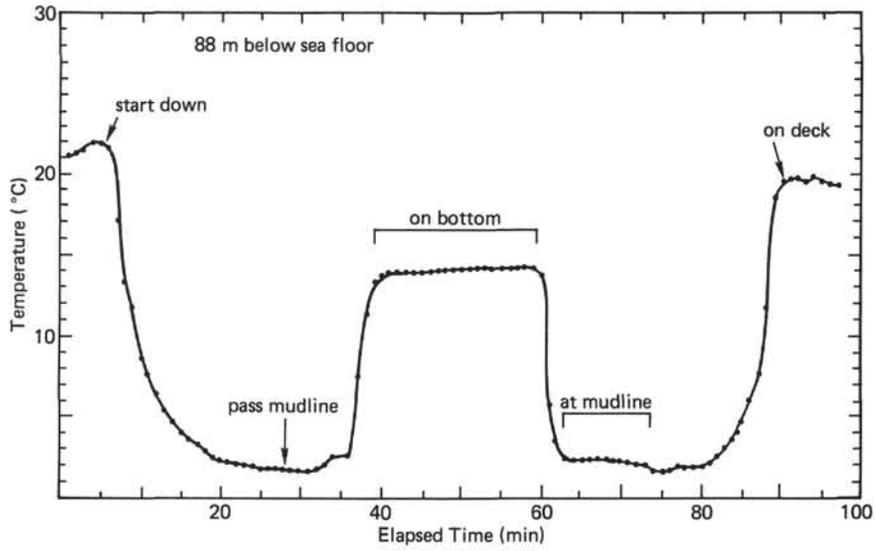


Figure 12. Heat-flow-probe run, Site 472. (See text for explanation.)

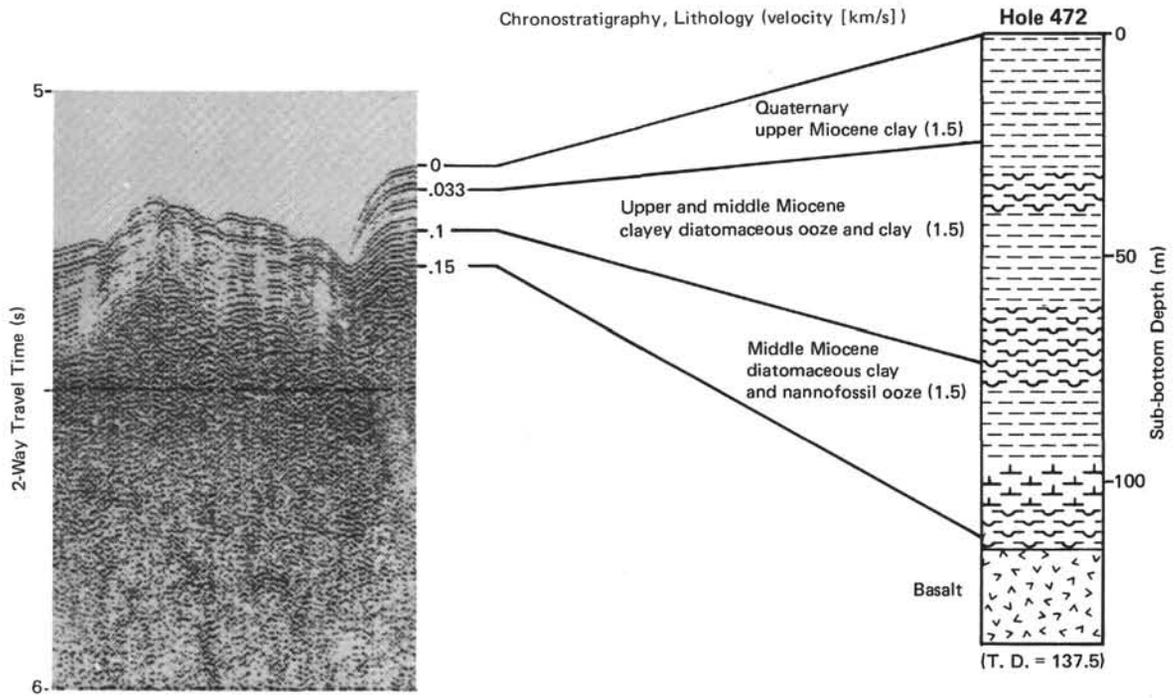


Figure 13. Correlation of *Challenger* seismic-reflection profile with lithologic units at Site 472.

SITE 472		HOLE			CORE 1		CORED INTERVAL 0.0-5.5 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE REGISTRY	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	MAMMOFOSILS	RADIOLARIANS				
LOWER QUATERNARY	PLIOCENE? TO QUATERNARY (R)	B	F	P	0.5		*	VOID
		B			1.0			
		B			1.5			10YR 5/4
		B			2.0			5YR 3/2
		B			2.5			10YR 5/4
		B			3.0			5YR 3/2
		B			3.5			10YR 5/4
		B			4.0			5YR 3/2
		B	RP	B	4.5			10YR 5/4
		B	RP	B	5.5			5YR 3/2

CLAY, moderate yellowish brown (10YR 5/4) mottled with streaks and patches of grayish brown (5YR 3/2). Darker colored sediment contains abundant iron oxides. Intense drilling deformation.

**ORGANIC CARBON AND CARBONATE**  
3-70  
% Organic Carbon -  
% CaCO<sub>3</sub> 1

**SMEAR SLIDE SUMMARY**  
1-13 2-97  
(D) (D)

**TEXTURE:**  
Sand - -  
Silt 10 4  
Clay 90 96

**COMPOSITION:**  
Quartz 2 2  
Feldspar TR TR  
Mica TR TR  
Heavy minerals TR 1  
Clay 90 95  
Volcanic glass TR 1  
Pyrite 1 1  
Carbonate unsp. - TR  
Sponge spicules TR TR  
Fe-oxides 6 -

SITE 472		HOLE			CORE 2		CORED INTERVAL 5.5-15.0 m	
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE REGISTRY	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	MAMMOFOSILS	RADIOLARIANS				
PLIOCENE(?)		B			5.5		*	CLAY, moderate yellowish brown (10YR 5/4) with some moderate brown (5YR 3/4) and grayish brown streaks. Clay is fairly homogeneous throughout. A deformed layer of greenish gray (5GY 6/1, volcanic rich?) clay occurs in Section 5. Intense drilling deformation.
		B			6.0			
		B			6.5			VOID
		B			7.0			10YR 5/4
		B			7.5			5YR 3/2
		B			8.0			10YR 5/4
		B			8.5			5YR 3/2
		B			9.0			10YR 5/4
		B			9.5			5YR 3/4
		B			10.0			10YR 5/4

CLAY, moderate yellowish brown (10YR 5/4) with some moderate brown (5YR 3/4) and grayish brown streaks. Clay is fairly homogeneous throughout. A deformed layer of greenish gray (5GY 6/1, volcanic rich?) clay occurs in Section 5. Intense drilling deformation.

**ORGANIC CARBON AND CARBONATE**  
3-95 3-97  
% Organic Carbon - 0.23  
% CaCO<sub>3</sub> 0 0

**SMEAR SLIDE SUMMARY**  
1-40 5-55  
(D) (M)

**TEXTURE:**  
Sand - -  
Silt 5 5  
Clay 95 95

**COMPOSITION:**  
Quartz 2 2  
Feldspar 1 1  
Mica TR TR  
Heavy minerals - -  
Clay 95 95  
Volcanic glass(?) 1 12 (Fe-oxides?)  
Pyrite TR TR  
Carbonate unsp. TR TR

SITE 472 HOLE CORE 3 CORED INTERVAL 15.0-24.5 m

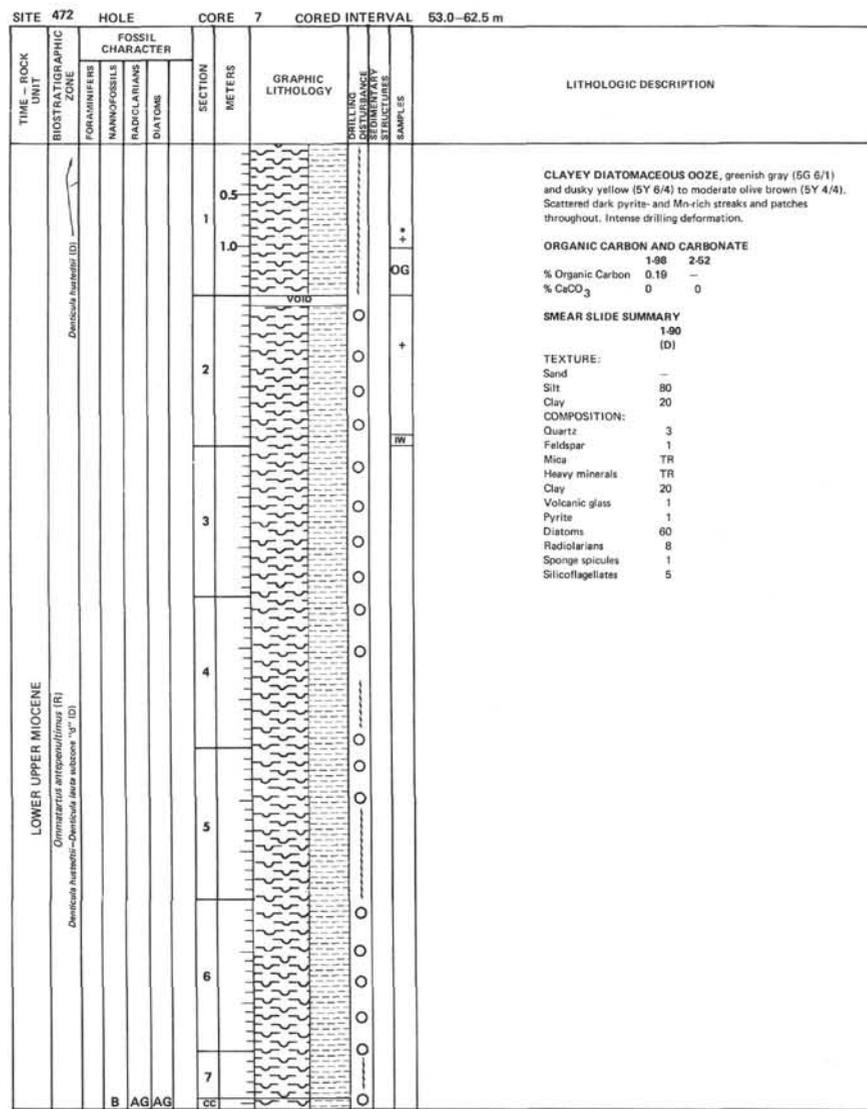
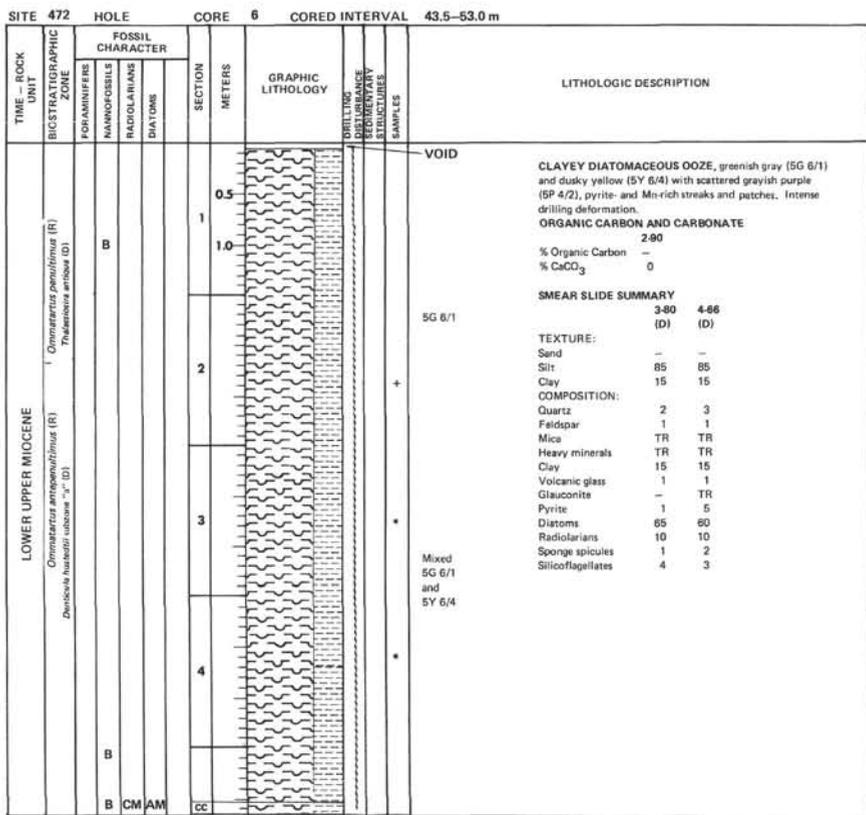
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	STRAIPLINES	SAMPLES	LITHOLOGIC DESCRIPTION	
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS							DIATOMS
UPPER MIOCENE(?)	UPPER UPPER MIOCENE TO LOWER MIOCENE (ID)				0.5					VOID  CLAY, moderates yellowish brown (10YR 5/4) with some grayish brown (5YR 3/2) to olive gray (5Y 3/2) patches and streaks. Darker colored sediment may contain more Fe-oxides. A deformed layer of greenish gray (5GY 6/1) clay with sharp upper and lower contacts occurs in Section 3. Intense drilling deformation.  ORGANIC CARBON AND CARBONATE 1-114 % Organic Carbon - % CaCO <sub>3</sub> 0  SMEAR SLIDE SUMMARY 3-57 (M)  TEXTURE: Sand - Silt 5 Clay 95 COMPOSITION: Quartz 1 Feldspar TR Mica TR Heavy minerals TR Clay 95 Volcanic glass(?) 1 Pyrite TR Diatoms TR Radiolarians 1 Sponge spicules 2 Silicoflagellates TR	
					1.0						10YR 5/4
					2.0						5GY 6/1
		B	B	FM							
					3.0						
					CC						

SITE 472 HOLE CORE 4 CORED INTERVAL 24.5-34.0 m

TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	STRAIPLINES	SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS						
UPPER MIOCENE(?)	U. U. MIOCENE TO LOWER PLEISTOCENE (ID) NEOGENE(?) (N)				0.5					CLAY, greenish gray (5GY 6/1) with scattered medium bluish gray (5B 5/1) streaks and patches. Color of sediments contrasts sharply with Core 3. Siliceous microfossils more abundant than in Core 3 (see Smear Slides). Intense drilling deformation.  No Core-Catcher. ORGANIC CARBON AND CARBONATE 1-38 % Organic Carbon - % CaCO <sub>3</sub> 0  SMEAR SLIDE SUMMARY 1-10 1-50 (D) (D)  TEXTURE: Sand - - Silt 7 13 Clay 93 87 COMPOSITION: Quartz 1 1 Feldspar TR TR Mica TR TR Heavy minerals TR TR Clay 93 87 Volcanic glass 1 1 Pyrite TR 1 Diatoms 2 3 Radiolarians 1 3 Sponge spicules 2 4 Silicoflagellates TR -
					1.0					
		B			2.0					
		RP	B	FP						

SITE 472 HOLE CORE 5 CORED INTERVAL 34.0-43.5 m

TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE	STRAIPLINES	SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS						
UPPER MIOCENE	<i>Omniscalaria penultima</i> (lower) (P) <i>Thalassipora arctica</i> (ID)				0.5					CLAY, light olive gray (5Y 5/2) and homogeneous. Contains less than 10% diatoms and siliceous microfossils. Sediment changes to greenish gray (5G 6/1) CLAYEY DIATOMACEOUS OOZE at ~130 cm in Section 1. Change in lithology is marked by a distinct color change at this depth in core. Greenish gray ooze contains medium bluish gray (5B 5/1), dusky yellow (5Y 6/4), and medium dark gray (N4) streaks, patches and thin layers. Intense drilling deformation.  No Core-Catcher.  ORGANIC CARBON AND CARBONATE 1-64 2-115 % Organic Carbon - 0.22 % CaCO <sub>3</sub> 0 0  SMEAR SLIDE SUMMARY 1-100 1-128 1-140 2-10 (D) (D) (D) (D)  TEXTURE: Sand - - - - Silt 16 80 90 85 Clay 84 40 10 15 COMPOSITION: Quartz 1 1 2 2 Feldspar 1 1 1 TR Mica TR TR TR TR Heavy minerals - TR - - Clay 84 50 10 1 Volcanic glass 1 2 1 - Pyrite 1 1 - 1 Diatoms 5 25 70 80 Radiolarians 3 15 15 10 Sponge spicules 3 5 1 1 Silicoflagellates 1 TR 10 10
					1.0					
					2.0					
		B		AG						
		B	CM	AM						



TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE INDICATED BY STRONGLY STRUCTURED SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	DIATOMS				
		RADIOLARIANS	DIATOMS					
LOWER UPPER MIOCENE	<i>Ommatartus antipapillatus</i> (R) <i>Denticula laeta</i> subzone "c" (D)						<p>CLAYEY DIATOMACEOUS OOZE, greenish gray (5G 6/1) and dusky yellow (5Y 8/4) to moderate olive brown (5Y 4/4). Contains scattered grayish purple pyrite- and Mn-rich patches and streaks throughout. Intense drilling deformation.</p> <p>No Core-Catcher</p> <p><b>SMEAR SLIDE SUMMARY</b> 1-50 (D)</p> <p>TEXTURE: Sand - Silt 80 Clay 20</p> <p>COMPOSITION: Quartz 3 Feldspar 2 Mica TR Heavy minerals TR Clay 20 Volcanic glass 1 Pyrite 1 Diatoms 60 Radiolarians 5 Sponge spicules 3 Silicoflagellates 5</p>	
				0.5 1.0				
				2				
				3				
				4				

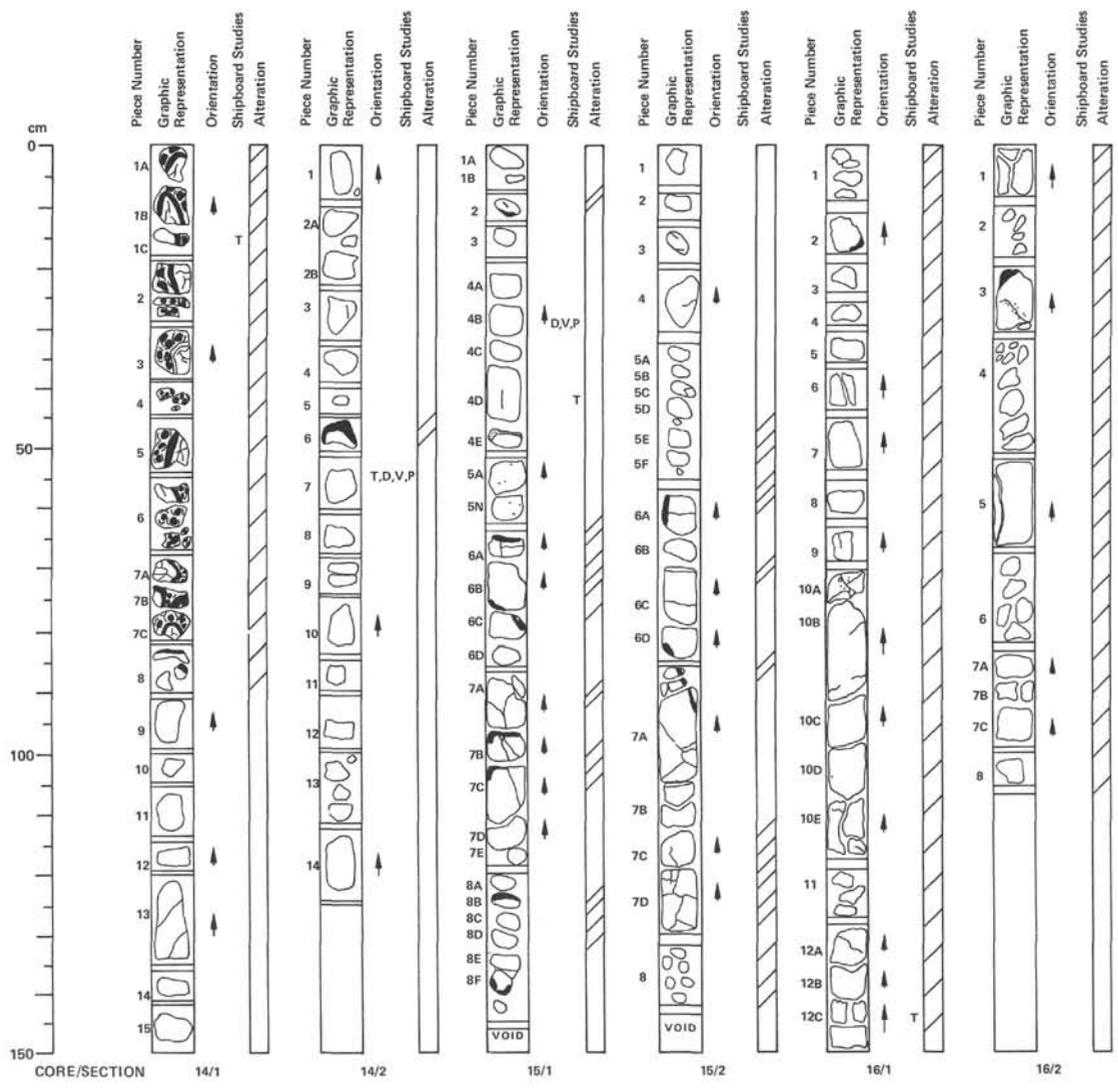
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE INDICATED BY STRONGLY STRUCTURED SAMPLES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	DIATOMS				
		RADIOLARIANS	DIATOMS					
UPPER MIDDLE MIOCENE	<i>Ommatartus antipapillatus</i> (R) <i>Denticula laeta</i> subzone "c" (D)						<p>DIATOMACEOUS CLAY, grayish green (5G 5/2) changing down core (in Section 1) to grayish green to greenish gray (5G 5/1) CLAY. Several patches of grayish yellow green (5GY 7/2) VITRIC ASH in Section 1. Grayish purple pyrite- and Mn-rich patches and streaks scattered throughout. Intense drilling deformation.</p> <p><b>ORGANIC CARBON AND CARBONATE</b> 1-58 1-110 4-70 % Organic Carbon 0.14 - - CaCO<sub>3</sub> 0 0 0</p> <p><b>SMEAR SLIDE SUMMARY</b> 1-50 1-127 4-45 (D) (D) (D)</p> <p>TEXTURE: Sand - - - Silt 10 13 10 Clay 90 87 90</p> <p>COMPOSITION: Quartz 5 3 7 Feldspar 1 TR 1 Mica 1 TR 1 Heavy minerals - - TR Clay 54 87 85 Volcanic glass 3 1 - Glauconite TR - TR Pyrite TR TR 1 Calc. Nannofossils - TR - Diatoms 18 6 1 Radiolarians 15 1 2 Sponge spicules 2 2 2 Silicoflagellates 1 TR TR</p>	
				0.5 1.0				
				2	VOID			
				3	VOID			
				4	VOID			
				5				

SITE 472		HOLE		CORE 10		CORED INTERVAL 81.5-91.0 m			
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER				SECTION METERS	GRAPHIC LITHOLOGY	LITHOLOGIC DESCRIPTION	
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS				
		DRILLING DEPTH (M)	DRILLING DEPTH (M)	DRILLING DEPTH (M)	DRILLING DEPTH (M)				
MIDDLE MIOCENE	<i>Dorcadopyriza alata</i> (R) - <i>Canonius petrosorum</i> (R) <i>Denticula nuttalli</i> - <i>Denticula leira</i> subzone "c" (D)	B				0.5		Mottled 5G 5/1 and 10YR 5/4  CLAYEY DIATOMACEOUS OOZE, medium greenish gray (5G 5/1) changing down core to greenish gray and moderate yellowish brown (10YR 5/4) DIATOMACEOUS CLAY. Several patches of pale olive (10Y 6/2) VITRIC ASH in Core-Catcher. Contains scattered pyrite- and Mn-rich streaks. Intense drilling deformation.  ORGANIC CARBON AND CARBONATE 1-80 % Organic Carbon - % CaCO <sub>3</sub> 0  SMEAR SLIDE SUMMARY 1-100 2-75 (D) (D)  TEXTURE: Sand - - Silt 60 36 Clay 40 64  COMPOSITION: Quartz TR 6 Feldspar - TR Mica - TR Heavy minerals - TR Clay 40 64 Volcanic glass 2 3 Pyrite - 1 Diatoms 52 21 Radiolarians 5 5 Sponge spicules 1 TR Silicoflagellates TR TR	
		B				1.0			
		B							
		RG							
		B							
		FP							
		RP							
		FM	FP	FP	FP				
		CC							

SITE 472		HOLE		CORE 11		CORED INTERVAL 91.0-100.5 m			
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER				SECTION METERS	GRAPHIC LITHOLOGY	LITHOLOGIC DESCRIPTION	
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS				
		DRILLING DEPTH (M)	DRILLING DEPTH (M)	DRILLING DEPTH (M)	DRILLING DEPTH (M)				
MIDDLE MIOCENE	<i>Coccolithus hupelaghius</i> (N) - <i>Dorcadopyriza alata</i> (R) <i>Denticula nuttalli</i> - <i>Denticula leira</i> subzone "b" (D) <i>Denticula nuttalli</i> - <i>Denticula leira</i> subzone "a" (D)	AM				0.5		VOID  Silty claystone clast Glauconite  Silty claystone clast 5G 8/1  NB  Ash, glauconite and pyrite  5G 4/1  Interbedded DIATOM NANNOFOSSIL OOZE AND DIATOM NANNOFOSSIL CLAY. Ooze is light greenish gray (5GY 8/1) and light gray (N8) to medium greenish gray (5GY 7/1) and occurs from Section 1, -100 cm, to Section 3, 130 cm. Contacts with more clay-rich sediment above and below are gradational. Clay is dark greenish gray (5G 4/1) to light greenish gray (5GY 8/1). Minor patches of VITRIC ASH occur in Sections 1 and 2 and two fragments of olive gray (5Y 3/2) silty claystone are in Section 1 (clast at 140 cm is 8 cm long). Glauconite and pyrite occur locally as marked. Intense drilling deformation.  ORGANIC CARBON AND CARBONATE 2-88 2-91 % Organic Carbon - 0.17 % CaCO <sub>3</sub> 50 38  SMEAR SLIDE SUMMARY 140 2-51 2-108 3-148 4-86 (D) (D) (D) (M) (D)  TEXTURE: Sand - - - - Silt 30 17 37 - 10 Clay 70 83 63 - 90  COMPOSITION: Quartz 1 1 - 1 5 Feldspar - - - - 1 Mica TR - - TR - Clay 50 15 9 45 53 Volcanic glass 5 2 2 - - Glauconite - - - 3 TR Pyrite TR TR TR 5 TR Carbonate unsp. - - - 1 - Foraminifers - TR TR TR TR Calc. Nannofossils 20 66 54 40 25 Diatoms 20 9 35 3 10 Radiolarians 4 7 - 1 5 Sponge spicules TR - - 1 1 Silicoflagellates - TR - TR TR	
		AM				1.0			
		AM							
		AM							
		AM							
		AM							
		AM							
		AM							
		AM							
		AM							

SITE 472		HOLE		CORE 12		CORED INTERVAL 100.5-110.0 m		
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE IDENTIFICATION STRUCTURES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS				
LOWER MIDDLE MIOCENE	Dorcasoptyris allea (R) Denticula humeralis Denticula bairdii subzone "1" (D)	CM		RP	0.5			<p><b>CLAY</b>, grayish orange (10YR 7/4) mottled with medium gray (N5) and greenish gray (5G 6/1) patches and streaks. Layers of grayish brown (5YR 3/2) <b>FE-OXIDE-RICH DOLOMITIC NANNOFOSSIL OOZE</b> occur in Sections 2 and 4. Contacts with surrounding clay are sharp. Dolomite occurs as rhombs, Fe-oxides as small, reddish brown aggregates. Drilling breccia in Sections 5-CC may contain sediment cavings from higher in the hole. Moderate to intense drilling deformation.</p> <p><b>ORGANIC CARBON AND CARBONATE</b> 2-8 % Organic Carbon - % CaCO<sub>3</sub> 0</p> <p><b>SMEAR SLIDE SUMMARY</b> 2-54 (D)</p> <p><b>TEXTURE:</b> Sand - Silt 40 Clay 60</p> <p><b>COMPOSITION:</b> Clay 9 Volcanic glass TR Carbonate unspec. 2 Foraminifers 1 Calc. Nannofossils 51 Fe-oxides 11 Dolomite 26</p>
		CM FP		RP RP	1.0			
		AM AM			2			VOID
					3			
		AM AM			4			
					5			
		AM FM			6			
		FM FP			CC			

SITE 472		HOLE		CORE 13		CORED INTERVAL 110.0-112.0 m		
TIME - ROCK UNIT	BIOSTRATIGRAPHIC ZONE	FOSSIL CHARACTER			SECTION METERS	GRAPHIC LITHOLOGY	DRILLING DISTURBANCE IDENTIFICATION STRUCTURES	LITHOLOGIC DESCRIPTION
		FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS				
		FM			CC			<p>Claystone fragment</p> <p>Drilling breccia of olive gray (5Y 5/2) to grayish orange (10YR 7/4) <b>CLAY</b>. Angular olive gray (5Y 3/2) <b>CLAYSTONE</b> fragment in breccia has Mn crust.</p> <p><b>NOTE:</b> Fragments of MnO<sub>2</sub> crust contain coccoliths of <i>Sphenolithus heteromorphus</i>. This lithology is not present above this core. Soft sediments are barren of coccoliths and are probably downhole slumped material.</p>
					1			



**SITE 472, CORE 14, SECTIONS 1-2, 112.0-114.8 m**

**MAJOR ROCK TYPE - BASALT**

**Macroscopic Description**

Basalt - medium dark gray, aphyric, fresh to moderately altered. Pieces 1-8 in Section 1 contain many glassy margins. Within individual pieces the glassy rinds grade to breccias composed of angular fragments of black basaltic glass with yellowish brown palagonitic rinds (some completely altered to palagonite). White noncalcareous (siliceous?) material occurs between (cements?) fragments. Pieces 9-15 in Section 1 are fresh aphyric basalt almost without fractures. Piece 6 in Section 2 has a glassy margin, remainder is aphyric basalt.

**Thin Section Descriptions**

Basalt - Section 1, Piece 1C, 13-15 cm (glassy margin)  
 Texture: glomeroporphyritic with holohyaline groundmass  
 Phenocrysts: plagioclase, 2%, 0.5-1 mm, euhedral, clusters of laths  
 Groundmass: plagioclase, 5%, <0.1 mm, euhedral, small laths; glass, 71%, fresh glass = 30% - devitrified spherulitic glass = 40%; opaques, 2%  
 Alteration: clay/silica(?) (10%) cements glassy fragments together; zeolites (TR) occur in cracks

**Basalt - Section 2, Piece 7, 55-57 cm (next to glassy margin)**

Texture: glomeroporphyritic with hyalopilitic groundmass  
 Phenocrysts: plagioclase, 1%, 0.2-0.3 mm, euhedral, clusters of laths  
 Groundmass: plagioclase, 30%, 0.05-0.1 mm, acicular prisms; clinopyroxene, 30%, 0.01-0.03 mm, equant to dendritic; 36%, partially devitrified glass  
 Vesicles: 2-3%, 0.2-0.5 mm, circular, mostly empty but few filled with brown clay

**Shipboard Data**

Sample	D	V (t)	V (L)	P
Section 2, Piece 7, 55 cm	2.94	5.55	-	5

**SITE 472, CORE 15, SECTIONS 1-2, 119.5-122.4 m**

**MAJOR ROCK TYPE - BASALT**

**MINOR ROCK TYPE - LIMESTONE, SILICEOUS(?) ROCK**

**Macroscopic Descriptions**

Basalt - medium dark gray, aphyric, fresh to moderately altered and fractured. Glassy margins in some pieces as marked. Alteration common in these pieces in form of yellowish brown palagonite. Brownish alteration rinds surround fractures. Calcite fills some fractures.

Limestone - Pieces 5A-8 in Section 1 are yellowish gray (5Y 8/1) with crystalline limestone with scattered inclusions of altered glass. Contact with basalt not recovered. Coccoliths in the limestone (Piece 8) are lower or lower middle Miocene and one moderately preserved.

Siliceous(?) Rock - Piece 2 in Section 1 is yellowish gray (5Y 8/1) siliceous(?) material with altered glass inclusions.

**Thin Section Descriptions**

Basalt - Section 1, Piece 4D, 40-42 cm  
 Texture: aphyric with intergranular groundmass  
 Phenocrysts: -  
 Groundmass: plagioclase, 4%, 0.1-0.2 mm, euhedral, prismatic laths; clinopyroxene, 30%, 0.05-0.1 mm, anhedral, equant; opaques, 10%, <0.05 mm, cubic; mesostasis, 2-3%  
 Vesicles: 2-3%, 0.2 mm, circular, empty or filled with calcite

**Shipboard Data**

Sample	D	V (t)	V (L)	P
Section 1, Piece 4B, 29 cm	2.82	5.33	-	9

**SITE 472, CORE 16, SECTIONS 1-2, 128.5-131.1 m**

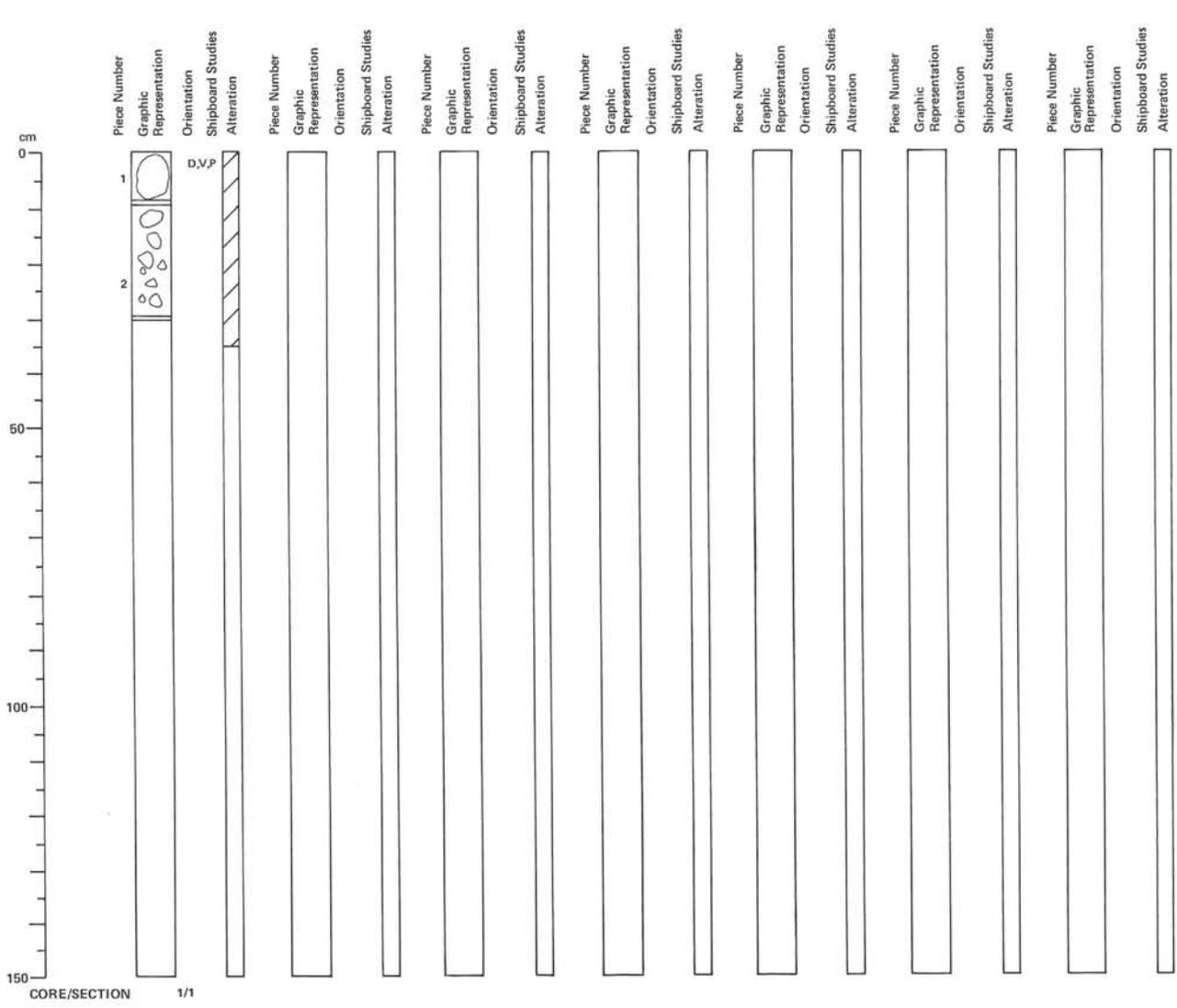
**MAJOR ROCK TYPE - BASALT**

**Macroscopic Description**

Basalt - medium dark gray, aphyric, moderately altered and slightly fractured. Glassy margins on Piece 2, Section 1 and Piece 5, Section 2. Calcite and clay fill some fractures. Brownish alteration rind commonly surrounds fractures.

**Thin Section Description**

Basalt - Section 1, Piece 12C, 142-144 cm  
 Texture: glomeroporphyritic with subvolcanic groundmass  
 Phenocrysts: olivine, 3%, 0.5-1.0 mm, euhedral; plagioclase, 3%, 0.5-1.0 mm, euhedral, laths  
 Groundmass: plagioclase, 32%, 0.05-0.2 mm, skeletal; clinopyroxene, 40%, 0.02-0.1 mm, feathery, dendritic; opaques, TR, 0.01-0.03 mm; mesostasis, 20%  
 Vesicles: 1%, 0.5-0.7 mm, irregular, filled with calcite or clay



HOLE 472A, CORE 1, SECTION 1, 94.3-94.5 m

MAJOR ROCK TYPE - BASALT

Macroscopic Description

Basalt - medium dark gray, aphyric, moderately altered. Calcite and clay fill vesicles (<0.5 mm)

Shipboard Data

Sample	D	V (i)	V (l)	P
Section 1, Piece 1, 3 cm	2.86	5.65	-	4

