3. SITE 327

The Shipboard Party[1]
With Additional Reports From
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SITE DATA

Date Occupied: 13-17 April 1974

Time on Site: 107 hours, 2 minutes

Position (satellite): 50°52.28′S, 46°47.02′W

Number of Holes: 2

Water Depth: 2400 corrected meters (echo sounding)

Bottom Felt at: 2411 meters (drill pipe)

Penetration:
Hole 327: 5.5 meters
Hole 327A: 469.5 meters

Number of Cores:
Hole 327: 1
Hole 327A: 27

Total Core Recovered:
Hole 327: 5.5 meters (100%)
Hole 327A: 128.1 meters (50%)

Age of Oldest Sediments: Neocomian?-Aptian

Acoustic Basement: Not reached, but estimated to lie approximately 940 meters below the sea bed.

Summary: Site 327, in 2400 meters of water on the western nose of the elevated eastern part of the Falkland Plateau, the Maurice Ewing Bank, was chosen to examine Southern Ocean shallow-water pre-Neogene biostratigraphy and to identify seismic reflectors of regional extent. The first hole was abandoned in bad weather after recovery of only a surface core, but the second was cored continuously to 118 meters and intermittently to 469.5 meters before also being abandoned due to excessive ship motion. Twenty-eight cores were taken, with 50% recovery. Ten meters of Quaternary ice-rafted terrigenous debris with manganese nodules overlie a sequence of upper-Paleocene to lower Eocene alternating siliceous ooze and zeolitic clay 80 meters thick. Hiatuses occur above this sequence (Eocene to Quaternary) and below (late Maestrichtian to late Paleocene). Below 52 meters of Maestrichtian foram-nanno ooze lies a condensed section, up to 12 meters, of Santonian zeolitic clay with probably a Turonian-Coniacian hiatus. Below 154 meters subbottom, about 170 meters of a mostly Albian nanno claystone (uppermost part is Cenomanian) overlies an Aptian to ?Neocomian sapropelic claystone which extends to the base of the hole. Thus, restricted circulation in Aptian times gave way to more open ocean conditions in the Albian, following the development of a deep-water connection between the Atlantic and Indian oceans as the Falkland Plateau cleared southern Africa. Subsidence and improved circulation followed, with the CCD largely above the sea bed at the site. Possible Late Cretaceous, and very probable Neogene, submarine erosion results from changes in circulation patterns, the latter possibly consequent upon opening of Drake Passage 20 to 30 m.y. ago. Cores contain unique siliceous flora and fauna at the Paleocene-Eocene boundary, with many new forms, and excellently preserved Maestrichtian calcareous fossils. Hole 327A penetrated about half of the sedimentary cover at the site.

BACKGROUND AND OBJECTIVES

Site 327 is located on the western nose of the elevated eastern part of the Falkland Plateau in 2400 meters of water (see Figure 1). The plateau is bounded to the north by the Falkland Fracture Zone which, with the Agulhas Fracture Zone, is the locus of eastward movement of the southeast margin of the African plate relative to the South American plate in the initial stages of opening of the South Atlantic (Dickson et al., 1968; Francheteau and Le Pichon, 1972). The Falkland Plateau is considered to be a southward-tilted continental block overlain by up to 4 km of sediment (Ewing et al., 1971). Sonobuoy reflection and refraction stations on the plateau (Lamont-Doherty unpublished data) show a variability of velocity of acoustic basement which, coupled with the known geology of the Falkland Islands (Greenway, 1972) and the general water depth suggest that basement at Site 327 is of Paleozoic or older continental material. The considerable thickness of sediment there (originally estimated at more than 1200 m, now thought to be about 940 m) and restrictions resulting from site survey shortcomings (see below) made penetration to basement an unrealistic objective. The major objectives were (1) to identify as many prominent reflectors as possible, to allow their extrapolation over the entire plateau using existing reflection profiles, and (2) to obtain a high-latitude, shallow-water biostratigraphic section, for comparison with deeper water sites, such as Site 328. By drilling where Neogene sediments might be expected to be thin (see Figure 2), particular emphasis would be placed upon the older part of the succession, which would reflect the early history of opening of the South Atlantic.

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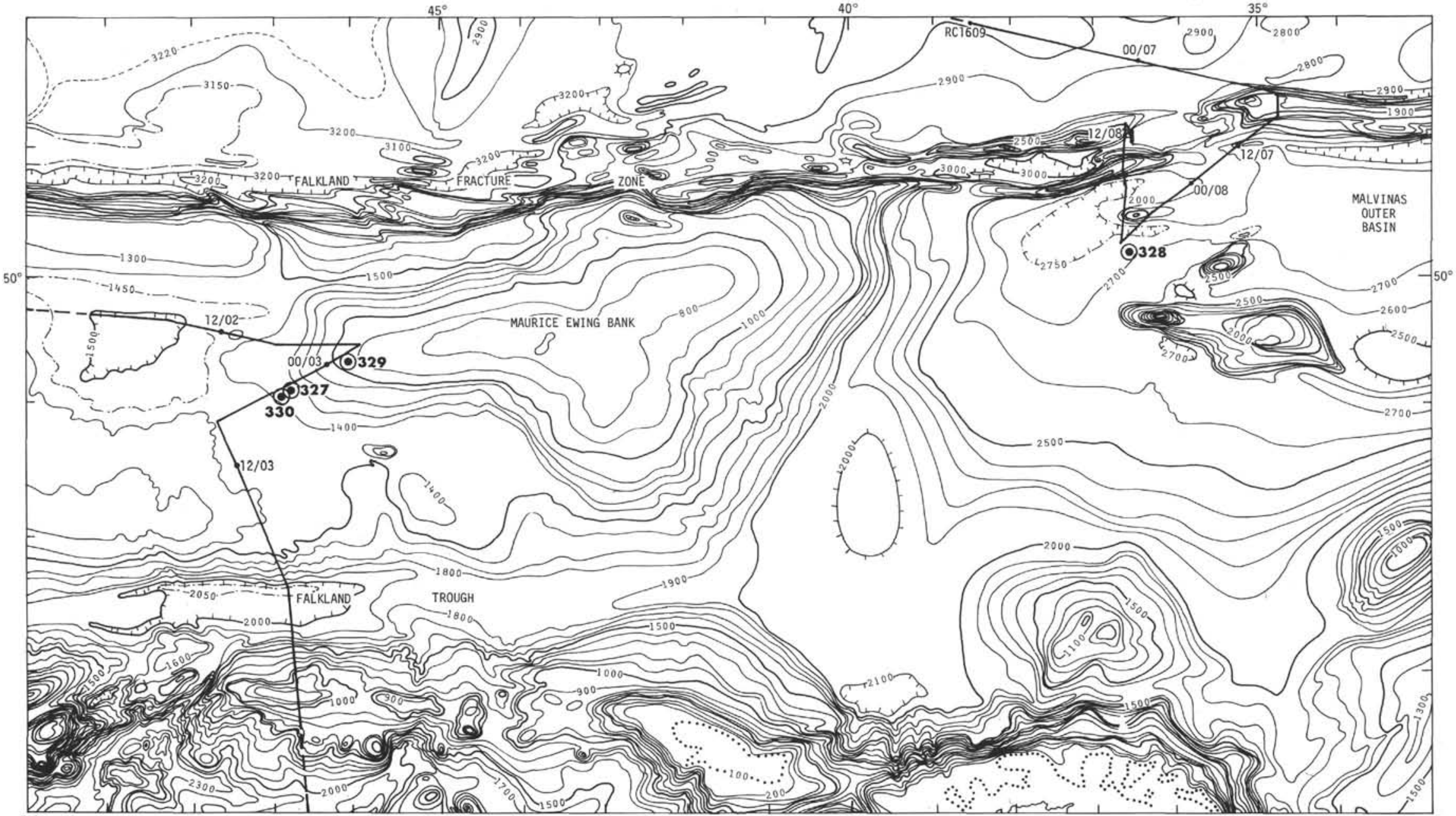

Figure 1. *Bathymetry of Maurice Ewing Bank in the vicinity of Site 327 (after Lonardi and Ewing, 1971), with* Robert D. Conrad *16-06 track.*

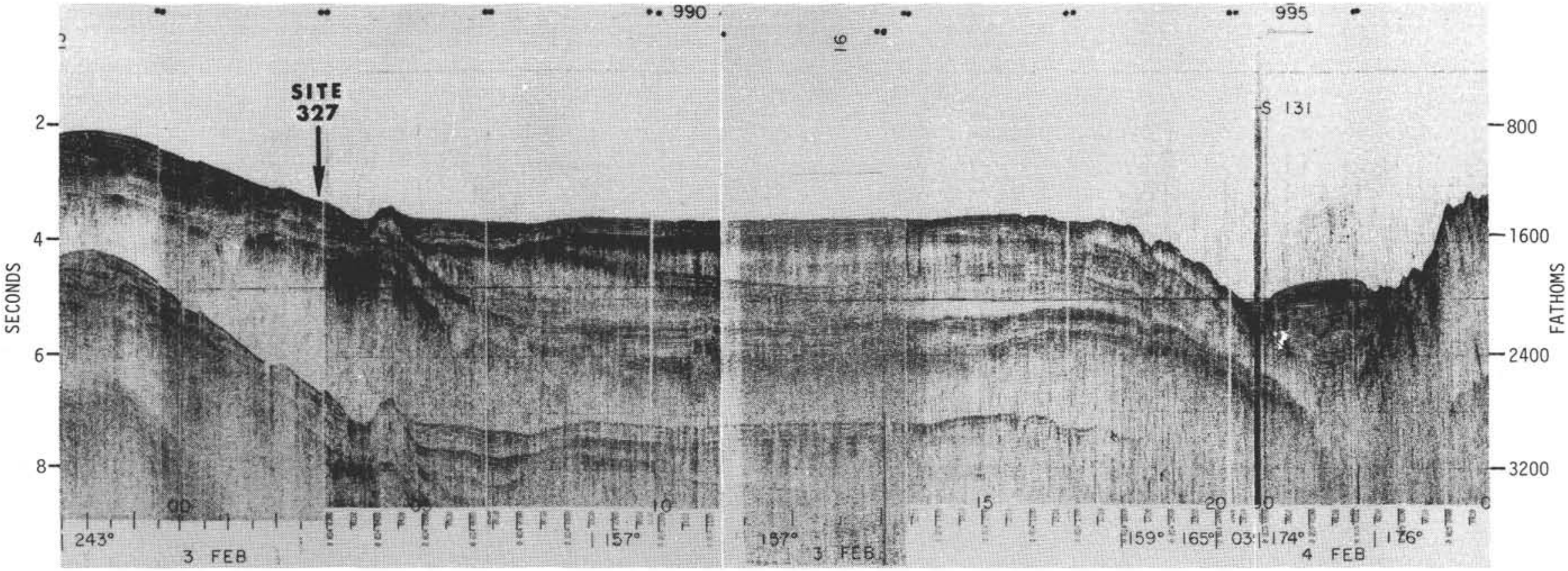

Figure 2. Robert D. Conrad *16-06 reflection profile in the vicinity of Site 327 (see Figure 1 for track).*

SURVEY AND OPERATIONS

Glomar Challenger was released by the Argentine authorities from detention in Bahia Aguirre on 9 April and got underway at 2130, heading eastward across Burdwood Bank and the Falkland Trough for Site 327, with geophysical gear in operation. Site 327 had been chosen on the basis of a single reflection profile bearing 242° (R/V *Robert Conrad*, Cruise 16-06, see Figure 2). The Advisory Panel on Pollution Prevention and Safety had moved the site downslope off a small structural high and recommended an additional profile crossing the RC16-06 line to check for closure on deeper reflectors. Hence the site was approached from the south on 13 April at about 6 knots, the slowest speed in the prevailing weather conditions which was consistent with maintaining steerageway. Acoustic penetration was 0.2 to 0.5 sec, too poor to check for closure, so the ship was allowed to pass 3 km east of the site and the line extended for 25 km to ensure that the return track was well fixed. A sonobuoy launched abeam of the site at 0335 gave no subbottom information because of choppy seas. No improvement in penetration was seen on the return track, but a 16-kHz beacon was dropped nevertheless at 0958, as close as possible to the Panel's suggested site (see Figure 3).

Thus far on Leg 36, *Glomar Challenger*'s reflection profiles had nowhere achieved such penetration of the sediments (~1 sec) as would be necessary here to test for closure, and unless weather conditions improved, seemed unlikely to do so. It was decided therefore to commence drilling and to ensure that the hole was abandoned before the questionably disposed lower layers were reached.

Hole 327, in 2400 meters of water, was spudded in at 0300 on 14 April and the first core recovered at 0145 (Table 1). Bad weather then caused the pipe to be pulled between 0400 and 1030 on 14 April; the ship remained on site without difficulty, while a cross-swell decayed until roll and pitch angles became consistently less than 7°.

At 1200 on 15 April the pipe was again lowered, and spudded in at 2030. The first of 27 cores from Hole 327A came on deck at 2230. Coring was continuous to 118 meters, then intermittent, but with the core barrel seated, to 469.5 meters. Pulling pipe started at 1415 on 17 April because of the development of 9° rolls. Positioning was good, as it had been throughout, and the bit, when retrieved at 2030, was not too worn. The bottom bumper sub was found to be bent, however, which may have explained a high initial incidence of core liner splitting. Mean recovery was 50%, varying between 18% and 100%, the lower percentages occurring mainly after drilled intervals and in the harder formations encountered at depth. The ship got underway at 2100 on 17 April, circling until the reflection profiling gear was streamed and then passing over the site along 153° towards a proposed site south of South

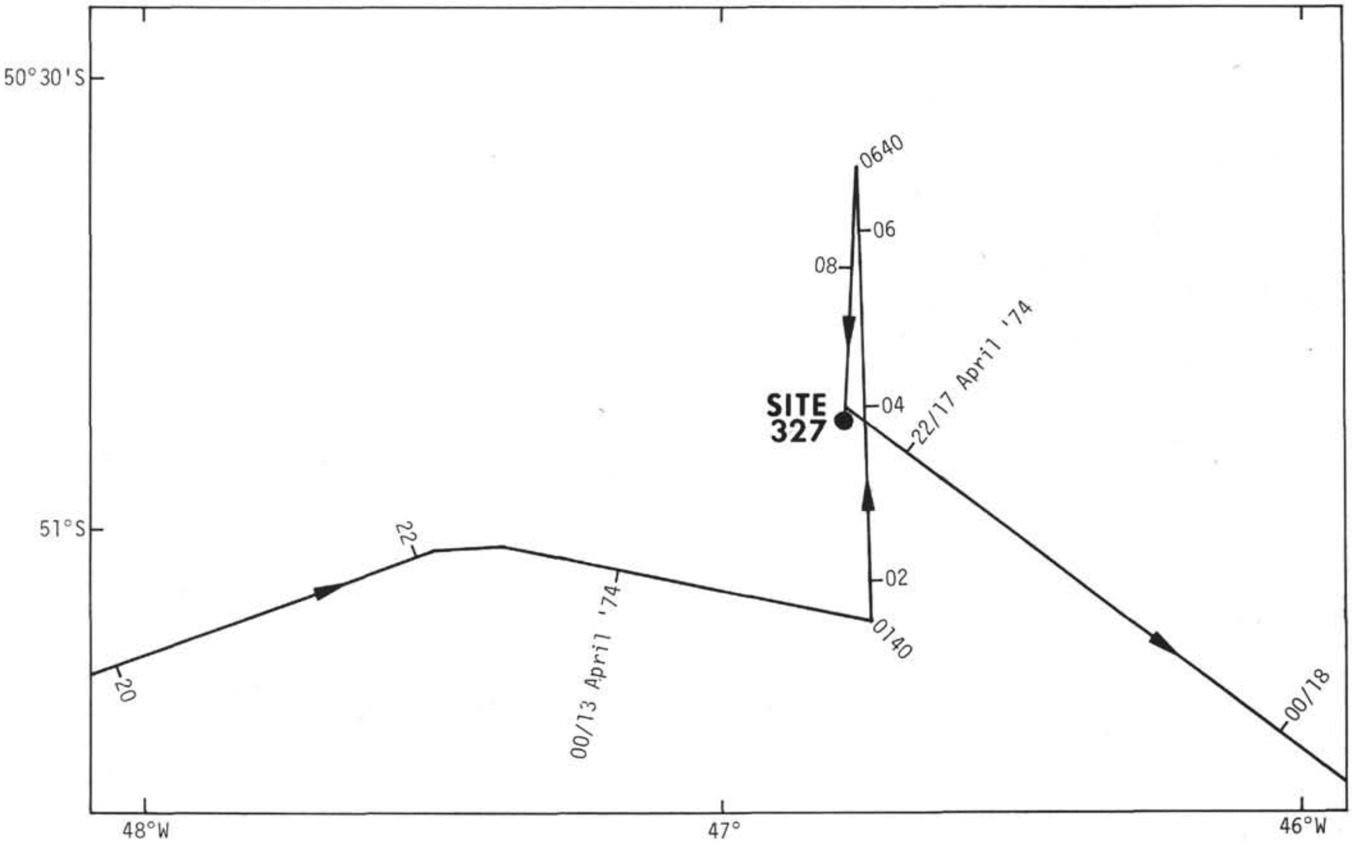

Figure 3. Glomar Challenger *track in the vicinity of Site 327.*

TABLE 1
Coring Summary, Site 327

Core	Date (April 1974)	Time (GMT Z)	Depth From Drill Floor (m)	Depth Below Sea Floor (m)	Cored (m)	Recovered (m)	Recovery (%)
Hole 327							
1	14	0145	2411.0-2416.0	0-5	5	5	100
Hole 327A							
1	15	2230	2411.0-2424.5	0.0-13.5	9.5	4.7	49
2	16	0000	2424.5-2434.0	13.5-23.0	9.5	6.5	68
3	16	0105	2434.0-2443.5	23.0-32.5	9.5	2.5	26
4	16	0210	2443.5-2453.0	32.5-42.0	9.5	4.5	47
5	16	0350	2453.0-2462.5	42.0-51.5	9.5	9.5	100
4	16	0510	2462.5-2472.0	51.5-61.0	9.5	9.3	98
7	16	0610	2472.0-2481.5	61.0-70.5	9.5	1.7	18
8	16	0720	2481.5-2491.0	70.5-80.0	9.5	7.4	78
9	16	9835	2491.0-2500.5	80.0-89.5	9.5	9.5	100
10	16	0945	2500.5-2510.0	89.5-99.0	9.5	3.4	36
11	16	1055	2510.0-2519.5	99.0-108.5	9.5	1.9	20
12	16	1205	2519.5-2529.0	108.5-118.0	9.5	5.6	59
13	16	1330	2548.0-2557.5	137.0-146.5	9.5	1.8	19
14	16	1445	2557.5-2567.0	146.5-156.0	9.5	8.2	86
15	16	1555	2586.0-2595.5	175.0-184.5	9.5	2.8	29
16	16	1705	2595.5-2605.0	184.5-194.0	9.5	8.7	92
17	16	1820	2624.0-2633.5	213.0-222.5	9.5	2.0	21
18	16	1920	2633.5-2643.0	222.5-232.0	9.5	9.5	100
19	16	2045	2662.0-2671.5	251.0-260.5	9.5	3.2	34
20	16	2215	2690.5-2700.0	279.5-289.0	9.5	2.1	22
21	17	0005	2719.0-2728.5	308.0-317.5	9.5	4.7	49
22	17	0250	2747.5-2757.0	336.5-346.0	9.5	3.8	40
23	17	0500	2776.0-2785.5	365.0-374.5	9.5	2.6	27
24	17	0730	2804.5-2814.0	393.5-403.0	9.5	2.8	29
25	17	1000	2833.0-2842.5	422.0-431.5	9.5	3.7	39
26	17	1215	2861.5-2871.0	450.5-460.0	9.5	3.0	32
27	17	1340	2871.0-2880.5	460.0-469.5	9.5	2.7	28
Total					256.5	128.1	50

Georgia. This site and all others within the Scotia Sea, all of which had been relocated at distances greater than 200 miles from Argentine-claimed land, were finally abandoned in view of the rapidly deteriorating weather and ice conditions encountered on the way south. After circumnavigating South Georgia while these decisions were being made, the ship headed finally for Site 328, in the oceanic Malvinas Outer Basin which lies between South Georgia and the Falkland Fracture Zone.

LITHOLOGICAL SUMMARY

Basement was not reached at Site 327, but a wide variety of lithological types was cored, ranging in age from Recent to ?Neocomian-Aptian. Evidence from the spot cores indicates eight distinctive lithological units (Figure 4).

Unit 1 (0-10 m, Core 1 of Holes 327, 327A)

The uppermost unit, 10 meters in thickness and of Quaternary age, consists principally of muddy sand and gravel with a 2-meter interbed of light olive-gray diatomaceous clay.

Manganese nodules and variegated clasts occur throughout, dominantly in the gravelly surface section, and their lithologies and proportions are indicated from a pebble count in Table 2. From this it is apparent that manganese nodules and glauconitic foram-bearing siliceous concretions dominate the coarse fraction. Faceted and striated shale pebbles, devitrified greenish felsic volcanic rocks, arkosic sandstone, dark gray mudstone, and graywacke constitute most of the obviously ice-rafted gravel-size material, while sand-sized components are made up of weathered glauconite grains, quartz, and feldspar. Size-grading, possibly the result of core handling, occurs within the sand and gravel layers.

The interbed of diatomaceous clay is dominantly composed of diatoms, fine-grained quartz, K-feldspar, micaceous clay, and montmorillonite, with traces of glauconite, Radiolaria, and spicules. Scattered ice-rafted clasts occur throughout.

Unit 2 (10-30 m, Cores 2 and 3 of Hole 327A)

This unit, approximately 20 meters in thickness, is a poorly fossiliferous grayish-orange zeolitic clay of late Paleocene to early Eocene age.

Euhedral crystals of clinoptilolite, accompanied by micaceous clay and montmorillonite, constitute the bulk of this sediment with traces of palagonite, glauconite, micronodules, Radiolaria, nannofossils, quartz, feldspar, and fish debris.

Two manganese nodules were cored, along with occasional faceted clasts. These coarse components invariably occur in disturbed zones and are probably cavings from Unit 1.

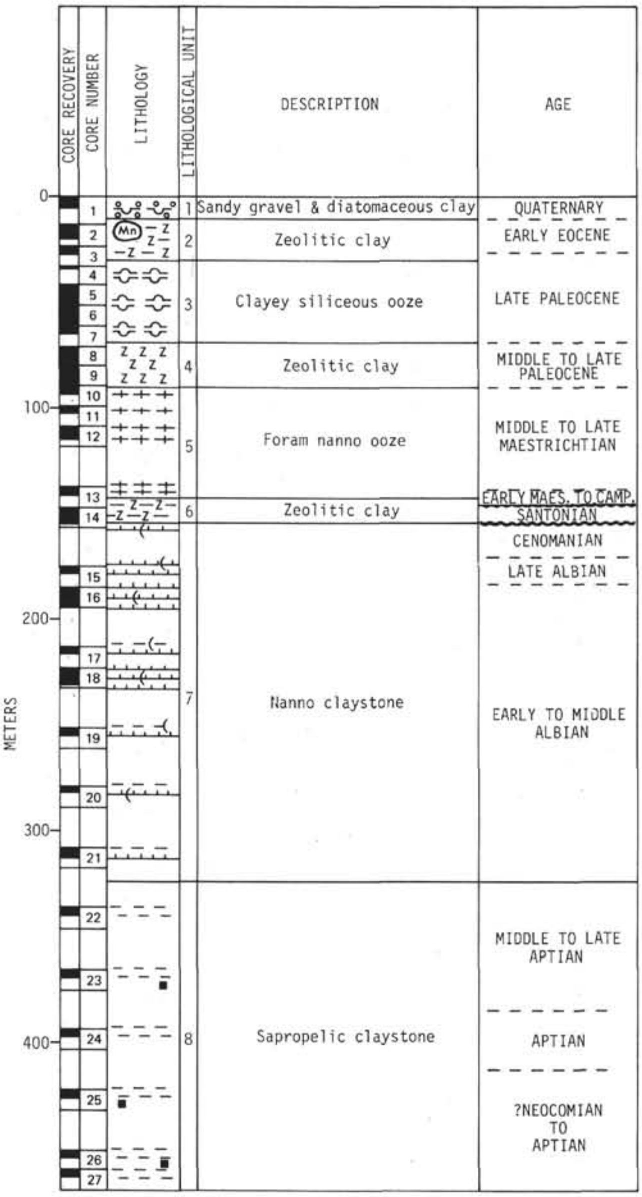

Figure 4. *Columnar section of Site 327 showing basic lithology recovered.*

Unit 3 (30-68 m, Cores 4-7 of Hole 327A)

Unit 3, approximately 38 meters in thickness, is a greenish-gray mottled clayey siliceous ooze of late Paleocene age.

The sediment is dominantly a diatom-rich radiolarian ooze containing a significant proportion of micaceous clay and montmorillonite with traces of glauconite, zeolite, calcareous nannofossils, spicules, silicoflagellates, and quartz silt. The clay content increases, glauconite appears, and bioturbation becomes increasingly apparent downwards within the unit.

Unit 4 (68-90 m, Cores 8-9 of Hole 327A)

A 22-meter zone of essentially nonfossiliferous, bioturbated, dark greenish-gray to olive-black zeolitic clay of late Paleocene age comprises Unit 4.

TABLE 2
Lithologies and Abundances
of Clasts in Unit 1 (Quaternary)

% of	Clast Lithology	Approx. Size (cm)
55	Manganese nodules	2.4
21	Siliceous concretions (w/ glauconite, etc)	3.5
10	Shale (faceted and striated in part)	2.0
5	Sandy mudstone	2.6
3	Arkosic sandstone	2.0
4	Rhyolite porphyry	1.3
2	Graywacke	1.8
<1	Pumice	2.2
<1	Garnetiferous biotite granite	7.0
<1	Granite	1.2

Clinoptilolite constitutes a significant portion of this sediment, commonly as white specks and pods. The remainder is dominantly micaceous clay and montmorillonite with trace amounts of quartz, feldspar, diatoms, and Radiolaria. Glauconite and micronodules constitute up to an estimated 5% of the sediment, pyrite occurs as localized fine-grained aggregates, and several fragments of siliceous mudstone containing glauconite-filled foram tests are present.

Unit 5 (90-142 m, Cores 10-13 of Hole 327A)

This unit is a 52-meter thick greenish-gray, slightly mottled foram nanno ooze, largely of middle to late Maestrichtian age but with its base perhaps as old as Campanian.

The sediment is dominantly composed of forams and calcareous nannofossils, but towards the top it contains zones with up to 50% clay minerals which include montmorillonite, micas, and minor palygorskite. Traces of clinoptilolite, micronodules, diatoms, Radiolaria, glauconite, and apatite occur throughout.

The calcareous microfossils are generally well preserved, but some zones have been recrystallized to micrite. Calcareous fragments, possibly remains of the pelecypod *Inoceramus* sp., occur near the middle of this unit.

Silicified limestone fragments, representing early stages of chert formation, occur in some zones.

The uppermost core, Core 10, is unusually indurated for this unit and may represent a "hard ground" which was exposed on the sea floor for a significant period of time.

Unit 6 (142-154 m, Core 14 of Hole 327A)

A 12-meter variegated moderate brown and mottled zeolitic clay, interbedded with diffuse zones of light greenish-gray micrite, comprises Unit 6. Most of this unit is Santonian in age with Cenomanian material in the bottom two meters. Sediments of Turonian to Coniacian age are apparently missing.

The sediment is dominantly montmorillonite, with significant amounts of clinoptilolite, quartz, and feldspar and traces of heavy minerals, glauconite, iron oxides, chalcedony, and fish teeth. Some of the clinoptilolite crystals are replacements of radiolarian tests. Minor ash pods occur in Sections 2 and 4 of Core 14.

Some brown zones contain weakly graded layers with up to 30% silt-sized quartz and feldspar grains coated with iron oxides. The feldspars are highly weathered and many silt-sized aggregates in these layers may represent former feldspars which have altered to clays.

Green micrite layers are dominantly recrystallized carbonate, derived possibly from former coccoliths, accompanied by minor clays and occasional recognizable calcareous nannofossils. *Inoceramus* fragments are scattered throughout, and a light greenish-gray glauconitic calcareous nodule, bored by marine organisms, occurs in Core 14.

Unit 7 (154 to 324 m, Cores 15-21 of Hole 327A)

This unit is a bioturbated, varicolored nanno ooze to chalk or claystone, 170 meters in thickness and of Albian age. Color variations are notable, particularly in upper zones (Core 15), where diffuse interbeds of light green-gray, dusky yellow-brown, pink, and light brown occur. The bulk of the unit, however, is typified by a diffuse interbedding of olive-gray, yellowish-gray, and bluish-gray. The degree of induration increases downwards from a semiconsolidated ooze to a chalk or claystone.

Sediments are dominantly coccoliths with up to 50% micaceous clay and montmorillonite, 15% clinoptilolite, traces of dolomite rhombs, apatite, and Radiolaria. Sparry barite occurs as irregular 2-cm-thick veins in Core 21, Sections 3 and 4. Fragments of *Inoceramus* and small (1-2 cm) thin-walled pelecypod tests are abundant throughout.

Unit 8 (324-469.5 m, Cores 22-27 of Hole 327A)

Unit 8, which is at least 145 meters thick, is a brownish-black to olive-gray organic-rich claystone, interbedded with occasional greenish-gray 10-20 cm thick micritic limestone layers. The unit is ?Neocomian to late Aptian in age. The top is marked by a sudden increase in degree of induration, from the overlying chalk to a sediment which is fully lithified and stony to shaly in character. Bedding dips of 3° occur (assuming a vertical hole).

Spot cores show that the uppermost 80 meters of this unit, down to Core 25, are a gray siliceous and calcareous shale to claystone, interbedded with minor thin layers of light colored micritic limestone. In most sections, cristobalite, micaceous clay, montmorillonite, and carbonaceous matter are the major constituents, associated with minor pyrite, apatite, quartz, and possible traces of sphalerite. One zone in Core 23 is dominantly composed of rhodochrosite with subsidiary dolomite, and occasional dolomite rhombs are observed to be scattered throughout the sediment. Plant debris is common and a 1.5 × 4 cm fragment of carbonized wood is present in Core 22, Section 2. Fragments of possible ammonite tests with well-preserved nacreous layers occur in Core 23, although fossil faunas are generally scarce. Nannos occur only in trace amounts.

Bioturbation is relatively intense, interrupted by occasional thin (5-10 cm) zones of undisturbed bedding and one 5-cm zone of graded bedding. In these instances the bedding is due to light colored sand- and silt-sized grains, which are aggregates of sparry calcite and fine-grained quartz in a clay and micrite matrix.

The character of Unit 8 changes from Core 25 downward to a greasy, semi-indurated dark sapropelic shale which persists to the bottom of the hole. The abundant carbonaceous material typical of the overlying sediment is replaced by what appears to be equally abundant hydrocarbons associated with scattered amber-colored plant remains and pyrite.

A fragmented belemnite rostrum was obtained from Core 25, Section 2 and coccoliths occur in decreasing amounts down to at least upper portions of Core 27. Some zones are rich in fine-grained quartz, with montmorillonite and micaceous clays common throughout.

Bioturbation decreases markedly between Cores 24 and 25 and is essentially nonexistent in the finely laminated sediments of Cores 26 and 27, which resemble an oil shale in character.

Interbedded with all but the lowermost core are the occasional light gray, hard, 5-10 cm thick layers of micritic limestone which occur throughout Unit 8. These are dominantly composed of micritic calcite with traces of coccoliths, varying amounts of montmorillonite and micaceous clay minerals, and some apatite.

PHYSICAL PROPERTIES

Sonic velocities and mass physical properties were measured on a variety of sediment samples consisting of sands, diatomaceous, radiolarian and siliceous oozes, foram oozes, nanno oozes, nanno chalks, carbonaceous zeolitic claystones, and micritic claystones, from depths of 0 to 470 meters below the sea floor. All eight lithological units of Site 327 were sampled, and measurements performed on 26 cores. These measurements are shown in the site summary graphic logs and core summaries. Core 4, consisting of siliceous ooze, was too disturbed by drilling for measurements to be taken.

Wet-bulk density, porosity, and water content, determined by gravimetric methods, vary considerably with depth. In general, each lithological unit exhibits a distinctive range of values.

Extreme values of sonic velocities and other physical properties occur within Lithologic Unit 3 consisting of Eocene-Paleocene siliceous oozes (30-70 m) and within the upper section of Unit 8 consisting of Aptian carbonaceous claystones (330-430 m).

Porosities range at Site 327 from 38% (Unit 8) to 90% (Unit 3).

Near the sea floor, typical porosities are close to 70%, and beyond the maximum mentioned above, decrease rather linearly with depth down to 450 meters near the bottom of the hole.

Wet-bulk densities follow a similar trend, ranging from 1.43 g/cm^3 to 1.70 g/cm^3 at the uppermost 32 meters, reaching a lowest value of 1.18 g/cm^3 within Unit 3, and increasing gradually with depth to an average of 2.00 g/cm^3 between 325 and 450 meters.

Water content determined at the same intervals shows values of 45% to 52% at the top 32 meters, reaching maximum values of 70% to 73% within Unit 3, and decreasing gradually with depth across nanno oozes and nanno clays, claystones, and chalks to characteristic values which decrease from 50% (70 m) to 26% (325 m). Lowest values are found within Aptian carbonaceous claystones of Unit 8 (325-460 m) ranging between 13% and 27%.

Sonic velocities measured in the laboratory exhibit a trend similar to that followed by the other physical properties. The first velocity inversion coincides with the top of Unit 3 (30 m) where average layer velocities decrease from about 1.70 km/sec to about 1.53 km/sec across the boundary with Unit 2 (zeolitic clays).

Between 30 and 90 meters, average layer velocities are uniform, increasing beyond the latter depth to an average value of 1.56 km/sec, between 90 and 140 meters depth across Unit 5 (foram nanno oozes of Maestrichtian age).

Beyond 140 meters and down to about 330 meters, velocity increases gradually across zeolitic clays (Unit 6) and nanno chalks and nanno claystones (Unit 7). The velocity gradient in this interval is about 1.63/sec, and typical velocities range from 1.58 km/sec at the top of the section, to 1.88 km/sec at the bottom.

Aptian sapropelic claystones and nanno-rich claystones of Unit 8 (330-430 m) exhibit higher velocities and induration than the shallower sections, averaging about 2.15 km/sec. The velocity increase across this section is apparently related to a corresponding increase in the amount of calcite.

The second velocity inversion found downhole occurs at about 430 meters in the last two cores recovered, which consist of organic-rich clay-claystones with typical velocities ranging from 1.85 to 1.88 km/sec. Acoustic impedance near the sea floor is about 3.3×10^5 g/cm^{2}sec and is a minimum at 60 meters within Eocene-Paleocene oozes of Unit 3 (1.8×10^5 g/cm^{2}sec). Impedance increases gradually downhole (maximum 4.7×10^5 g/cm^{2}sec at 320 m), and decreases in similar fashion down to 450 meters near the bottom of the hole averaging 3.9×10^5 g/cm^{2}sec.

The plotted values are estimated to be accurate to ±7% syringe porosity, ±6% GRAPE porosity, ±0.1 g/cm^3 syringe bulk density, and ±1% velocity.

PALEONTOLOGY

Biostratigraphic Summary

Hole 327A, drilled on the Falkland Plateau at a water depth of 2410 meters, recovered excellent high-latitude biostratigraphic reference sections for palynomorphs, calcareous and siliceous microfossils in selected portions of a Cretaceous-lower Tertiary sequence. All microfossil groups studied (foraminifera, calcareous nannofossils, silicoflagellates, Radiolaria, diatoms, palynomorphs) are represented to some degree in the Tertiary section, particularly in the upper Paleocene siliceous ooze of Lithologic Unit 3 (Cores 4 to 7), whereas only calcareous nannofossils, planktonic and benthonic foraminifera, palynomorphs, and sparse radiolarians are present in the Mesozoic section (Cores 10 to 27). Mesozoic benthonic foraminifera increase toward the base of the section eventually dominating, then replacing the planktonic foraminifera which, as a group, do not become abundant in the geologic record until the mid-Cretaceous.

Other microfossils and invertebrate fossils noted in Cretaceous samples include ostracodes, *Inoceramus* fragments, abundant pelecypod tests (portions of Unit 7), bivalve micromolluscs, belemnites, and numerous *Zoophycos* in portions of the Lower Cretaceous section.

Biostratigraphy

Ice-rafted, current-reworked glacial sands and gravels interbedded with diatom-rich clay at the top of the section (Core 1) contain mixed upper Miocene to Pleistocene siliceous microfossils and sparse calcareous microfossils. The older forms may have been reworked into the Quaternary material. A sharp lithologic change between Cores 1 and 2 represents a considerable stratigraphic hiatus as indicated by lower Eocene calcareous nannofossils (*Orthostylus tribrachiatus* Zone) in the first section of Core 2. Diagnostic fossils have not been encountered in the lowermost portion of Core 2, the sediment of which may represent much of the lowermost Eocene. Sparse, poorly preserved *Discoaster multiradiatus* are present in Section 1 of Core 3 and range down to the core catcher of Core 4. Although the predominant range of this taxa is uppermost Paleocene, it is reported from the lowermost Eocene by several authors; therefore, it is not possible to indicate precisely an Eocene-Paleocene boundary in these cores. This boundary is arbitrarily set between Cores 2 and 3. Core 4 contains mixtures of Paleogene and Quaternary material introduced by downhole slumping. Paleocene coccoliths occur in Cores 4 to 6. Cores 5 and 6 are assigned to the Paleocene coccolith *Heliolithus universus* and *Fasciculithus involutus* Zones. The siliceous assemblages continue with little change in species composition down to Core 8, Section 2. The rest of Core 8 and Core 9 contains late Paleocene palynomorphs, but no other microfossils.

The Cretaceous/Tertiary boundary is placed between Cores 9 and 10. Cores 10, 11 and 12 belong to the calcareous nannofossil *Nephrolithus frequens* Zone which is considered middle to late Maestrichtian in age. The lower portion of Core 13 contains a nannoflora similar to that of the previous three cores except that it lacks *Nephrolithus frequens* and is considered middle Campanian to early Maestrichtian in age.

The interval between Cores 13 and 15 contains a highly condensed section with at least two stratigraphic hiatuses. Core 14 consists of alternating lenses of mottled red and green clays in which most calcareous fossils are rare or absent due to dissolution. Although age determinations cannot be made for most of these sparse assemblages, Sections 1 to 5 of Core 14 contain the coccolith *Marthasterites furcatus* and/or foraminifera which suggest a Santonian age. Section 6 and the core-catcher sample for Core 14 contain the planktonic foraminifera *Rotalipora reicheli* and coccoliths which indicate a Cenomanian age for these samples.

Planktonic foraminifera, minute forms of the mollusc *Aucellina*, and coccoliths assigned to the *Eiffellithus turriseiffeli* Zone data Core 15 as late Albian. Thus a major hiatus representing the Coniacian and Turonian occurs in the lower part of Core 14. A second major hiatus occurs between Cores 14 and 13. Cores 16 to 21 are assigned to the coccolith *Prediscosphaera cretacea* Zone which Thierstein (1974, personal communication) considers early to middle Albian in age. Planktonic foraminifera indicate a middle Albian age for all of these cores except for Core 21 which is considered early to possibly middle Albian.

Cores 22 and 23 contain the coccolith *Lithostrinus floralis* and are assigned to the *Parhabdolithus angustus* Zone which Thierstein (1974, personal communication) considers middle Aptian to early Albian in age. Palynomorphs suggest an Aptian age. Core 24 does not contain *Lithostrinus floralis* and is assigned to the lower Aptian *Chiastozygus litterarius* Zone of Thierstein (1973). The Albian-Aptian boundary is placed between Cores 21 and 22 on the basis of calcareous nannofossils and pollen studies. The oldest sediments in the hole were recovered in Cores 25 to 27 which are considered early Aptian or possibly Neocomian on the basis of palynomorphs and calcareous nannofossils.

Preservation

Preservation of all microfossil groups varies radically in this section due to highly varied depositional conditions that existed at the site during the long time interval represented (Early Cretaceous to Recent). Siliceous microfossils are poorly preserved in the mixed and reworked glacial deposits of Core 1 of Holes 327 and 327A, moderate to well preserved in the Paleogene siliceous ooze of Unit 3, moderately well preserved in the Maestrichtian of Core 10, and poorly preserved, fragmentary, or absent in cores below that level. Occasional porcelanite nodules and opal-CT lepispheres in the Maestrichtian (Cores 11 to 12) indicate postdepositional dissolution and reprecipitation of most biogenic opal in this part of the section.

Calcareous microfossils are generally poorly preserved in the Tertiary section, and are sparse and etched by dissolution in the siliceous ooze of the Paleogene section which was deposited well below the lysocline close to the carbonate compensation depth (CCD). The zeolitic clay of Unit 4 is practically barren of all microfossils indicating the presence of aggressive (strong, corrosive) bottom currents and/or a shallow CCD at the site during the early-middle Paleocene. Only palynomorphs indicative of some terrestrial influences are present in this interval.

Conditions during the Maestrichtian were excellent for the preservation of all calcareous microfossils. Calcareous nannofossils in this interval are in a pristine state with only some etching but practically no secondary calcite overgrowth. All delicate forms (for example, *Kamptnerius magnificus*) are preserved intact. The near absence of secondary calcite overgrowths on these specimens renders exceptionally weak interference figures under crossed nicols so that all forms exhibit an unusually delicate, transparent-translucent appearance. Planktonic foraminifera are also well preserved as evidenced by the presence of porticos and other delicate features on many specimens; however, fine clay in the matrix makes the foraminifera difficult to clean during processing.

Coccolith assemblages below the apparent hiatus between Cores 13 and 14 show more typical states of preservation for this age sediment, particularly in regard to degree of apparent calcification. Only forms highly resistant to dissolution such as *Marthasterites* and *Lithostrinus* are preserved in the gray Santonian clay of Unit 4 which is interbedded with oxidized, brown zeolitic clay devoid of calcareous nannofossils. Calcareous benthonic foraminifera are preserved in the gray clay, whereas only arenaceous species are present in the oxidized material.

Preservation of both coccoliths and foraminifera improves in the Albian section below Core 15, indicating deposition well above the CCD with preservation and diversity being limited primarily by reworking and postdepositional diagenesis rather than by paleodepth of deposition.

Paleoecology

Diversity and preservation of microfossils at Site 327 vary as a function of paleodepth of deposition, paleodepth of the lysocline and CCD, planktonic productivity, latitude of deposition, and postdiagenetic dissolution.

Planktonic foraminifera are severely restricted in diversity throughout the section as a result of the cooler water, high latitudinal site of deposition. Most primary foraminiferal guide fossils are essentially absent, including the genera *Globotruncana* and *Rotalipora* which comprise most of the key Cretaceous index species for lower latitude zonations. Calcareous nannofossils are reasonably diverse in the Lower Cretaceous at intervals where preservation is good, but are ecologically restricted in the Campanian to Maestrichtian interval (Cores 10 to 13), where the generally ubiquitous coccolith genus *Watznaueria* is essentially absent. Other coccoliths such as *Microrhabdulus* and *Lithraphidites* are also missing.

Calcareous faunas and floras through the Lower Cretaceous section (including the abundant remains of the bivalves *Inoceramus* and *Aucellina*) indicate deposition well above the CCD for Units 7 and 8 (Cores 15 to 27). Benthonic foraminifera suggest shelf break depths (100 to 400 m) up to Core 15 where a deepening of the site of deposition (probably due to tectonic subsidence) becomes apparent. The sparse, dissolution-resistant coccolith and foraminiferal species in the gray and reddish mottled clay of Unit 6 (Core 14), however, indicate deep, cold water conditions with deposition near the base of the CCD during the Santonian. This may be attributed both to (1) subsidence of the site of deposition to deeper water depths following the Early Cretaceous rifting of the Falkland Plateau from Africa, and (2) a rise of the CCD with the movement of strong or corrosive bottom currents over the site during the Turonian to Santonian interval as a consequence of the interchange of bottom waters between major ocean basins to the north and east as rifting proceeded. A 20-meter coring gap between Cores 15 and 14 masks evidence of the major time of subsidence for the plateau. However, the disconformity between Sections 6 and 5 of Core 14 may be attributed to submarine erosion or nondeposition resulting from strong bottom currents during the Turonian-Conaician. A similar hiatus is present at other high latitude sites in the Indian Ocean (Veevers and Heirtzler, 1974). This indicates that during mid Cretaceous time, sharp changes in current patterns were felt throughout the region as the Atlantic-Indian Ocean systems were enlarged sufficiently to allow broad circulation patterns to become established in the higher latitudes of the southern hemisphere. Bottom currents at the site were sufficiently slow by Santonian times to allow accumulation of the mottled clays, but their carbonate-poor oxidized condition indicates movement of cold (polar?), carbonate-deficient waters over this area of the plateau, the net effect of which would raise the carbonate compensation depth close to that of the site of deposition. A second consequence of the movement of cold bottom waters over the plateau would be the migration of cold water benthonic foraminifera from their bathyal and abyssal habitats upslope to positions higher on the plateau. Thus the benthonic foraminiferal assemblages in the Santonian interval resemble those normally found at much greater depths (as deep as 3000 m or more) in the central Pacific. Regional tectonic evidence does not support subsidence of the plateau to such depths at any time during its history, thus a circulation model as suggested above supplementary to a normal ridge flank tectonic subsidence model appears most likely.

Slow and interrupted sedimentation probably continued well into the Campanian although the extent of Campanian sedimentation cannot be estimated exactly due to the 20-meter coring gap between Cores 13 and 12. Nevertheless, the diverse and well preserved calcareous nannofossils and foraminiferal assemblages of Core 13 indicate deposition well above the CCD by the end of the Campanian, a condition which prevailed throughout the Maestrichtian (Unit 5, Cores 13 to 10).

Deep-water benthonic foraminifera indicate a paleodepth of deposition of about 1500 to 2000 (±500) meters for this unit. The restricted coccolith flora of this interval plus the presence of the provincial, high-latitude coccolith *Nephrolithus frequens* is interpreted as an indication of global cooling of the oceans during the Maestrichtian due to the beginning of a climatic deterioration which Hay (1960) and Worsley and Martini (1970) postulate as a major event at the end of the Mesozoic era. The near exclusion of *Watznaueria* from the coccolith flora in sediment of Core 13 below the *Nephrolithus frequens* Zone is probably the first evidence of this cooling event recorded at this site. That, plus the highly restricted planktonic foraminiferal fauna suggest that Site 327 may provide a record of the highest known oceanic paleolatitude site of calcareous deposition for this time interval yet available for study.

According to Hay (1970) and Worsley (1974), the CCD rose sharply during the close of the Maestrichtian, as part of the "Terminal Cretaceous Event" postulated by Worsley (1971). A sharp rise in the CCD is indicated at Site 327 by the abrupt change from Maestrichtian foram nanno ooze capped by a hard ground in Unit 5 (Core 10) to the zeolitic clay of Unit 4 (Core 9) of late Paleocene age. A similar Mesozoic/Cenozoic transition is recorded at other DSDP sites in the Atlantic (DSDP Legs 3, 12, 14) as well as other parts of the world. A second hypothesis attributes the biostratigraphic hiatus in the early Paleocene to the action of strong bottom currents (Pimm and Hays, 1972) which may well have accompanied a rise in the CCD as the oceans were stirred during the establishment of climatic zonations during the early Tertiary. Such strong currents may account for the absence of early Paleocene sediments at this site.

The earliest Cenozoic calcareous microfossils recorded at Site 327 are poorly preserved, dissolution-resistant species of low diversity and late Paleocene age (Core 6). These sparse, resistant forms indicate a paleosite of deposition close to the CCD. We attribute the presence of these forms to a gradual lowering of the CCD during the Paleocene, affecting calcareous deposition in most parts of the Atlantic by late Paleocene times (Worsley, 1974). Shortly prior to this event, profuse production of siliceous plankton produced a change at the site from zeolitic clay deposition (Unit 4) to siliceous ooze deposition (Unit 3, Cores 4 to 7).

Sparse, resistant calcareous nannofossils continue to occur intermittently through Unit 3 and into the lower Eocene, orangish zeolitic clay of Unit 2 (Cores 2 and 3). The biostratigraphic hiatus between the lower Eocene of Unit 2 and the Plio/Pleistocene of Unit 1 (between Cores 2 and 1) is probably a function of strong bottom currents which effected some erosion and prevented deposition at this site until the beginning of ice-rafted glacial deposition and the onset of high siliceous ooze productivity associated with the establishment of the Antarctic Convergence during the Neogene. Strong currents may have been initiated by a number of tectonic events (such as the separation of Antarctica and Australia and opening of Drake Passage) and subsequent climatic events such as the establishment of continental glaciation on the Antarctic continent.

Foraminifera

Biostratigraphy

Of the two holes drilled at Site 327, the first one (Hole 327) resulted in only one core containing late Pleistocene-Recent assemblages. A particularly well-preserved assemblage was derived from Sample 327-1-3, 48-50 cm with *Globorotalia truncatulinoides, G. inflata, G. scitula*, left-coiling *Neogloboquadrina pachyderma* (surface and bottom form), *Globigerina bulloides, G.* cf. *bulloides, G. quinqueloba, Globigerinita glutinata*, and *G. vula*.

The first core of Hole 327A covers the same stratigraphic interval as Core 327-1. Of Core 2, only Section 1 contains planktonic foraminifera, but preservation is very poor and in most cases clayey casts are the only remains. Among the species identified are: *Planorotalites* cf. *australiformis, Acarinina mckannai* group, *A. primitiva*, and *Morozovella caucasia*, indicative of an early Eocene age.

The remaining part of Core 2 through Core 10 is deprived of planktonic foraminifera, but at several levels (Core 5, Sections 1 and 3, and Core 6, Section 5) some dissolution-resistant calcareous benthonic foraminifera are present. Species identified are:

Gravelinella beccariformis, Pullenia coryelli, Nuttallides truempyi, Oridorsalis umbonatus, Spiroplectammina spectabilis, Tritaxia globulifera, Bolivinoides delicatulus, and *Coryphostoma limonense*.

All of these species are long ranging; only the latter is confined to the Paleocene. All of them are present in the Paleocene assemblages of Site 329.

Foraminifera recovered from Cores 10-12 (89.5 to 118.0 m) are moderately diverse, well preserved, and include the planktonic species *Rugoglobigerina rotundata, Heterohelix glabrans, Globotruncana arca, Globotruncanella havanensis*, and the benthonic species *Bolivina incrassata* and *Neoflabellina reticulata* indicating a late Maestrichtian age.

Foraminifera from Core 13 (137.0 to 146.5 m) include the planktonic species *Rugoglobigerina pilula, Schackoina multispinata*, and *Pseudotextularia carseyae* and the first occurrence of the benthonic species *Bolivinoides laevigatus, Globorotalites spineus, Nuttallinella florealis, Reusella szajnochae*, and *Neoflabellina praereticulata* indicating a late Campanian age.

Core 14 foraminifera from Sections 1 to 5 (146.5 to 151.0 m) are rare and poorly preserved but include the planktonic species *Hedbergella delrioensis, Heterohelix reussi, Whiteinella baltica, Archaeoglobigerina bosquensis* and the first occurrence of *Rugoglobigerina pilula* in addition to the benthonic species *Aragonia materna kugleri* and *Gyroidinoides quadratus*, suggesting a Santonian age.

Core 14 foraminifera from Section 6 and the core catcher (154.5 to 156.0 m) are poorly preserved and include the planktonic species *Rotalipora reicheli, Praeglobotruncana delrioensis, Hedbergella amabilis, Hedbergella planispira*, and *Schackoina cenomana* that represent a Cenomanian age.

Planktonic foraminifera from Core 15 (175.0 to 184.5 m) are moderately well preserved and include *Hedbergella delrioensis, H. portsdownensis, H. infracretacea*, and the first appearance of *Praeglobotruncana delrioensis* indicating a late Albian age.

Foraminifera from Cores 16 to 20 are poorly to moderately well preserved and include the planktonic species *Globigerinelloides bentonensis, G. caseyi, Hedbergella delrioensis, H. amabilis, H. portsdownensis*, and *H. planispira*, and benthonic species such as *Conorboides minultissima, Patellinella australis, Planularia bradyana, Pleurostomella obtusa, P. reusse, Tristix quadrata, Tritaxia gabonica, Uvigerinammina jankoi*, and *Vaginulina recta* that characterize a middle Albian age.

Foraminifera from Core 21 are moderately well preserved and include the planktonic species *Hedbergella sigali, H. planispira, H. delrioensis, Globigerinelloides gyroidinaeformis*, and the benthonic species *Dorothia trochus, Gavelinella indica, G. intermedia, Gyroidinoides primitiva, Osangularia utaturensis, Spirobolivina australis, Tribrachia australiana* that indicate an early to possibly middle Albian age.

Paleoecology

Quaternary planktonic foraminiferal assemblages (first core of each hole) are characteristic of waters directly north of the Antarctic Convergence. Identical faunas have been described by Herb (1968) from the area southeast of the Falkland Islands. *Globorotalia truncatulinoides* is represented by a low-conical form with inconspicuous structures (considered a cold water variant by Herb, 1968).

Benthonic foraminifera in the Paleocene-Eocene section are too badly preserved to analyze accurately as to paleodepth, however, the residue assemblages there suggest upper to lower bathyal depths of deposition.

Moderately diverse and well-preserved benthonic faunas from Cores 10 to 13 (89.5 to 145.5 m) are composed of species equivalent to modern low latitude, lower bathyal faunas (1500-2000 ±500 m) and include species of *Allomorphina, Gavelinella, Gyroidinoides, Pleurostomella, Praebulimina, Pullenia*, and *Stilostomella*. Admixtures of shelf faunas include moderately diverse nodosariids, rare encrusting agglutinated species, fistulose polymorphinids, abraded miliolids, and specimens of *Neoflabellina*.

Core 14 benthonic foraminifera from Sections 1 to 5 (146.5 to 154.0 m) are strongly dissolved and consist primarily of rare agglutinated species. This fauna is composed of genera such as *Allomorphina, Ammodiscus, Bathysiphon, Glomospira, Glomospirella, Hyperammina, Kalamopsis*, and *Lituotuba*, and is equivalent to modern low-latitude species from lower bathyal abyssal environments (2000 m or greater). The presence of this fauna could be accounted for by subsidence or more likely, a rise in the lysocline to upper bathyal-outer shelf water depths and the upward migration of the deeper water fauna in response to both a change in the temperature and source of the bottom water.

Benthonic foraminifera from Cores 15 to 21 (175.0 to 317.5 m) are diverse and moderately well preserved and compare to modern low-latitude shelf break faunas (100 to 400 m). These include genera such as *Conorboides, Dorothia, Gavelinella, Gyroidinoides, Osangularia, Pleurostomella, Tribrachia, Tritaxia, Uvigerammina*, numerous nodosariids, fistulose polymorphinids, encrusting species, and rare miliolids and praebuliminids.

Ostracodes

Fairly rich ostracode faunas are found throughout most of the Cretaceous (Cores 10 to 21). Smooth-walled types prevail in the lower part of the section (Cores 14 to 21).

Calcareous Nannofossils

Calcareous nannofossils are present to some degree in nearly all cores from Site 327, but are abundant only in the uppermost Cretaceous (Cores 10 to 13) where many new taxa were observed and in minor portions of the Pleistocene and Lower Cretaceous. Preservation and diversity of nannofloras in units above the Lower Cretaceous appears to have been limited primarily by the position of the CCD in relation to the site of deposition although some ecologic restriction due to the high latitudinal position of the site is evident in the species composition of some of these assemblages. Poor preservation and low diversity due to deposition near the limits of the CCD are evident in the Santonian and Paleogene assemblages whereas ecologic restriction due to cooler waters at the high latitudinal site of deposition is noted in the Maestrichtian and Quaternary floras. Some restriction in the Paleogene floras is undoubtedly attributable to temperate water conditions, but climates then were sufficiently mild to enable a few discoaster groups to exist at the site, thus reasonable correlation with type zones in California and southwestern France can be established for this interval.

Section 3 of Core 1 from Hole 327 contains a thin lamina of micrite with abundant small coccoliths which are probably *Emiliania huxleyi*, common *Helicopontosphaera kamptneri, Cyclococcolithina leptopora, Coccolithus pelagicus*, and rare *Gephyrocapsa oceanica.* This assemblage indicates surface water temperatures of above 6°C, and may represent a flurry of productivity associated with a warm interval during the late Pleistocene. Coccoliths are rare or absent throughout the rest of the Neogene interval.

Sections 1 to 3 of Core 2 contain sparse, heavily etched coccolith assemblages deposited near the base of the CCD. Included are rare to common *Tribrachiatus orthostylus, Chiasmolithus grandis, C. consuetus, C. expansus, Coccolithus formosus, Discoaster barbadensis*, and *D. germanicus.* These may be assigned to the lower Eocene *Tribrachiatus orthostylus* Zone of most authors. Rare late Eocene coccoliths scattered throughout this interval were introduced by downhole reworking. The lower two sections of Core 2 are essentially barren, but contain scattered elements of the above assemblages.

Core 3 contains a few etched, dissolution-resistant coccoliths such as *Fasciculithus involutus* and *Discoaster multiradiatus*, and can probably be assigned to the Paleocene *Discoaster multiradiatus* Zone. A more diverse flora attributable to this zone is present in the first section of Core 4. The assemblage is little changed from Core 5 down to Core 6, except for the absence of *Discoaster multiradiatus* and the addition of rare *Discoaster binodosis, D. Helianthus, Heliolithus universus*, and a wide variety of other forms of *Heliolithus.* The assemblage is assigned to the *Heliolithus universus* and *Fasciculithus involutus* Zones. Sparse *Fasciculithus involutus* and *Toweius eminens* in the first two sections of Core 7 constitute the oldest Tertiary coccolith assemblage recovered at this site. The section below their occurrence is barren of calcareous nannofossils down to Core 10.

The dark green zeolitic clay in Unit 4 (Cores 9 and 10) represents deposition below the CCD. Below Unit 4 are Mesozoic carbonates. Below a meter or so of chalk crust, the foram nanno ooze of Unit 5 contains excellently preserved coccoliths. Their pristine condition is evidenced by the preservation of delicate structures such as large flanges of *Kamptnerius magnificus* and complete bases and stems of *Lucianorhabdus cayeuxi*, as well as a glassy, transparent-translucent low order gray appearance under crossed nicols.

Assemblages from the top of Core 10 to the first section in Core 13 belong to the *Nephrolithus frequens* Zone, and form a high-latitude assemblage characterized by abundant *Cribrosphaerella ehrenbergi, Kamptnerius magnificus* (large flange), *Lucianorhabdus cayeuxi, Nephrolithus frequens, Arkhangelskiella cymbiformis*, and species of the *Heteromarginatus* plexus. Nineteen new coccolith species were described from this unit (Wise and Wind, this volume). The near absence of *Microrhabdulus decoratus* and members of the genera *Watznaueria* and *Tetralithus* indicate ecologic restriction at the site due to climatic cooling during the latter part of the Late Cretaceous.

Section 2 of Core 13 contains an assemblage similar to that immediately above, but lacks *Nephrolithus frequens* and includes rare *Watznaueria.* It also lacks *Eiffelithus eximius*, and is considered late Campanian to early Maestrichtian in age.

Core 14 is composed largely of noncalcareous brown clay with intermittent patches of greenish clay, some of which yield sparse, dissolution-resistant coccoliths. Apparently the CCD fluctuated above and below the site of deposition during the time represented. Sections 1 and 3 of Core 14 contain *Marthasterites furcatus* which has been reported most often from Santonian material in deep-sea and land sections.

Core 15 contains the first abundant *Watznaueria* encountered downhole, common *Lithastrinus foralis, Braarudosphaera bigelowi, B. africana*, nannoconids and poorly preserved *Eiffellithus turriseiffeli* and *Prediscosphaera cretacea.* The assemblage is best characterized by an abundance of *Seribiscutum primitivum* which flourished in the high latitudes of the southern hemisphere during mid Cretaceous times. Core 15 is late Albian in age and is assigned to the *Eiffellithus turriseiffeli* Zone. Cores 16 to 21 lack *Eiffellithus turriseiffeli* and are assigned to the *Prediscosphaera cretacea* Zone.

Cores 22 and 23 contain *Lithostrinus floralis* but apparently lack *Prediscosphaera cretacea*, thus are assigned to the *Parhabdolithus angustus* Zone. Cores 24 to 26 do not contain *Lithostrinus floralis*, but apparently do contain some *Chiastozygus litterarius* and thus, belong to the *Chiastozygus litterarius* Zone. Cores 26 and 27 are sparsely fossiliferous, but contain no coccoliths unequivocally older than Aptian.

Diatoms

Hole 327

Diatoms are common to abundant and are moderately well preserved in Hole 327. The core catcher of Core 1 contains a predominantly Plio/Pleistocene assemblage of diatoms with a few older (late Miocene) forms also present. Among the species observed are *Coscinodiscus lentiginosus, Nitzschia kerguelensis, Actinocyclus ingens, Cosmiodiscus insignis, Hemidiscus karstenii, Coscinodiscus* sp. 2 (McCollum), *Denticula antarctica*, and *Denticula hustedtii.*

Only one core was recovered from this hole.

Hole 327A

Diatoms are rare and poorly preserved in Sample 1-1, 129-130 cm, and are common to abundant and poor to moderately well preserved in Samples 1-2, 10-11 cm through 1-4, 126-127 cm.

Core 1 contains an admixture of Pliocene and Quaternary diatoms, possibly due to deformation of the core. The admixture of Pliocene and Quaternary forms makes zonal assignments difficult. The last occurrence of *Actinocyclus ingens* in Sample 1-3, 9-11 cm suggests the position there of the base of the *Coscinodiscus lentiginosus* Partial-Range Zone of McCollum (1975). The top of this zone is defined as "recent sediment being formed in the Southern Ocean containing *Coscinodiscus lentiginosus.*" Therefore, if the base of the *Coscinodiscus lentiginosus* Zone is located between Samples 1-2, 28-30 cm and 1-3, 9-11 cm, all samples above and including 1-2, 28-30 cm are Quaternary. Zonation of the interval 1-3, 9-11 cm through 1-4, 126-127 cm was not possible; that interval is assigned a Pliocene/Quaternary age.

The interval including Samples 2-1, 103-105 cm through 3-2, 120-121 cm is barren of diatoms.

Diatoms are common to abundant and are moderately well preserved in the interval including Samples 5-1, 45-48 cm through 8-1, 46-48 cm. This interval has been dated as late Paleocene by calcareous nannofossils, radiolarians, and silicoflagellates. Three diatom zones have been defined from this section. The *Hemiaulus inaequilaterus* Zone is present in Core 5. The *Sceptroneis* sp. A Zone is present in Samples 6-1, 102-103 cm through 6-2, 146-148 cm. The *Odontotropis falklandensis* Zone is present in Samples 6-3, 109-111 cm through 7-2, 147-148 cm.

Radiolaria

Radiolaria are never abundant at this site and their preservation ranges from good to very poor. Diversity is generally low.

Core 1 of Hole 327 contains common Radiolaria of assemblages ranging in age from the late Miocene to Quaternary. The older, less frequently occurring species, such as *Eucyrtidium calvertense, Clathrocyclas bicornis, Cyrtocapsella tetrapera, Desmospyris spongiosa, Helotholus vema*, and *Theocorys redondoensis* indicate that these Miocene-Pliocene assemblages are reworked into the Quaternary sediments. Species diversity and preservation are moderate.

A sample taken between Sections 2 and 3 of Core 1 of Hole 327A yielded a very similar assemblage as that of the core catcher of Core 1, Hole 327, except that *Prunopyle antarctica* is apparently absent. This may indicate a late Pliocene-early Pleistocene age for this sample. Core 1 core catcher contains a very much admixed assemblage of late Tertiary to Quaternary age.

Cores 2 and 3 contain very rare, very poorly preserved radiolarians. The presence of rare *Theocampe* sp. cf. *apicata* and *Dictyomitra* sp. indicates admixing of Late Cretaceous sediments into those of Tertiary age.

Core 4 contains a strongly mixed fauna with elements from the upper Paleocene, Oligocene, upper Miocene, Pliocene, and Quaternary. This core was severely disturbed and is useless for biostratigraphic purposes.

Samples from Cores 5, 6, and 7 all yield similar assemblages, characterized by a.o., *Stylosphaera coronata, S. goruna, Amphiptermis* sp. cf.?, *Stichomitra alamedaensis, Buryella* sp. cf., *L. pentadica, Lychnocanoma babylonis, Clathrocycloma* sp. cf., *C. parcum, Dictyomitra andersoni, Stichomitra* sp., *?Spongopyle* sp. C., *Dictyophimus* spp., and *Bekoma* sp. of *B. campechensis.* This fauna is indicative of a Paleocene age. The diversity in the samples examined is moderate and preservation is in general good.

Cores 8 and 9 are barren of Radiolaria.

In the core catcher of Core 10 and throughout Core 11, a moderately well preserved, low diversity radiolarian fauna of Late Cretaceous age is observed as indicated by the presence of a.o. *Amphipyndax enesseffi, A. stocki, Dictyomitra multicostata, D. formosa, Spongodiscus* sp. cf., *S. maximus.* According to the available information on Cretaceous radiolarian biostratigraphy, these species point to a Maestrichtian-Campanian age.

From Core 12 on down the Radiolaria become increasingly more sparse, their diversity is very low, probably as a result of the very poor preservation. In many instances the Radiolaria are only present in the form of zeolitic casts which subsequently have been severely corroded. No age determination on the basis of Radiolaria below Core 12 could be made.

Silicoflagellates

The upper part of Core 1 contains a sparse flora probably mixed Miocene to Recent. Cores 5 through 8 of Hole 327A contain exceptionally well-preserved and abundant assemblage of Paleocene silicoflagellates. These are assigned to the *Corbisema hastata* and *Naviculopsis constricta* Zones. Common species include *Corbisema hastata, Corbisema apiculata, Corbisema triacantha, Dictyocha navicula, Corbisema geometrica, Corbisema arkangelskiana*, and *Dictyocha fibula.*

Palynomorphs

In Hole 327A, well-preserved assemblages of spores, pollen, and marine organic walled microplankton are present in two sections. Late Cretaceous to early Tertiary assemblages are separated from the Early Cretaceous units by a barren interval from Cores 13 to 21.

A small assemblage of spores and pollen, dinoflagellate cysts, and tracheid fragments are present in Core 5. The assemblage is not distinctive but is of early Tertiary aspect.

Well-preserved and reasonably diverse assemblages in Cores 8 and 9 indicate a late Paleocene age. In particular the assemblages contain *Eisenackia crassitabulata, Deflandrea* sp., and *Wetzeliella homomorpha.* Spores and pollen are common and include *Nothofagidites* spp., *Phyllocladidites mawsonii*, and *Clavatipollenites* cf. *C. Hughesii.*

The Late Cretaceous assemblages of Cores 11 and 12 are dominated by marine components. They include *Odontochitina* sp., *Deflandrea belfastensis, Eisenackia crassitabulata*, and *Gilliana hymenophora* indicating a Maestrichtian age.

The dark gray sediments between Cores 22 and 27 yielded diverse and well-preserved assemblages of spores and pollen, dinoflagellate cysts, acritarchs, and tasmanitids (Prasinophyceae algae). In particular Cores 22 and 23 contain *Cicatricosisporites australiensis, Ephedripites* sp., abundant *Tsugaepollenites* spp., *Dictyotosporites speciosus, Spinidinium boydii, Odontochitina operculata*, and *Gonyaulacysta helicoidea* and are of Aptian age. *Belodinium* aff. *B. dysculum, Muderongia simplex*, and *Broomea* sp. are present in Core 24 indicating an early Aptian to Neocomian age. Dinoflagellate cyst assemblages in the more sapropelic sediments of Cores 25 and 27 are often dominated by one species and Prasinophyceae are common. These assemblages are no older than Neocomian.

CORRELATION OF REFLECTION PROFILE WITH LITHOLOGY

Site 327 was occupied in very bad weather; the reflection profiles obtained on the approach to the site, and on leaving, gave very little penetration, and a sonobuoy line shot during attempts at site survey gave no subbottom reflections. The reflection profile on which site selection was based, a Lamont-Doherty Geological Observatory profile from cruise RC 16-06, lies within 0.5 km of the eventual site location and is used here in their stead (Figure 2), for comparison with the section cored at the site. Elsewhere in this volume (Barker), this profile and others acquired later during the leg are used to correlate between this site and two others (329 and 330) drilled nearby in order to supplement the information obtained at Site 327.

At this, as at other Leg 36 sites, the section cored did not include a sharp, unambiguously identifiable reflector which, in the absence of sonobuoy data, would have provided an independent check on the validity of the acoustic velocities of the core samples measured onboard ship. Errors in velocity measurement, and the extent to which shipboard measurements represent the velocity of the sediments in situ, are discussed elsewhere. It is assumed here that measured values are essentially valid and precise at the limited depths of burial encountered at this and other sites, and they are plotted unmodified in Figure 5, together with a velocity-depth model simplified so as to ease its application to the RC 16-06 reflection profile. Velocities greater than 2.4 km/sec are plotted on the depth axis in Figure 5, to save space.

Velocities are high and variable in the top 20 meters because of the presence of varying amounts of ice-rafted terrigenous clasts, sand- and silt-sized debris, and manganese nodules (perhaps representing contamination below 13.5 m). Within the underlying Eocene and Paleocene zeolitic clays and siliceous ooze (Units 2 to 4) velocities are low, but increase steadily within the Maestrichtian calcareous oozes of Unit 5, the thin condensed Late Cretaceous section of Unit 6, and the Albian nanno chalk of Unit 7. The scatter of velocities within Units 5 to 7 is about ±3% and minor lithologies of high velocity, such as chert or limestone are very rare. Within the upper part of the underlying Unit 8, however, thin cherts and limestones of high velocity range up to 7% of particular cored intervals and increase the average velocity by up to 5%. A valid average velocity for the upper part of Unit 8 is difficult to compute because the measurements are few and the scatter is great. The assumed value 2.25 m/sec could be in error by up to 10%. Unmistakable, however, is the reduction in velocity in the underlying sapropelic claystone of the lowest two cores (26 and 27), which are less consolidated and have no interbedded limestones.

The RC 16-06 reflection profile displayed in Figure 2 is a single-channel unprocessed record, obtained using a large volume low pressure pneumatic source, without bubble-pulse attenuation. The dominant frequency of the reflected energy is about 25 Hz and the wave-train of the primary pulse extends over 0.2 sec. This means that, although penetration is excellent, the record is confusing, full of reflections whose primary nature is doubtful, but which are of sufficient amplitude to obscure weaker primary reflections from other interfaces. The identifications made below, and even more so the correlations between sites made elsewhere, are therefore partly subjective. The upper part of the record is largely obscured by the wave-train of the sea-bed reflection and the earliest certain reflector lies at 0.23 sec TW, equivalent to 180 meters, near the top of Unit 7. There are slight lithological and age differences between Cores 15 and 16 at about this depth, but no great change in acoustic properties. A second prominent reflector at 0.39 sec TW coincides with the top of Unit 8, as might be expected. The later part of the reflection from this interface interferes with another which could lie at about 0.49 sec TW, the time to the velocity inversion within Unit 8. The base of the hole lies at 0.52 sec TW, and it is obvious in Figure 2 that at least a further 0.5 sec TW of sediments (0.5 km?) lie between there and acoustic basement. Figure 5 contains depths to other lithologic intervals within the section which do not, however, give rise to distinctive reflections.

SUMMARY AND CONCLUSIONS

Summary

Site 327 at 50°52.28'S and 46°47.02'W was occupied from 0958 on 13 April 1974 to 2100 on 17 April 1974. Two holes were drilled, both being abandoned because of adverse weather conditions, the first (327) after only a surface core had been obtained. The site is located in 2400 meters of water on the southwestern flank of the elongate rise forming the eastern end of the Falkland Plateau, the Maurice Ewing Bank (Figure 1).

The objectives of the site were to obtain a shallow-water biostratigraphic section for comparison with proposed sites in deeper water to the east (Site 328) and north (Site 331), and a pre-Neogene section to aid interpretation of the many existing Lamont-Doherty reflection profiles crossing the Falkland Plateau. Both objectives bear on the early tectonic history of the plateau, and on the influence of South Atlantic opening on paleoclimates and paleocirculation within the growing ocean. The Neogene section was avoided deliberately, so as to ease access to older sediments, with the aid of the RC 16-06 reflection profile (Figure 2).

The uppermost 118 meters were cored continuously, the remainder intermittently. Hole 327A bottomed at

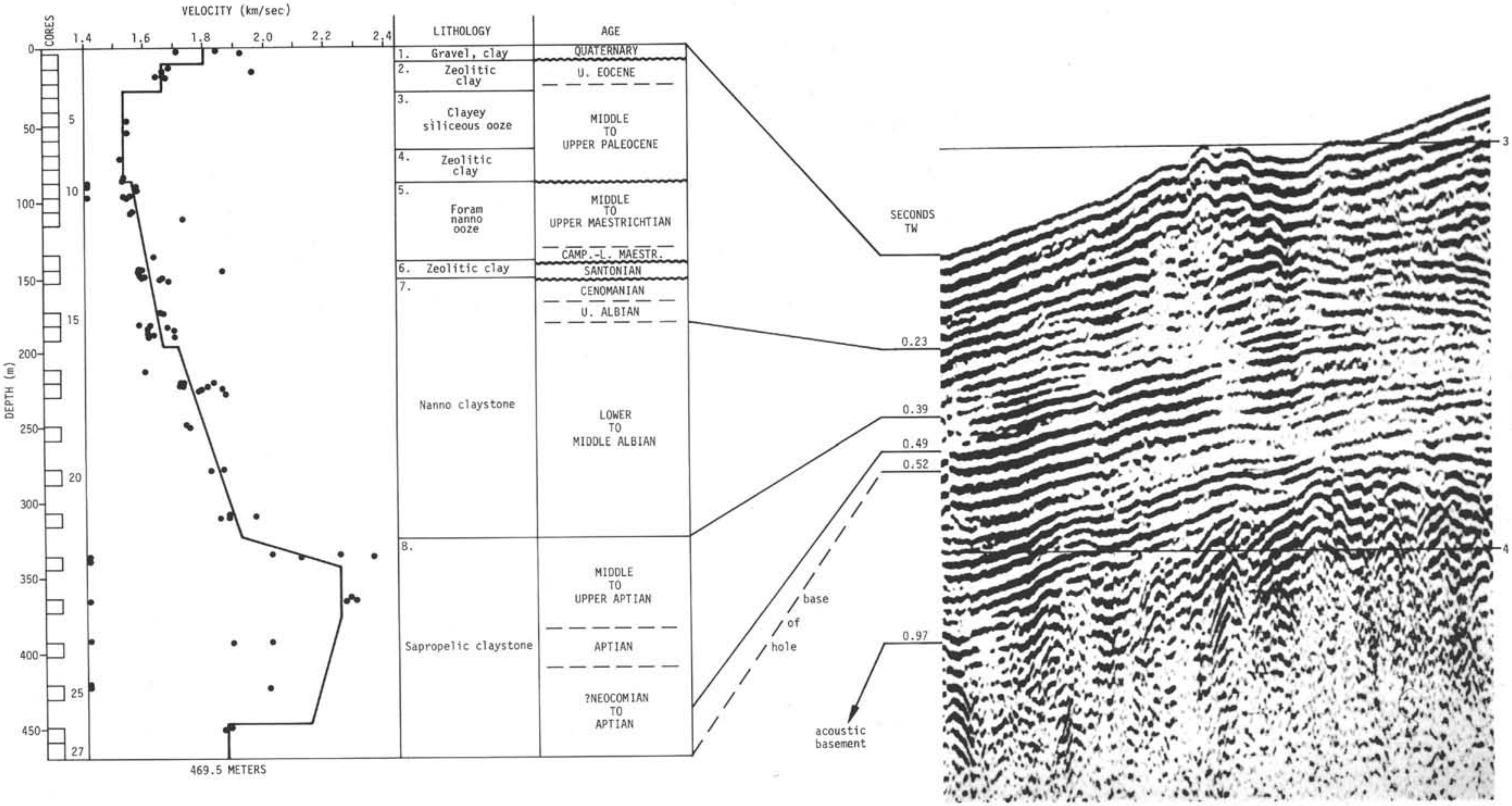

Figure 5. *Correlation* Robert D. Conrad *16-06 reflection profile near Site 327 and lithic column at site.*

469.5 meters in ?Neocomian to Aptian dark sapropelic shale, after coring 256.5 meters of sediment, of which 128.1 meters (50%) were recovered. Approximately half of the sedimentary cover overlying continental basement (see Site 330 and Figure 2) was penetrated.

The cored section is divided into eight lithologic units. The uppermost unit, 10 meters thick, comprises Quaternary sands and gravels with associated manganese nodules, interbedded with diatomaceous clay. Clasts of mudstone, sandstone, graywacke, rhyolite porphyry, pumice, granite, and garnetiferous biotite granite are present. All of these lithologies are represented by bedrock on the Pacific or Weddell sea margins of the Antarctic continent, although none uniquely so. All clasts are considered to be ice rafted. This unit overlies Unit 2, a zeolitic clay extending to 30 meters, which is poorly fossiliferous but dated as late Paleocene to early Eocene. The main components are clinoptilolite and clay minerals. Unit 3 consists of 38 meters of upper Paleocene diatom-rich radiolarian ooze with 10% to 30% clay minerals and traces of glauconite. Unit 4 is 22 meters of middle to upper Paleocene zeolitic clay consisting largely of clinoptilolite and clay minerals (montmorillonite and illite as in Units 2 and 3), with up to 5% of glauconite and micronodules. Units 2 to 4 reflect variations in the depth of the CCD, calcareous fossils being rare in Unit 3 and absent in Units 2 and 4. The siliceous microfossils in Unit 3 are excellently preserved, as are calcareous microfossils in the underlying 52 meters of foram nanno ooze, of Campanian to mid Maestrichtian age, which forms Unit 5. Some zones within this unit contain *Inoceramus* fragments; some are rich in clay minerals. The uppermost 0.6 meters cored are of chalk, much more indurated than the underlying ooze, and may have been a "hard ground," exposed at the sea bed for a significant period. Further fluctuation in the relative depth of the CCD is indicated by Unit 6. Twelve meters of variegated clay of Santonian age were sampled and contained clinoptilolite, thin micrite beds, and ash pods. This unit appears to represent a condensed section, being the only sediment deposited between the (probably late) Campanian of Unit 5 and the (perhaps early) Cenomanian clayey micrite ooze at the bottom of Core 14. Unit 7 is a 170-meter-thick clay-rich nannofossil ooze or chalk, largely of early to middle Albian age, but of late Albian in the uppermost 20 meters. Unit 8 extends from about 324 meters to the base of the hole at 469.5 meters; its upper part is a middle to late Aptian indurated sapropelic claystone with thin interbedded limestones. The lower part of Unit 8, in contrast, is neither indurated nor bioturbated and emanates a strong petroliferous odor; it is of ?Neocomian to Aptian age.

Although it might be expected that the siliceous productivity of Unit 3 would be superimposed upon the clay deposition of Units 2 and 4, a uniform sedimentation rate of 8 m/m.y. for all three units is an equally good fit in Figure 6. The calcareous ooze of Unit 5 (deposited at 9.6 m/m.y.) is bounded above by a hiatus at the Cretaceous-Tertiary boundary, and below by hiatuses and a condensed section between Cenomanian and Campanian. Units 7 and 8 share a high minimum average rate of sedimentation of 18 m/m.y., except for the uppermost, Cenomanian part of Unit 7 which appears to have been more slowly deposited, perhaps as the site approached the CCD.

Conclusions

The history of the Maurice Ewing Bank, as revealed at Site 327, is one of a deepening marine environment, developing open oceanic circulation after an initial restricted basin stage. The CCD has clearly fluctuated considerably relative to the sea bed at the site and variations in both temperature and bottom current strength are revealed.

The sapropelic claystone of ?Neocomian to Aptian age at the base of the section indicates euxinic conditions of deposition and poor circulation. Similar sediments have been reported in the mid-Cretaceous sections at several DSDP sites around the Atlantic Ocean (for example, Sites 105, 361, and 363: see Hollister, Ewing, et al., 1972; Bolli, Ryan, et al., 1975) and at Site 249 on the Mozambique Ridge (Simpson, Schlich, et al., 1974). This restricted circulation appears to have been associated with the early stages of creation of an ocean basin and, at all of the above sites, circulation improved in the uppermost Aptian or Albian.

Some uncertainty probably still accompanies the age of 127 m.y. for the initial opening of the South Atlantic (Larson and Ladd, 1974), partly for lack of reliable radiometric ages for Cretaceous biostratigraphic zones. If presently available estimates of South Atlantic rates and rotational poles of opening are accepted, however, it becomes apparent that the eastern end of the Falkland Plateau would have cleared the southern tip of Africa at about the Aptian-Albian boundary. Thus the improved Albian circulation evident in Unit 7 at Site 327 and at the other sites has an obvious explanation, provided it can be demonstrated that the earlier circulation was restricted for plausible reasons.

Site 327 lies on the south side of the Falkland Plateau together with Site 249 on the Mozambique Ridge; therefore, it demonstrates that before the Albian, the embryo Indian Ocean/Weddell Sea basin or basins were also restricted, in addition to the Atlantic Ocean basin. A further requirement is that the plateau was an effective barrier to circulation between these oceans before the Albian; this introduces the somewhat confusing problem of the paleodepth of the plateau, as revealed at Site 327. Benthonic foraminifera within Unit 7 indicate a depth no greater than 400 meters; the unit also contains *Inoceramus* remains and thin-walled pelecypods as reworked coquinas, which is taken to reflect shallow-water conditions at the site or upslope. Essentially, given that there has been no significant subsidence of one part of the eastern Falkland Plateau relative to another subsequently, the present depth of acoustic basement (near-surface along most of the northern margin) combined with that 400-meter limit, indicates that the plateau probably *was* an effective barrier to circulation before and during the Albian. Thus the thesis holds that the significant factor in improving circulation within the growing, intra-

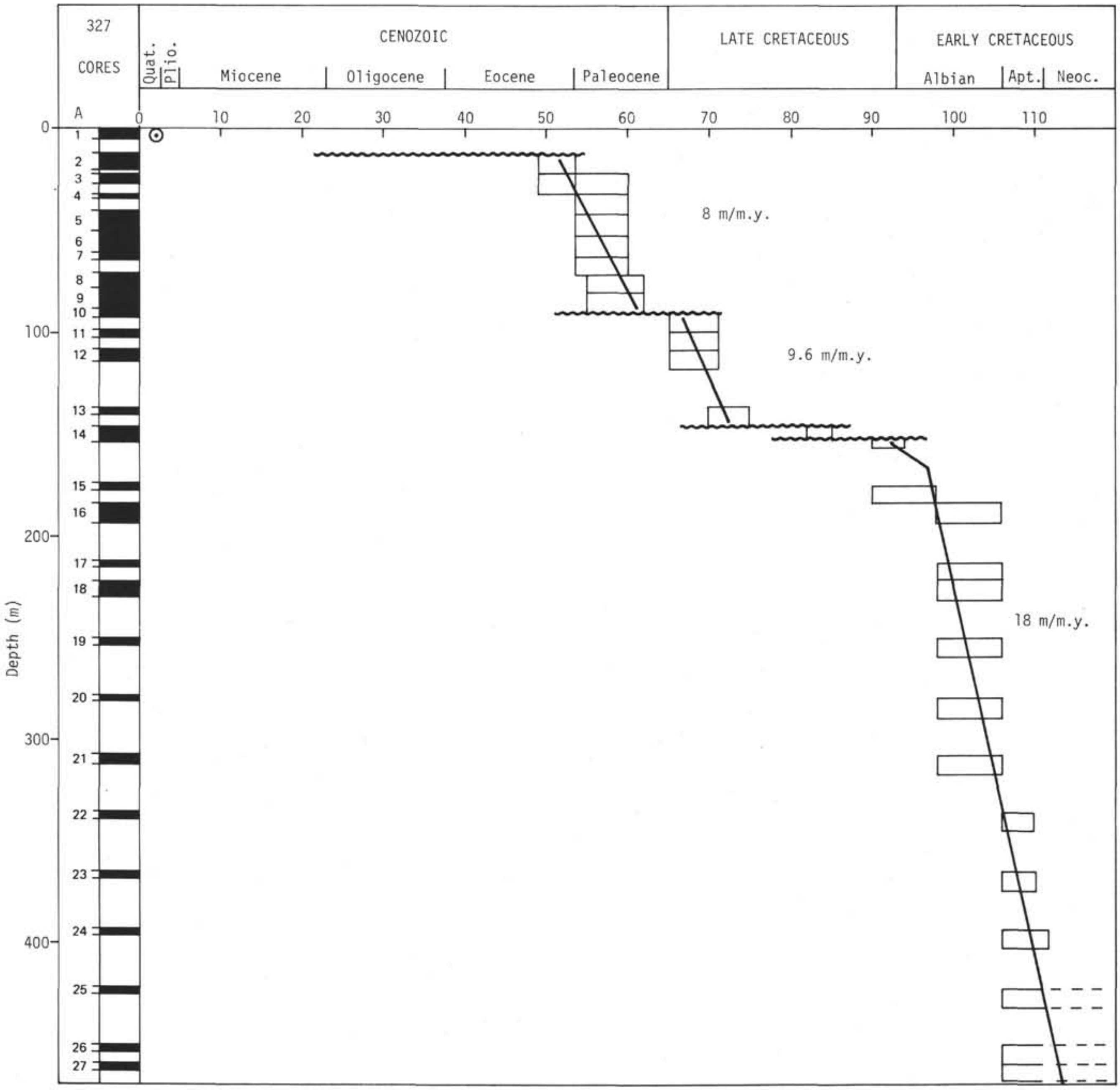

Figure 6. *Sedimentation rates at Site 327.*

Gondwanaland oceans was their connection at abyssal depths as Africa cleared the Falkland Plateau.

It is difficult to disentangle estimated post-Albian paleodepths from CCD excursions at Site 327. A straightforward tectonic interpretation of the paleontologic factors, for example, gives rapid subsidence at Site 327 from 400 meters in the Albian to more than 3000 meters by Santonian times, followed by elevation above 2000 ±500 meters depth by the Maestrichtian. There is no independent evidence whatever in support of this interpretation in what is known of the geological history of the region. A more acceptable tectonic history would be of an exponentially decaying rate of subsidence of the plateau, as would be expected under a simple thermal regime, operating on a small continental block surrounded by ocean. Figure 7 shows the theoretical subsidence of the sea bed at Site 327, under such an assumption. A thermal time constant appropriate to oceanic crust (approximately 30 m.y.; see Parker and Oldenburg, 1973) is assumed to govern a single episode extending from the Aptian-Albian boundary (106 m.y.), when the plateau separated from southern Africa, to the present, without tectonic perturbation. The initial (106 m.y.) depth is taken to be 100 meters and post-Aptian sediment cover is added without isostatic correction. It is obvious that the

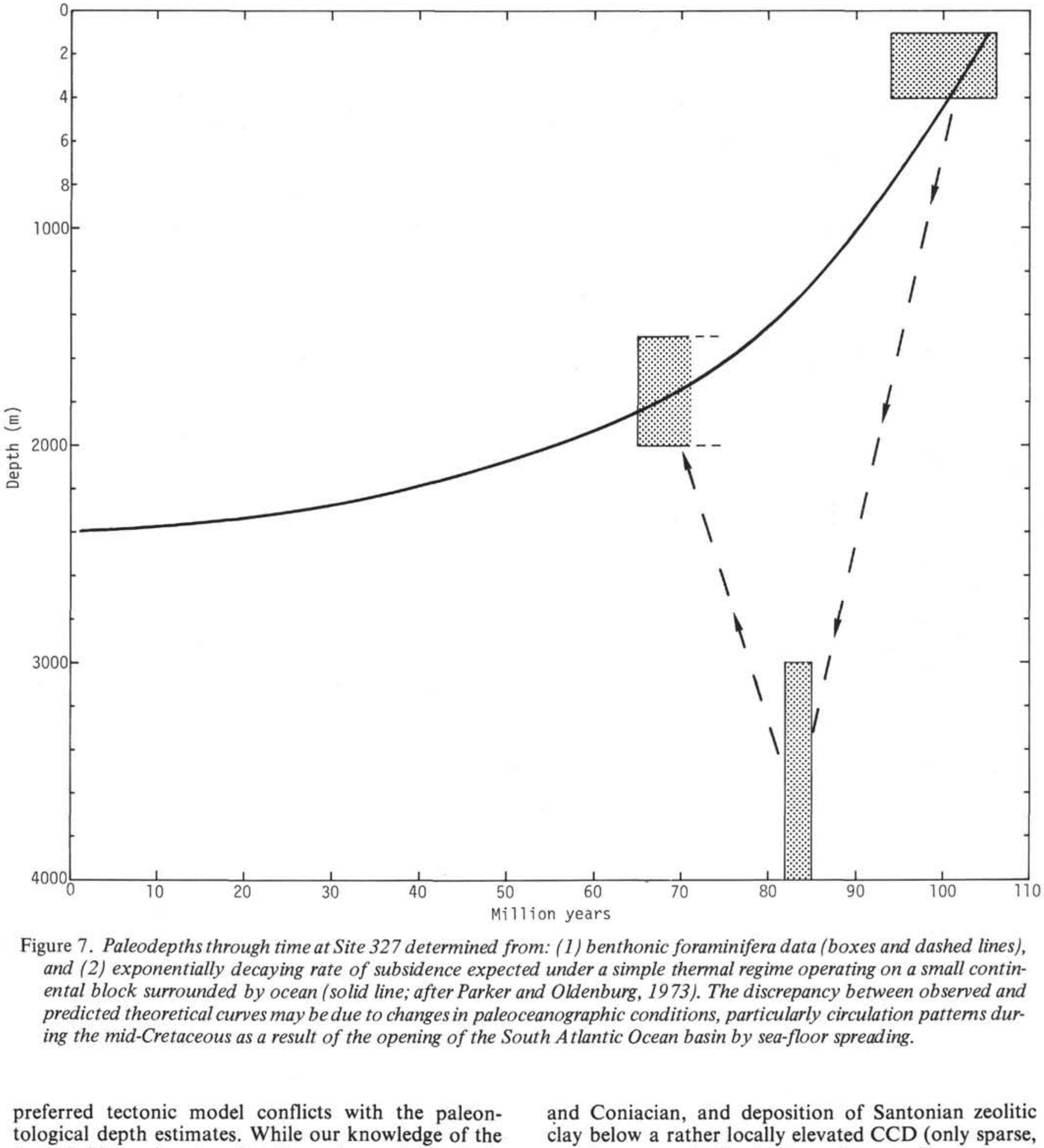

Figure 7. *Paleodepths through time at Site 327 determined from: (1) benthonic foraminifera data (boxes and dashed lines), and (2) exponentially decaying rate of subsidence expected under a simple thermal regime operating on a small continental block surrounded by ocean (solid line; after Parker and Oldenburg, 1973). The discrepancy between observed and predicted theoretical curves may be due to changes in paleoceanographic conditions, particularly circulation patterns during the mid-Cretaceous as a result of the opening of the South Atlantic Ocean basin by sea-floor spreading.*

preferred tectonic model conflicts with the paleontological depth estimates. While our knowledge of the tectonic history is not perfect, it may be prudent to look elsewhere for a resolution of these inconsistencies.

A major Coniacian-Santonian hiatus has also been reported at widespread sites in the southern Indian Ocean (Girdley et al., 1974; Veevers and Heirtzler, 1974), where it is considered to result from a change (unspecified) in regional circulation which produced bottom scouring. Circulation of cold water across the subsiding plateau starting in late Cenomanian times could account for nondeposition during the Turonian and Coniacian, and deposition of Santonian zeolitic clay below a rather locally elevated CCD (only sparse, poorly preserved, dissolution-resistant calcareous nannofossils and rare abyssal cold-water benthonic foraminifera are found in the zeolitic clay). This somewhat arbitrary explanation is nevertheless preferable to one of a purely tectonic nature.

The first signs of climatic deterioration are seen in Unit 5, where the coccoliths show marked ecological restriction, being nevertheless excellently preserved. Further climatic variations may be indicated by the continuing high but variable CCD in the Paleocene and

Eocene, after a hiatus at the Cretaceous-Tertiary boundary (a well-known worldwide event; Worsley, 1974).

The gap in the section between early Eocene and Quaternary almost certainly results from vigorous submarine erosion by strong bottom currents, following the ?Oligocene opening of Drake Passage.

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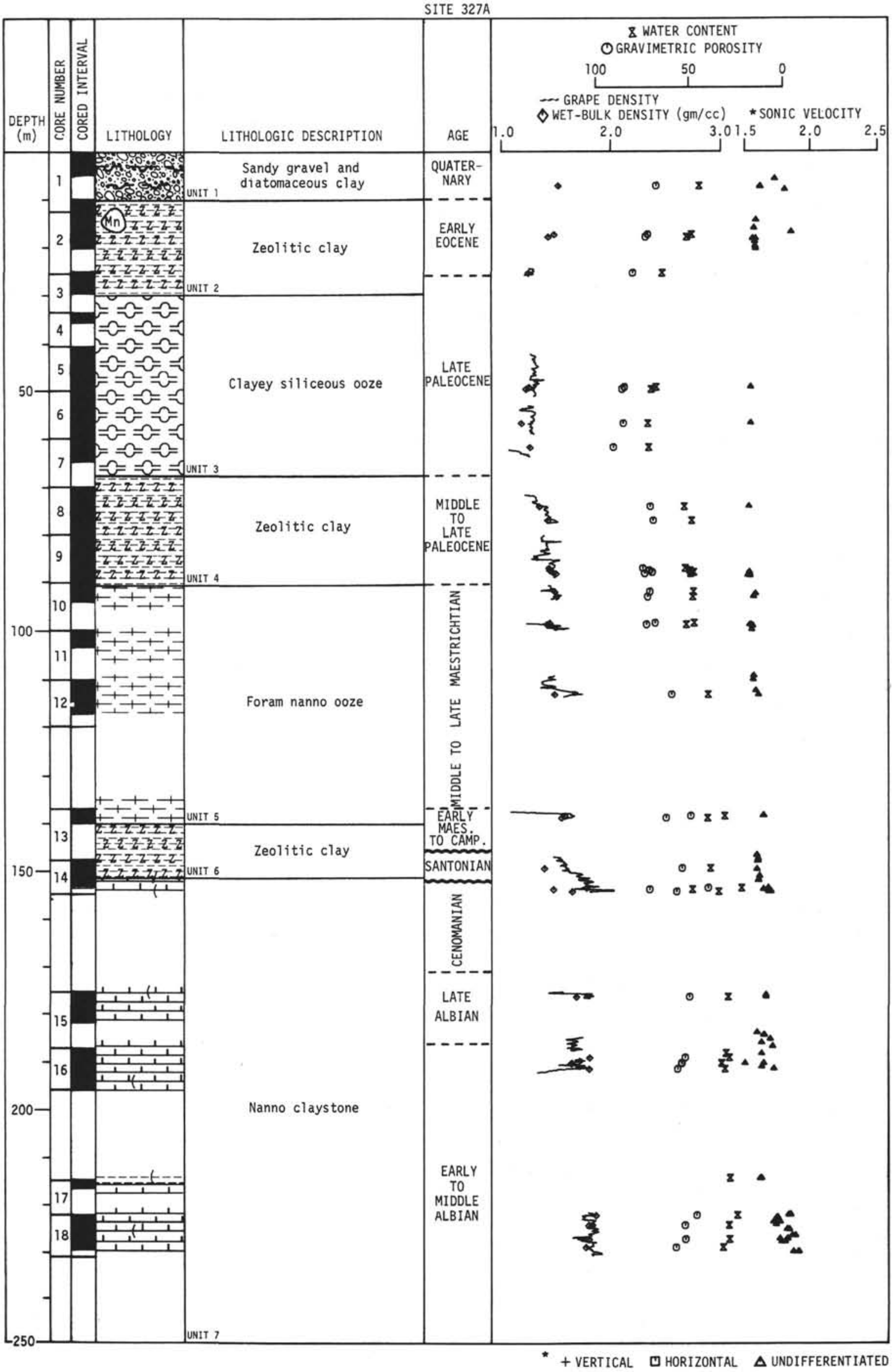
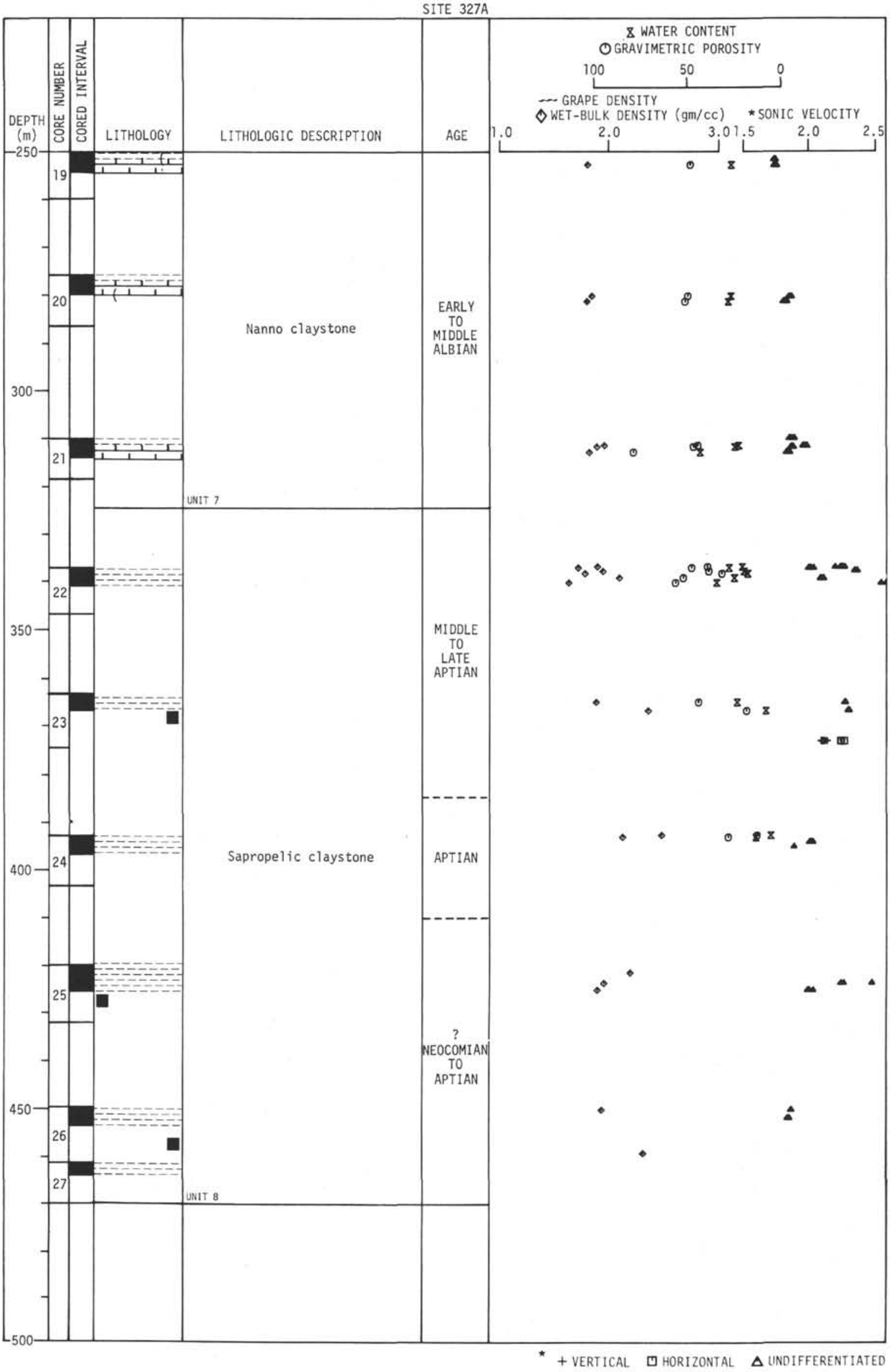
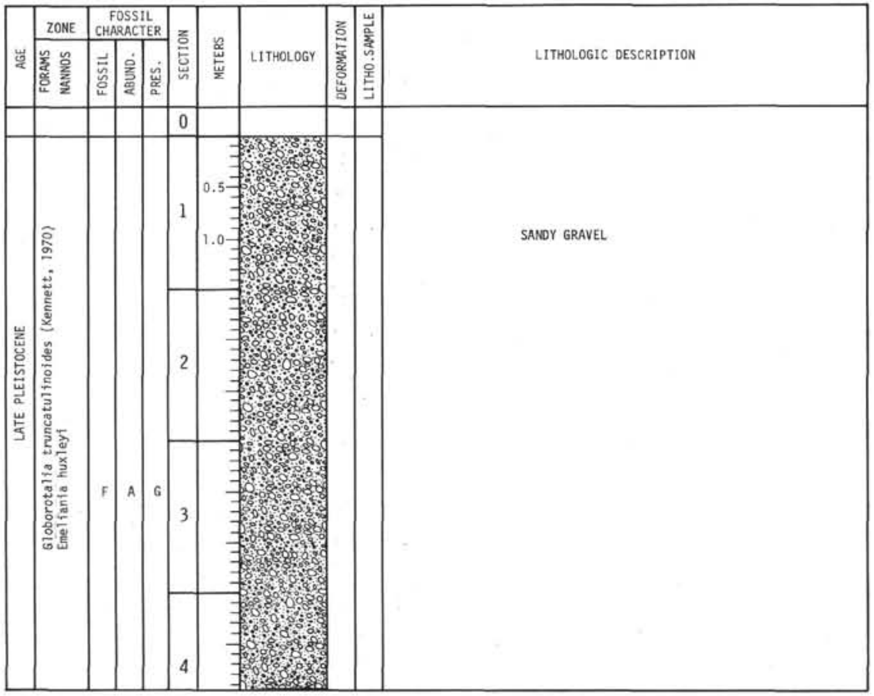

SITE 327A
DEPTH (m)
CORE NUMBER
CORED INTERVAL
LITHOLOGY
LITHOLOGIC DESCRIPTION
AGE
X WATER CONTENT
O GRAVIMETRIC POROSITY
100
50
0
--- GRAPE DENSITY
◇ WET-BULK DENSITY (gm/cc)
1.0
2.0
3.0
* SONIC VELOCITY
1.5
2.0
2.5
50
100
150
200
250
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Mn
UNIT 1
UNIT 2
UNIT 3
UNIT 4
UNIT 5
UNIT 6
UNIT 7
Sandy gravel and diatomaceous clay
Zeolitic clay
Clayey siliceous ooze
Zeolitic clay
Foram nanno ooze
Zeolitic clay
Nanno claystone
QUATERNARY
EARLY EOCENE
LATE PALEOCENE
MIDDLE TO LATE PALEOCENE
MIDDLE TO LATE MAESTRICHTIAN
EARLY MAES. TO CAMP.
SANTONIAN
CENOMANIAN
LATE ALBIAN
EARLY TO MIDDLE ALBIAN
* + VERTICAL
☐ HORIZONTAL
△ UNDIFFERENTIATED

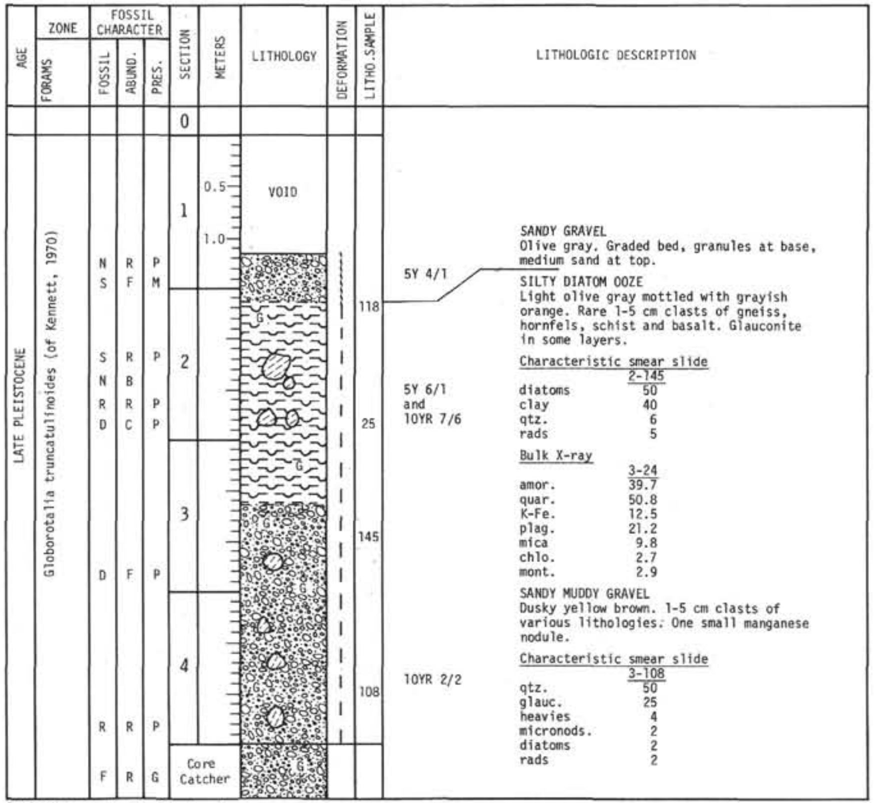

SITE 327A
DEPTH (m)
CORE NUMBER
CORED INTERVAL
LITHOLOGY
LITHOLOGIC DESCRIPTION
AGE
⧗ WATER CONTENT
○ GRAVIMETRIC POROSITY
100
50
0
--- GRAPE DENSITY
◇ WET-BULK DENSITY (gm/cc)
1.0
2.0
3.0
* SONIC VELOCITY
1.5
2.0
2.5
250
300
350
400
450
500
19
20
21
22
23
24
25
26
27
Nanno claystone
UNIT 7
EARLY TO MIDDLE ALBIAN
Sapropelic claystone
MIDDLE TO LATE APTIAN
APTIAN
? NEOCOMIAN TO APTIAN
UNIT 8
* + VERTICAL
◻ HORIZONTAL
△ UNDIFFERENTIATED

Site 327 Hole Core 1 Cored Interval: 0.0-5.4 m



SANDY GRAVEL

Site 327 Hole A Core 1 Cored Interval: 4.5-13.5



SANDY GRAVEL
Olive gray. Graded bed, granules at base, medium sand at top.

SILTY DIATOM OOZE
Light olive gray mottled with grayish orange. Rare 1-5 cm clasts of gneiss, hornfels, schist and basalt. Glauconite in some layers.

Characteristic smear slide

	2-145
diatoms	50
clay	40
qtz.	6
rads	5

Bulk X-ray

	3-24
amor.	39.7
quar.	50.8
K-Fe.	12.5
plag.	21.2
mica	9.8
chlo.	2.7
mont.	2.9

SANDY MUDDY GRAVEL
Dusky yellow brown. 1-5 cm clasts of various lithologies. One small manganese nodule.

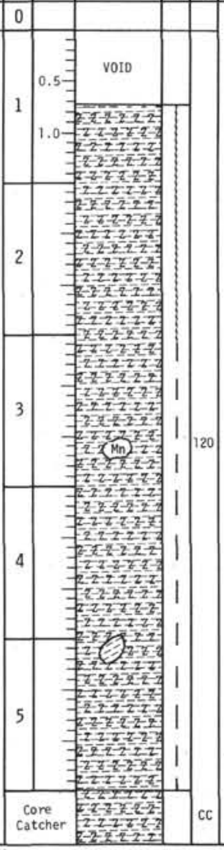
Characteristic smear slide

	3-108
qtz.	50
glauc.	25
heavies	4
micronods.	2
diatoms	2
rads	2

Explanatory notes in Chapter 1

Site 327 Hole A Core 2 Cored Interval: 13.5-23.0 m

AGE	ZONE: NANNOS	FOSSIL	ABUND.	PRES.
EARLY EOCENE	Tribrachiatus orthostylus	N	F	P
		N	F	M
		D	R	P
		F	R	P
		N	R	P
		N	R	P
		N	R	P
		N	R	M
		N	B	
		N	B	
		N	R	P
		N	B	
		R	R	P
		N	R	P



LITHOLOGIC DESCRIPTION

10YR 7/4

ZEOLITIC SILTY CLAY
Grayish orange. Granule and pebble-sized clasts in Sections 2 and 5, including manganese nodules, shale, granodiorite, siltstone and porphyry.

Characteristic smear slide

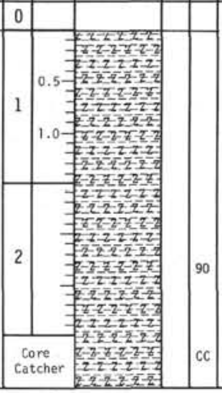
	3-120	CC
clay	78	40
zeol.	20	40
qtz.	TR	TR
palagonite	TR	-
glauc.	1	-
micronods.	1	20
rads.	TR	TR
feld.	-	TR
glass	-	TR
fish debris	-	TR

Bulk X-ray

	3-98
amor.	59.7
quar.	7.6
K-Fe.	7.2
plag.	5.4
kaol.	0.5
mica	7.3
chlo.	0.6
mont.	12.1
clin.	57.8

Site 327 Hole A Core 3 Cored Interval: 23.0-32.5 m

AGE	ZONE: NANNOS	FOSSIL	ABUND.	PRES.
LATE PALEOCENE-EARLY EOCENE	Discoaster multiradiatus	N	R	P
		N	R	P
		N	F	G
		R	R	VP
		N	F	M



LITHOLOGIC DESCRIPTION

10YR 7/4

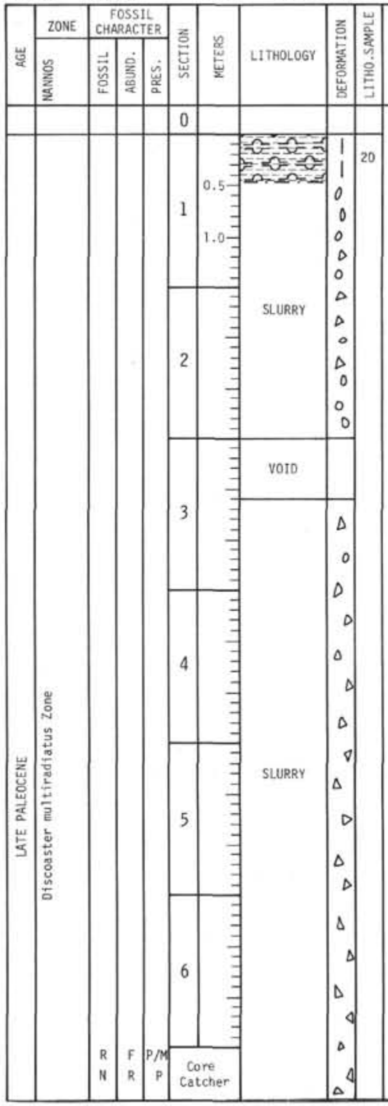
ZEOLITIC SILTY CLAY
Grayish orange.

Characteristic smear slide

	2-90	CC
clay	59	60
zeol.	35	35
nannos	5	TR
qtz. & feld.	TR	TR
mica	TR	-
spic.	TR	-
fish debris	TR	-
palag.	-	TR
glauc.	-	TR
glass	-	3

Explanatory notes in Chapter 1

Site 327 Hole A Core 4 Cored Interval: 32.5-42.0 m



LITHOLOGIC DESCRIPTION

5Y 7/2

DETRITAL CLAY, DIATOM & NANNO-RICH RAD OOZE
Yellowish gray.

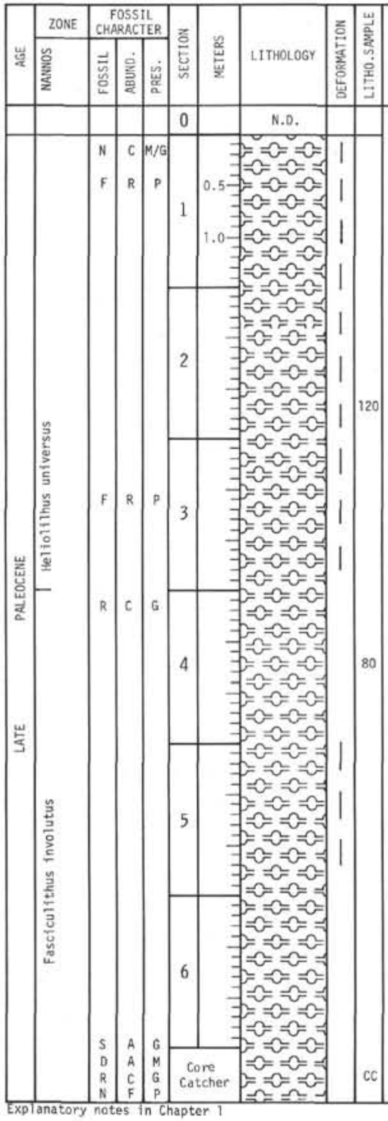
ZEOLITIC CLAY
Light olive gray. Slurry, with manganese nodules and clasts of siltstone, phyllite, and acid volcanics. Quartz and glauconite grains. All except the upper portion of Section 1 represents cavings.

5Y 5/2

Bulk X-ray

	1-33
amor.	66.3
calc.	26.7
quar.	11.3
K-Fe.	3.6
plag.	7.6
kaol.	1.6
mica	11.8
chlo.	1.0
mont.	28.2
clin.	7.0
anal.	0.5
amph.	0.7

Site 327 Hole A Core 5 Cored Interval: 42.0-51.5 m



LITHOLOGIC DESCRIPTION

NANNO DIATOM-RICH RAD OOZE
Greenish gray with occasional mottles of grayish orange.

5G 6/1
and
10YR 7/4

Characteristic smear slide

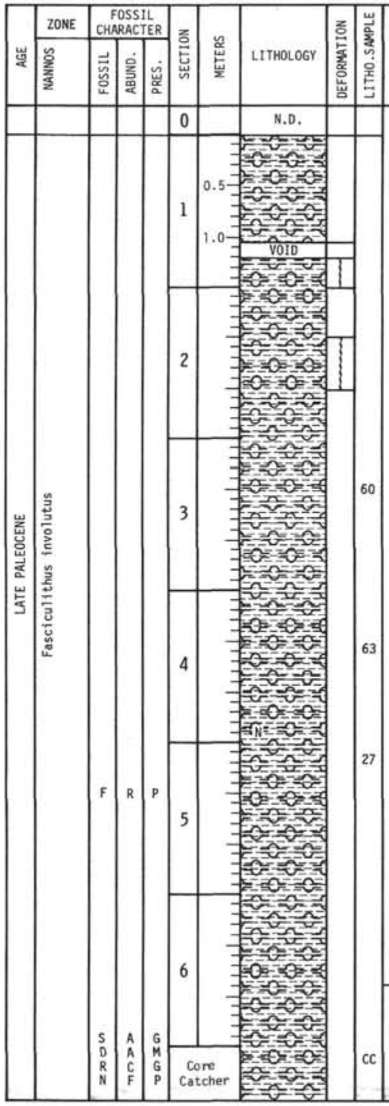
	2-120	4-80	CC
rads	59	49	30
diatoms	20	20	45
nannos	10	20	10
clay	10	10	10
glauc.	1	-	-
qtz. & heavies	TR	-	-
forams	TR	-	5
silico.	-	1	-
spic.	-	TR	-
glauc.	-	TR	-
glass	-	-	TR

Bulk X-ray

	5-98
amor.	70.1
calc.	29.2
quar.	12.5
K-Fe.	3.0
plag.	5.6
kaol.	2.3
mica	19.5
chlo.	1.4
mont.	14.2
clin.	1.5
amph.	1.6

Explanatory notes in Chapter 1

Site 327 Hole A Core 6 Cored Interval: 51.5-61.0 m



LITHOLOGIC DESCRIPTION

5G 4/1

CLAYEY SILICEOUS OOZE
Dark greenish gray, slightly mottled with darker greenish gray.

Characteristic smear slide

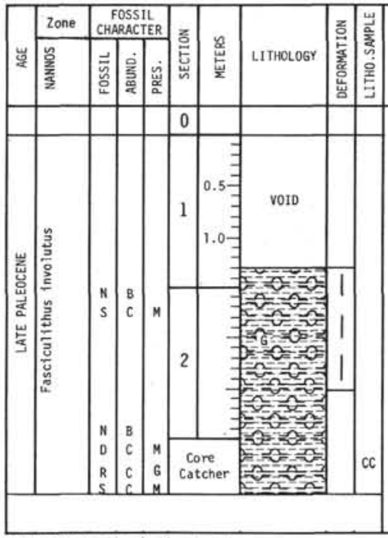
	3-60	5-27	CC
rads	35	27	20
clay	30	30	30
diatoms	20	20	35
spic.	4	4	3
silico.	1	1	2
qtz.	TR	TR	TR
feld.	TR	TR	TR
glauc.	TR	8	TR
nannos	TR	10	5
fish debris	-	TR	-

Bulk X-ray

	4-81
amor.	78.0
calc.	4.4
quar.	15.2
K-Fe.	4.4
plag.	10.8
kaol.	2.9
mica	11.9
chlo.	1.5
mont.	37.5
paly.	3.2
phil.	5.3
anal.	1.2
amph.	1.6

5GY 4/1

Site 327 Hole A Core 7 Cored Interval: 61.0-70.5 m



LITHOLOGIC DESCRIPTION

5G 4/1

CLAYEY SILICEOUS OOZE
Dark greenish gray.

Characteristic smear slide

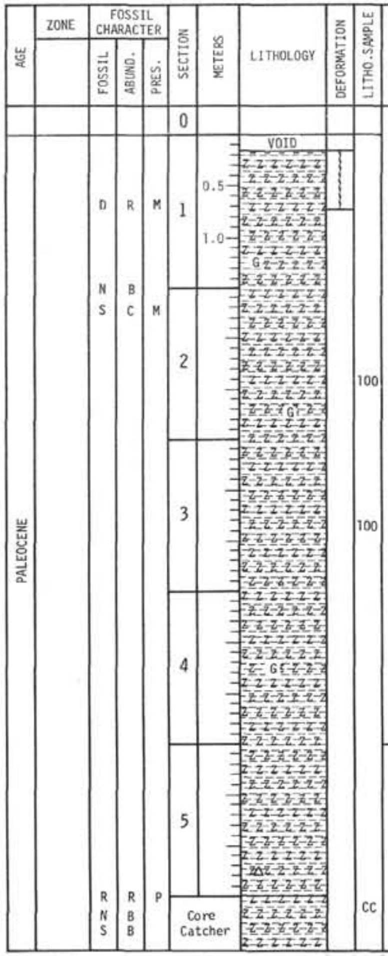
	CC
rads	40
diatoms	25
clay	25
glauc.	5
silico.	3
spic.	2
qtz.	TR
feld.	TR
mica	TR
fish debris	TR

Bulk X-ray

	2-112
amor.	78.1
quar.	17.3
K-Fe.	9.8
plag.	11.1
kaol.	3.2
mica	15.6
chlo.	2.0
mont.	32.9
clin.	1.7
phil.	5.7
amph.	0.8

Explanatory notes in Chapter 1

Site 327 Hole A Core 8 Cored Interval: 70.5-80.0 m



LITHOLOGIC DESCRIPTION

5GY 4/1

5Y 2/1

ZEOLITIC CLAY
Dark greenish gray to olive black, slightly mottled. Porcellanite nodule at 5-130.

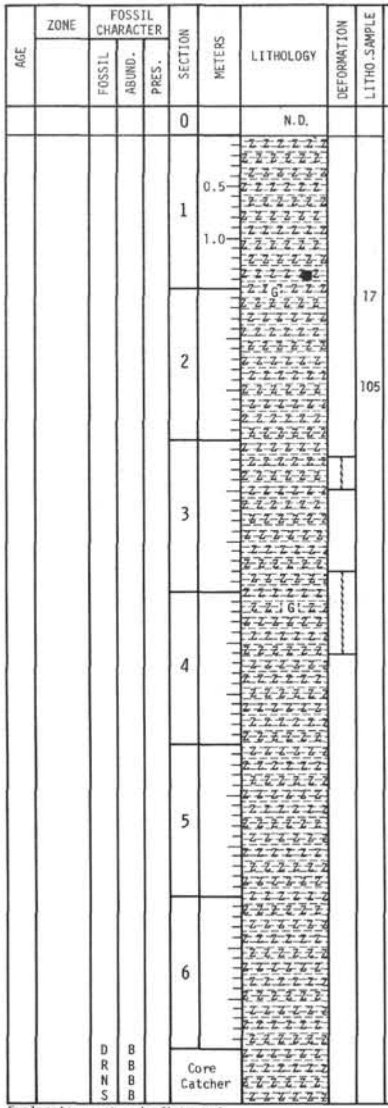
Characteristic smear slide

	3-100	CC
clay	46	70
zeol.	40	15
diatoms	5	-
glauc.	5	8
mica	2	-
qtz.	1	TR
micronods.	1	5
rads	TR	-
feld.	-	TR
nannos	-	TR

Bulk X-ray

	3-101
amor.	60.6
quar.	12.9
K-Fe.	4.0
plag.	6.7
kaol.	0.4
mica	10.3
chlo.	0.3
mont.	19.7
paly.	2.4
clin.	30.2
phil.	3.8
anal.	0.9
pyri.	2.5

Site 327 Hole A Core 9 Cored Interval: 80.0-89.5 m



LITHOLOGIC DESCRIPTION

ZEOLITE-RICH CLAY
Olive black. Pyrite aggregate at 1-130.

Characteristic smear slide

	2-17	2-105
zeol.	70	15
clay	25	70
glauc.	20	5
micronod.	3	5
qtz.	TR	-
mica	-	TR

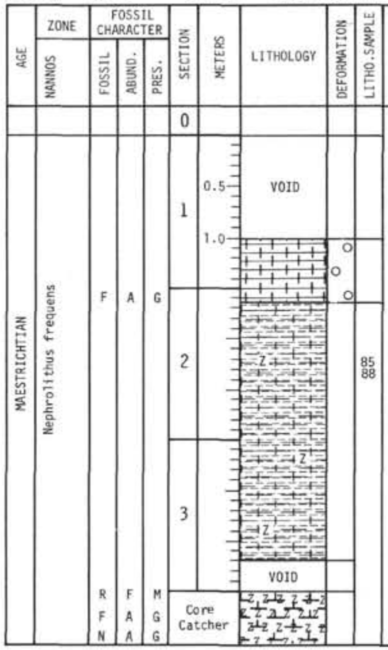
Bulk X-ray

	5-102
amor.	57.0
quar.	10.0
K-Fe.	3.7
plag.	6.9
kaol.	0.4
mica	14.4
chlo.	0.2
mont.	20.0
clin.	32.8
phil.	6.4
anal.	0.7
pyri.	4.5

5Y 2/1

Explanatory notes in Chapter 1

Site 327 Hole A Core 10 Cored Interval: 89.5-99.0 m



LITHOLOGIC DESCRIPTION

5BY 7/2

FORAM NANNO CHALK

CLAYEY FORAM NANNO OOZE
Pale blue-green.

Characteristic smear slide

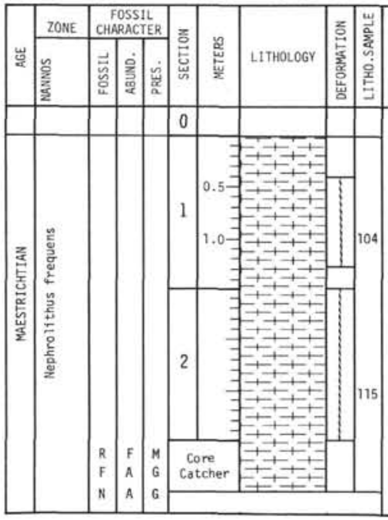
	2-85	2-88
nannos	53	15
forams	30	30
clay	10	50
zeol.	5	5
sericite	2	-
qtz.	-	TR
feld.	-	TR

Bulk X-ray

	3-97
amor.	44.2
calc.	67.6
quar.	3.9
K-Fe.	1.4
plag.	2.3
mica	5.4
mont.	9.6
paly.	3.3
clin.	6.4

ZEOLITIC CLAY AND NANNO OOZE
Fragments.

Site 327 Hole A Core 11 Cored Interval: 99.0-108.5 m



LITHOLOGIC DESCRIPTION

5G 6/2
and
5GY 4/1

FORAM NANNO OOZE
Greenish gray with chips of dark greenish gray silicified limestone.

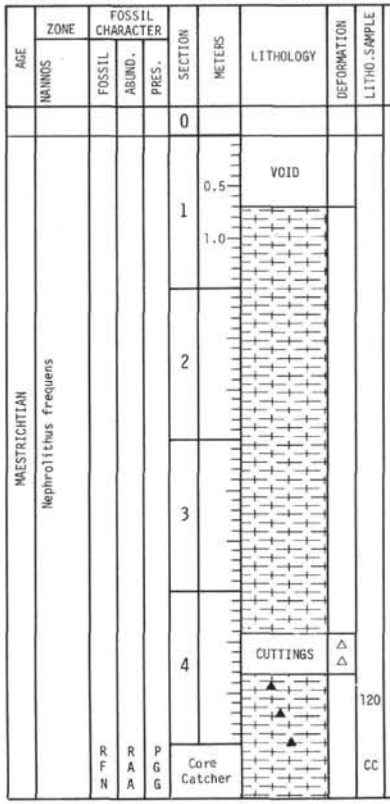
Characteristic smear slide

	1-104
nannos	75
forams	15
rads.	5
diatoms	2
micronods.	3

Bulk X-ray

	1-32
amor.	40.9
calc.	69.1
quar.	3.5
K-Fe.	2.1
plag.	1.2
mica	5.5
mont.	12.2
clin.	6.5

Site 327 Hole A Core 12 Cored Interval: 108.5-118.0 m



LITHOLOGIC DESCRIPTION

5G 6/1
and
5GY 4/1

NANNO OOZE
Greenish gray, slightly mottled, with dark greenish gray chert fragments in core catcher and Section 6. Inoceramus fragments in 3-60.

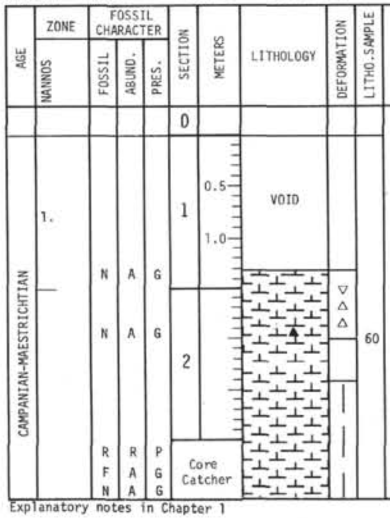
Characteristic smear slide

	4-120
micrite	50
nannos	25
forams	25
glauc.	TR
zeol.	TR

Bulk X-ray

	CC
amor.	30.8
calc.	84.7
quar.	2.1
mica	3.3
mont.	5.9
clin.	3.9

Site 327 Hole A Core 13 Cored Interval: 137.0-146.5 m



LITHOLOGIC DESCRIPTION

5G 6/1

NANNO OOZE
Greenish gray, slightly mottled with lighter greenish gray.

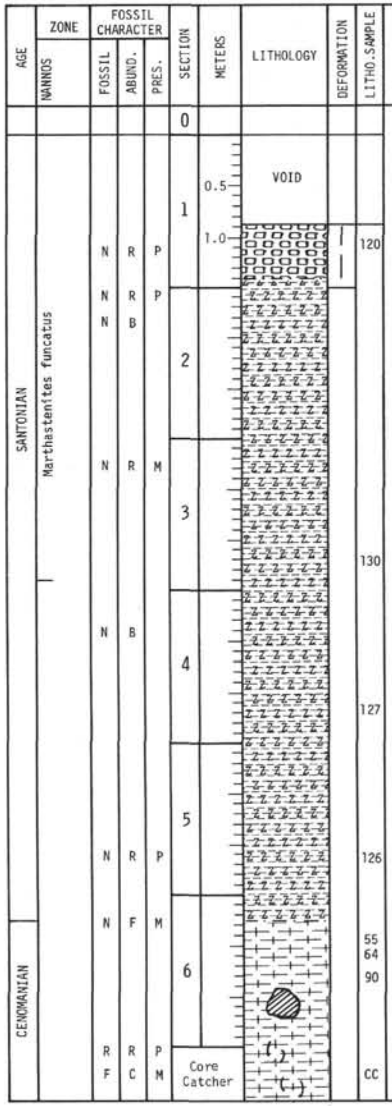
Characteristic smear slide

	2-60
nannos	74
forams	25
rads	1

1.Nephrolithus frequens

Explanatory notes in Chapter 1

Site 327 Hole A Core 14 Cored Interval: 146.5-156.0 m



LITHOLOGIC DESCRIPTION

5G 8/1
and
5YR 4/4

5YR 4/4
and
5G 8/1

5G 8/1
10YR 7/4
5G 8/1
10YR 7/4
5G 6/1

5G 8/1

MICRITE OOZE
Greenish gray.

Characteristic smear slide

	1-120
carb. frags.	40
micrite	40
forams	10
nannos	10
qtz.	TR
heavies	TR
glauc.	TR

ZEOLITIC CLAY interbedded with MICRITE OOZE. Moderate brown, slightly mottled. *Inoceramus* fragments present.

Characteristic smear slide

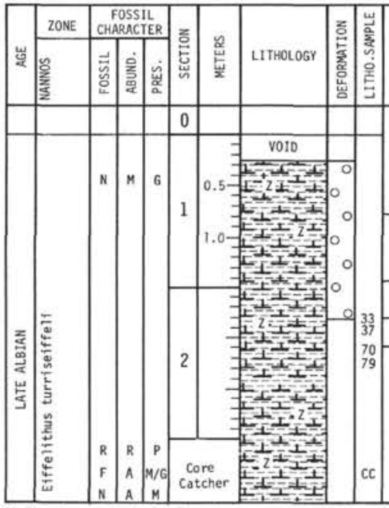
	3-130	5-126
clay	88	50
zeol.	10	20
nannos	TR	1
glauc.	TR	-
qtz.	TR	5
aggregates	-	19
heavies	-	TR
forams	-	TR

Bulk X-ray

	4-95
amor.	74.4
quar.	18.1
K-Fe.	34.2
plag.	3.3
kaol.	0.7
mica	7.7
chlo.	0.4
mont.	26.1
clin.	5.5
pyri.	1.2

CLAYEY MICRITE OOZE
Greenish gray dominantly. *Inoceramus* fragments throughout. Bored calcareous clast, 5 cm diameter, at 6-100. Thin-walled pelecypod tests abundant in catcher.

Site 327 Hole A Core 15 Cored Interval: 175.0-184.5 m



LITHOLOGIC DESCRIPTION

5G 8/1

5YR 4/4

5G 8/1
10YR 2/2
and
5YR 4/4

10YR 6/2
and
5B 7/1

ZEOLITE-RICH NANNO CLAY
Variegated light greenish gray, light brown, dusky yellow brown, pale yellowish brown and bluish gray.

Characteristic smear slide

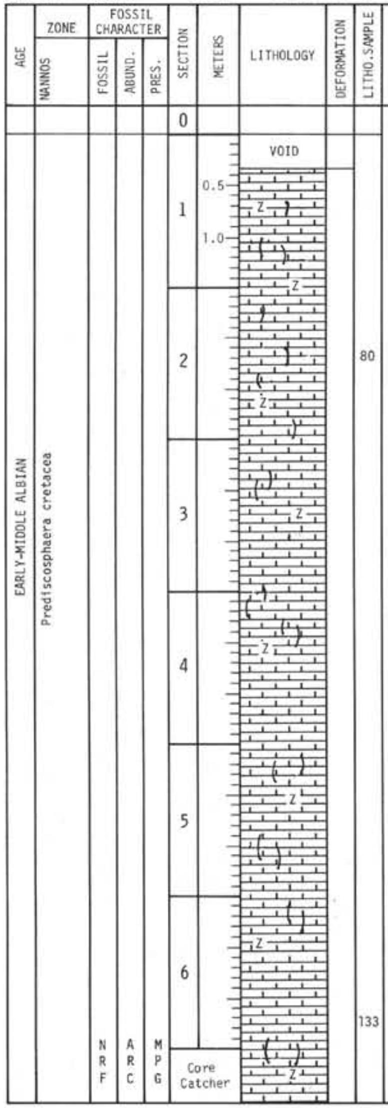
	2-33	CC
clay	50	43
nannos	25	20
zeol.	15	10
carb. frags.	5	-
goethite	3	TR
dolom.	TR	-
forams	TR	10
rads	-	10

Bulk X-ray

	2-115
amor.	38.3
calc.	51.3
quar.	6.6
K-Fe.	4.7
plag.	2.7
mica	8.3
mont.	9.2
clin.	17.2

Explanatory notes in Chapter 1

Site 327 Hole A Core 16 Cored Interval: 184.5-194.0 m



LITHOLOGIC DESCRIPTION

5Y 6/1
and
5G 8/1

ZEOLITE-RICH NANNO CHALK
Light olive gray, mottled and diffusely interlayered with light greenish gray. Scattered Inoceramus fragments and thin-walled pelecypod tests throughout. Bioturbated.

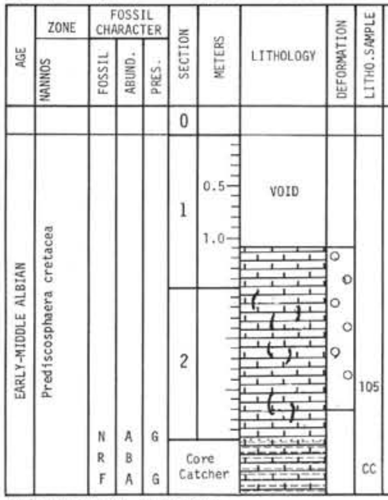
Characteristic smear slide

	2-80	6-132
nannos	60	70
forams	15	5
zeolite	10	20
carb. frags.	5	5
glauc.	-	TR

Bulk X-ray

	3-102	5-89
amor.	19.6	25.5
calc.	52.9	67.8
quar.	5.1	3.4
K-Fe.	3.2	1.4
plag.	4.6	1.2
mica	4.2	5.4
mont.	16.8	14.3
paly.	-	3.3
clin.	5.0	3.2
phil.	8.4	-

Site 327 Hole A Core 17 Cored Interval: 213.0-222.5 m



LITHOLOGIC DESCRIPTION

5Y 8/1
5YR 6/1
5Y 6/1

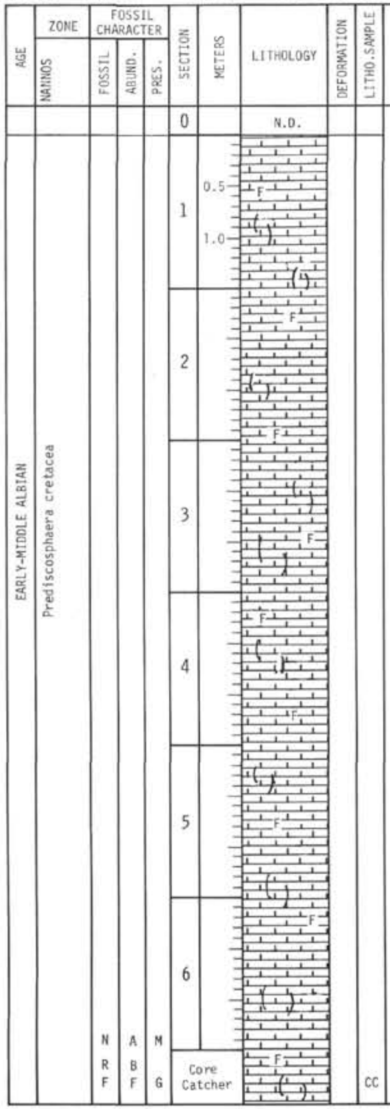
NANNO CHALK
Yellowish gray, light brownish gray and olive gray, interbedded in diffuse layers. Bioturbated. Thin-walled pelecypod tests common in some zones.

Characteristic smear slide

	2-105	CC
nannos	90	30
forams	5	-
carb. frags.	5	20
clay	-	38
zeol.	-	3
rads	-	3

Explanatory notes in Chapter 1

Site 327 Hole A Core 18 Cored Interval: 222.5-232.0 m



LITHOLOGIC DESCRIPTION

5Y 6/1
and
5GY 8/1

NANNO CHALK
Light olive gray, diffusely interbedded with light greenish gray. Bioturbated. Forams present. Thin-walled pelecypod tests common.

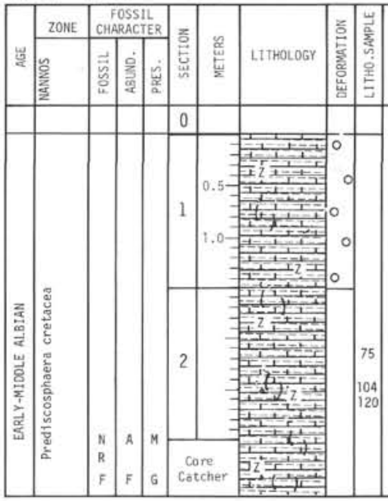
Characteristic smear slide

	CC
nannos	80
forams	10
carb. frags.	10

Bulk X-ray

	4-101
amor.	17.0
calc.	25.3
quar.	3.8
cris.	36.0
K-Fe.	1.6
plag.	1.8
mica	4.1
mont.	4.5
trid.	6.5
clin.	16.4

Site 327 Hole A Core 19 Cored Interval: 251.0-260.5 m



LITHOLOGIC DESCRIPTION

5Y 8/1
and
10YR 6/2

CLAY-RICH ZEOLITIC NANNO OOZE
Yellowish gray, diffusely laminated with pale yellowish brown. Bioturbated. Thin-walled pelecypod tests common.

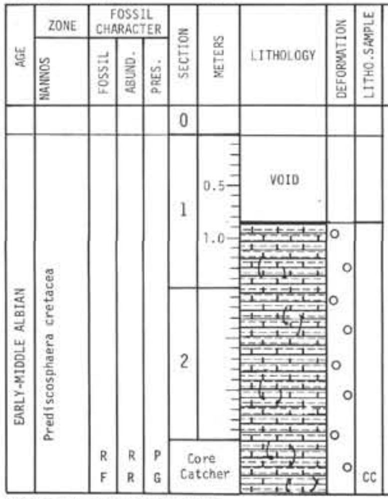
Characteristic smear slide

	2-104	2-75
clay	70	40
nannos	15	45
zeol.	5	5
forams	3	5
rads	2	-
micronods.	1	-
qtz.	TR	-
feld.	TR	-
carb. frags.	-	5

Bulk X-ray

	2-120
amor.	31.0
calc.	53.9
quar.	5.5
K-Fe.	1.6
plag.	0.9
mica	8.6
mont.	3.8
clin.	25.5

Site 325 Hole A Core 20 Cored Interval: 279.5-289.0 m



LITHOLOGIC DESCRIPTION

5Y 6/1
and
5Y 8/1

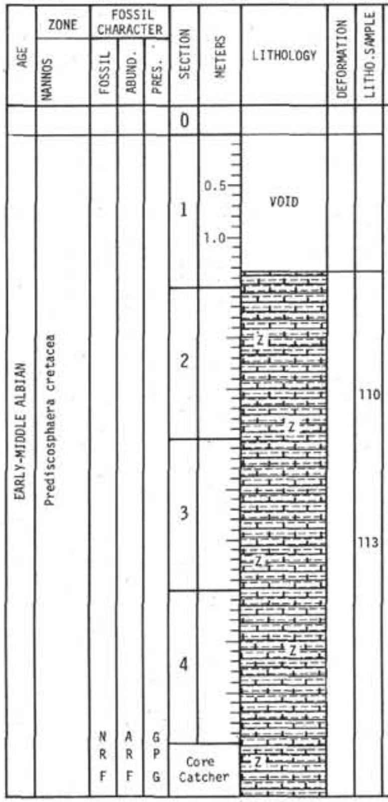
CLAY-RICH NANNO CHALK
Olive gray, moderately mottled with yellowish gray. Bioturbated. Thin-walled pelecypod tests common.

Bulk X-ray

	2-76
amor.	24.4
calc.	70.2
quar.	4.4
K-Fe.	2.1
plag.	2.4
mica	5.5
mont.	7.3
clin.	8.1

Explanatory notes in Chapter 1

Site 327 Hole A Core 21 Cored Interval: 308.0-317.5 m



LITHOLOGIC DESCRIPTION

5Y 6/1
5G 6/1
5B 7/1

NANNO CLAYSTONE
Diffuse layers and mottles of light olive gray, greenish gray and light bluish gray. Barite veins at 3-65 and 4-130.

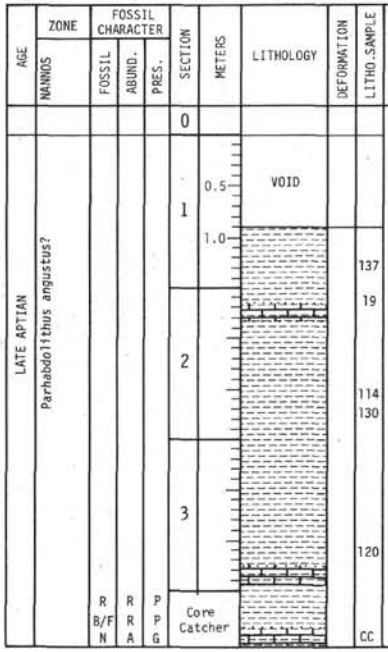
Characteristic smear slide

	2-110	3-113	CC
clay	53	62	43
nannos	40	30	25
zeol.	5	5	10
carb. frags.	2	-	-
forams	1	-	-
pyr.	-	1	-
goethite	1	1	2
qtz.	1	1	3
feld.	1	1	2
glauc.	-	-	TR
dolom.	-	-	TR

Bulk X-ray

	4-101
amor.	30.6
calc.	60.4
quar.	8.4
K-Fe.	3.6
plag.	3.1
mica	9.6
mont.	10.6
clin.	4.2

Site 327 Hole A Core 22 Cored Interval: 336.5-346.0 m



LITHOLOGIC DESCRIPTION

5YR 2/1

SAPROPELIC CLAYSTONE WITH MICRITIC LIMESTONES
Brownish black with occasional greenish-gray zones. Bioturbated. Occasional lighter-colored zeolite-rich layers. Carbonized wood fragments at 2-52. Rare pelecypod fragments. Possible rare sphalerite grains.

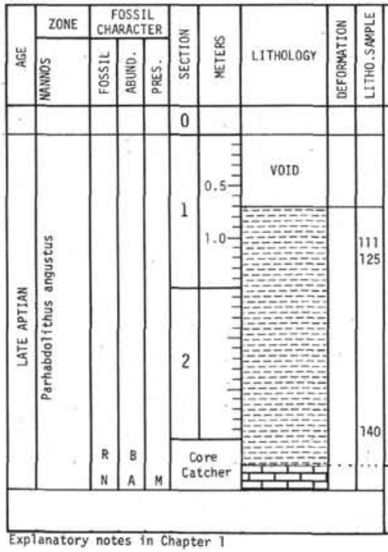
Characteristic smear slide

	2-19	2-130
carb. frags.	40	-
clay	53	68
zeol.	5	25
nannos	2	1
pyr.	-	4
qtz.	-	2
rads	-	TR
pollen	-	TR
lignin	-	TR
dolom.	-	TR

Bulk X-ray

	3-120	3-139
amor.	12.6	-
calc.	3.3	24.3
quar.	4.4	3.1
cris.	70.2	56.5
K-Fe.	1.6	-
plag.	1.6	-
mica	2.8	2.0
mont.	4.6	-
paly.	1.2	-
trid.	6.0	14.1
clin.	3.4	-

Site 327 Hole A Core 23 Cored Interval: 365.0-374.5 m



LITHOLOGIC DESCRIPTION

5YR 2/1
5Y 8/1
N8

N8

SAPROPELIC CLAYSTONE
Dominantly brownish black, with 2-3 cm zones of very light gray. Ammorite fragments in Section 2. Light gray sparry calcite zones, 5 cm thick, at 1-110 and 2-130. Limestone in core catcher.

Characteristic smear slide

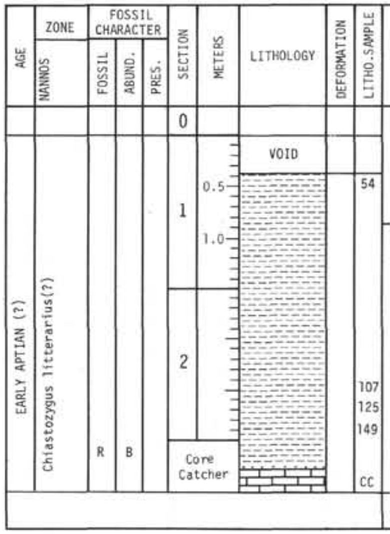
	1-111	1-125	2-140
carb. frags.	100	-	10
clay	-	43	63
chlorite	-	40	-
zeol.	-	15	25
pyr.	-	20	-
opaques	-	-	2
qtz.	-	-	TR

Bulk X-ray

	1-105	1-111	2-131
amor.	45.4	42.3	23.3
dolo.	-	8.8	-
rhod.	-	78.2	-
quar.	57.0	5.0	3.7
K-Fe.	5.7	-	-
plag.	3.2	-	-
mica	14.8	-	3.3
mont.	16.5	8.0	8.8
pyri.	2.8	-	-
calc.	-	-	84.2

Explanatory notes in Chapter 1

Site 327 Hole A Core 24 Cored Interval: 393.5-403.0 m



LITHOLOGIC DESCRIPTION

5Y 4/1

5YR 2/1

NANNO-RICH SAPROPELIC CLAYSTONE

Olive gray to brownish black. Micritic limestone in catcher with abundant forams replaced by sparry calcite. Veins of sparry calcite.

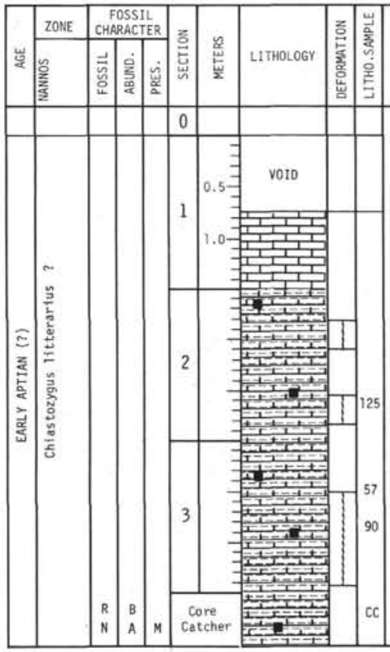
Characteristic smear slide

	1-54	2-125	2-149
clay	66	74	43
nannos	15	7	1
lignin	5	-	-
pyr.	5	3	-
carb. frags.	2	5	30
zeol.	TR	-	10
qtz.	-	TR	-
apatite(?)	-	-	15
micronods.	-	-	TR

Bulk X-ray

	1-78	2-131	2-140
amor.	23.6	47.4	17.3
calc.	74.3	14.5	93.1
quar.	14.0	57.5	2.9
mica	2.9	7.5	-
chlo.	-	1.0	-
mont.	7.8	16.6	-
pyri.	1.1	2.8	4.0

Site 327 Hole A Core 25 Cored Interval: 422.0-431.5 m



LITHOLOGIC DESCRIPTION

5Y 4/1

MICRITIC LIMESTONE

PYRITE AND NANNO-RICH CLAYSTONE

Olive gray. Rock fractured from 75-150 cm in Section 1. Irregular calcite veins common. Belemnite rostrum at 2-45.

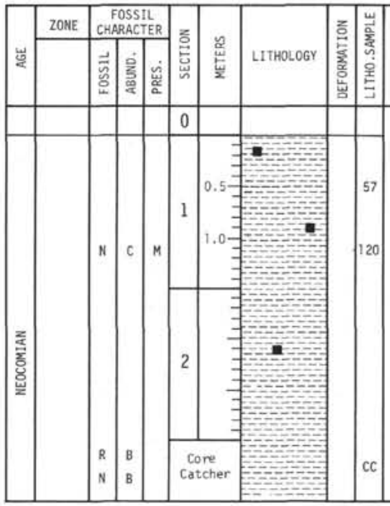
Characteristic smear slide

	2-5	2-125	3-113
carb. frags.	95	5	-
nannos	5	7	20
lignin	TR	10	5
clay	-	74	55
pyr.	-	3	15
qtz.	-	TR	-
zeol.	-	-	5

Bulk X-ray

	1-80	1-148	2-95	2-145	3-148
amor.	14.9	20.4	9.9	24.4	25.0
calc.	86.7	83.8	95.7	75.8	68.8
quar.	7.0	9.9	3.0	11.9	11.6
K-Fe.	-	-	-	-	4.1
plag.	-	-	-	-	2.3
mica	3.4	3.2	-	5.9	5.4
mont.	3.0	2.9	-	5.3	4.8
pyri.	1.2	1.4	1.1	3.0	7.6

Site 327 Hole A Core 26 Cored Interval: 450.5-460.0 m



LITHOLOGIC DESCRIPTION

5Y 4/1

CLAYSTONE

Olive gray. Rich in lignin, including recognizable stems. Thin-bedded, with sand and silt-sized "clasts" of what appear to be zeolitic clay.

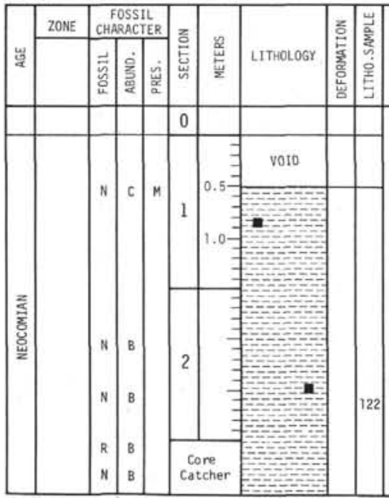
Characteristic smear slide

	1-120
clay	65
carb. frags.	15
zeol.	8
nannos	5
spic.	2
lignin	2
pyr.	3

Bulk X-ray

	1-120
amor.	49.3
quar.	44.7
K-Fe.	14.2
plag.	7.6
kaol.	2.6
chlo.	3.2
mont.	12.9
paly.	7.2
pyri.	7.6

Site 327 Hole A Core 27 Cored Interval: 460.0-469.5 m



LITHOLOGIC DESCRIPTION

5Y 6/1
and
5Y 4/1

CLAYSTONE

Olive gray. Abundant organic matter.

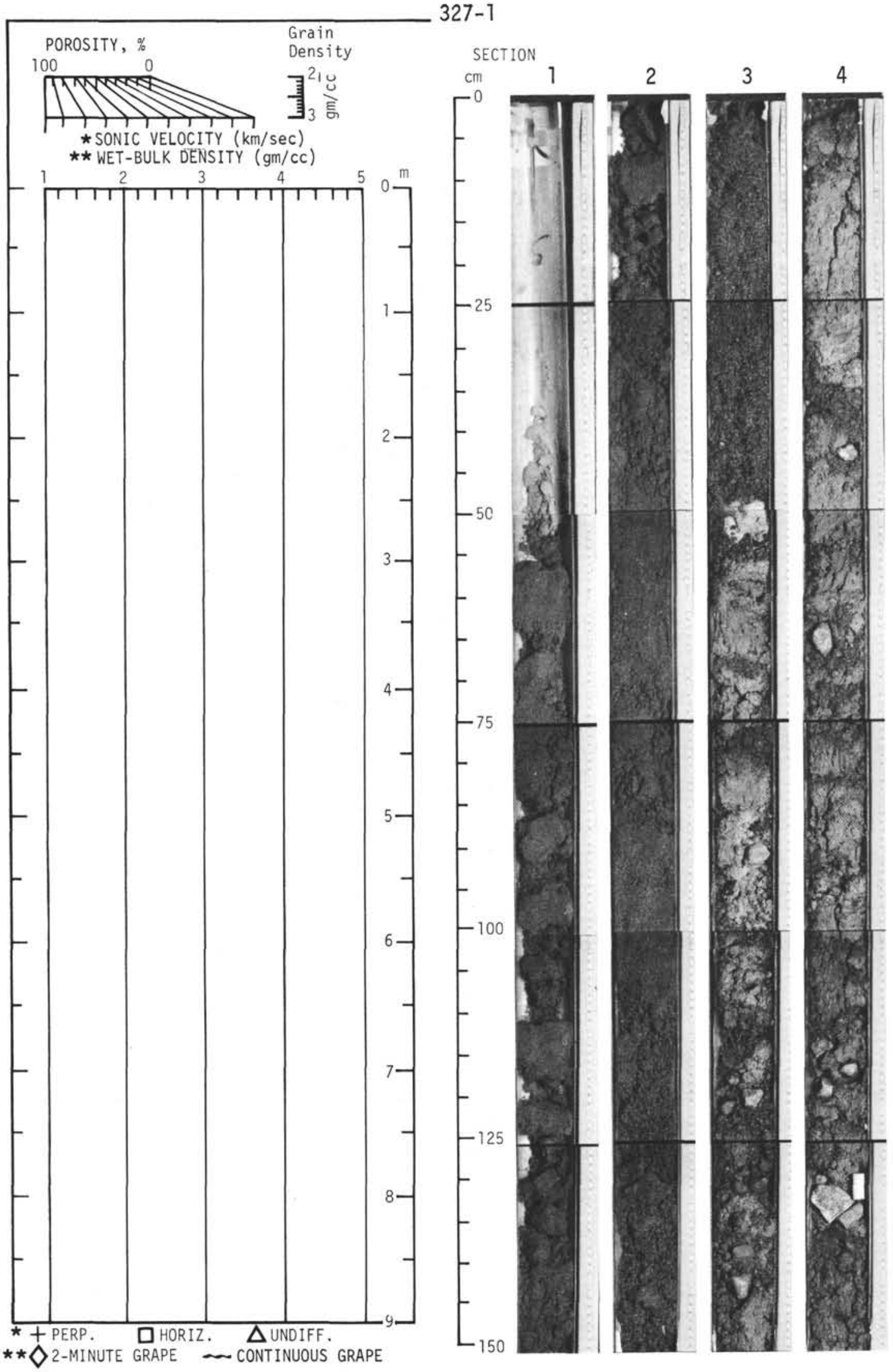
Characteristic smear slide

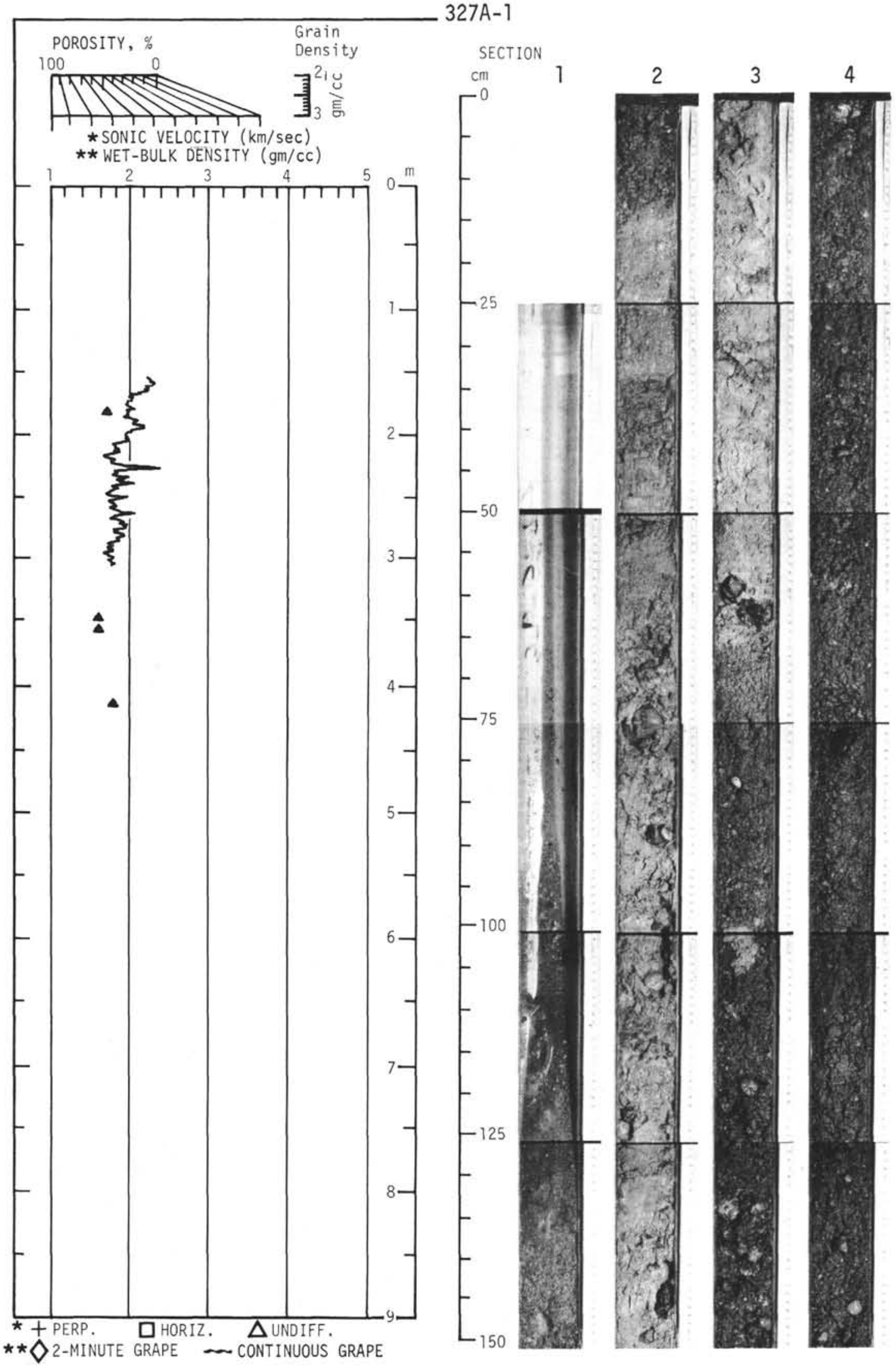
	2-122
clay	90
zeol.	5
pyr.	5
lignin	TR

Bulk X-ray

	1-78
amor.	26.3
calc.	78.4
quar.	8.8
mica	6.1
mont.	5.5
pyri.	1.1

Explanatory notes in Chapter 1


327-1
POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE
SECTION
1
2
3
4
cm
0
25
50
75
100
125
150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Grain Density
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gm/cc
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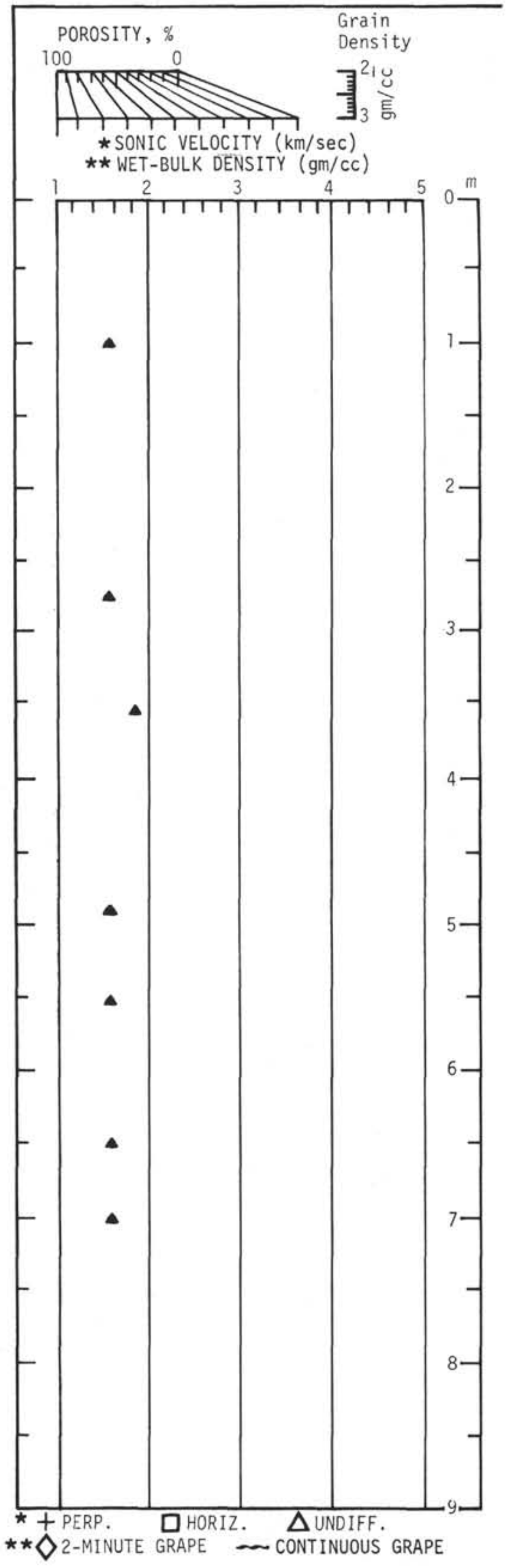
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
〰 CONTINUOUS GRAPE
SECTION
cm
0
25
50
75
100
125
150
1
2
3
4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gm/cc
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** WET-BULK DENSITY (gm/cc)
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2
3
4
5
m
0
1
2
3
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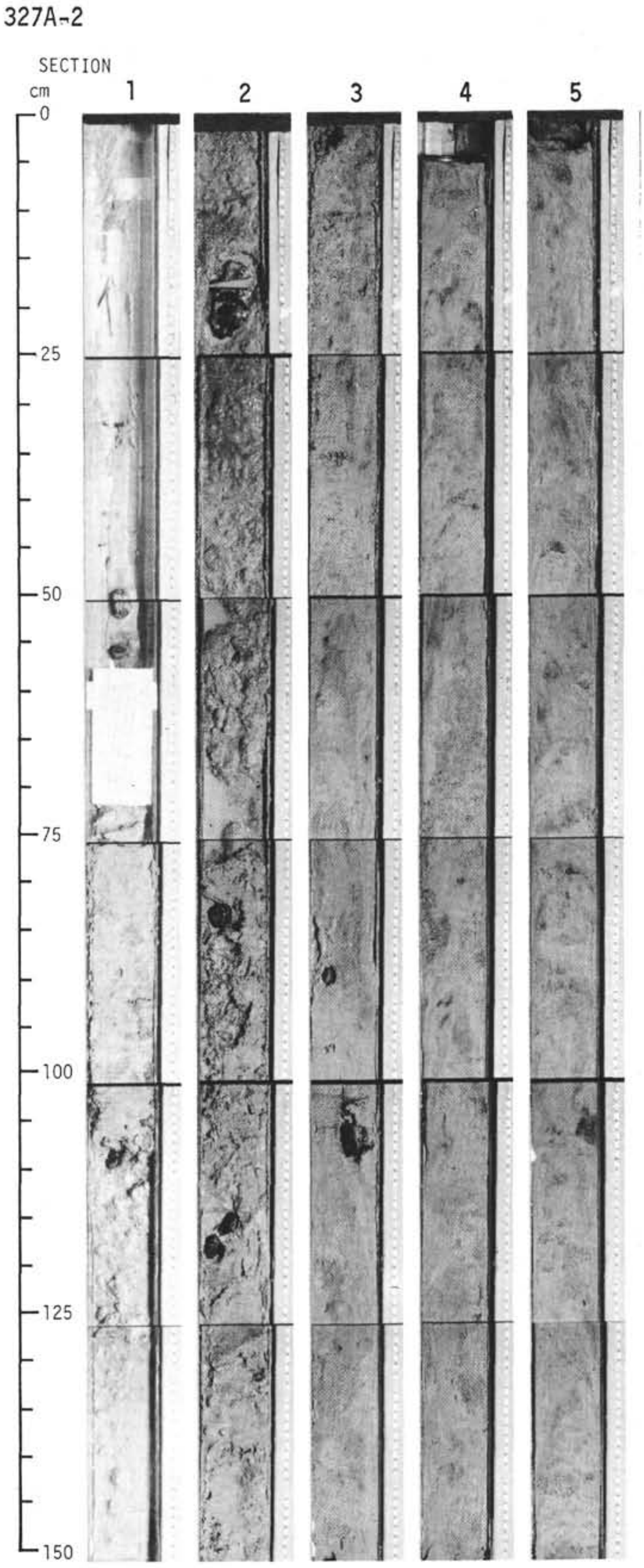
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
〰 CONTINUOUS GRAPE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cm
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4
5
0
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75
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125
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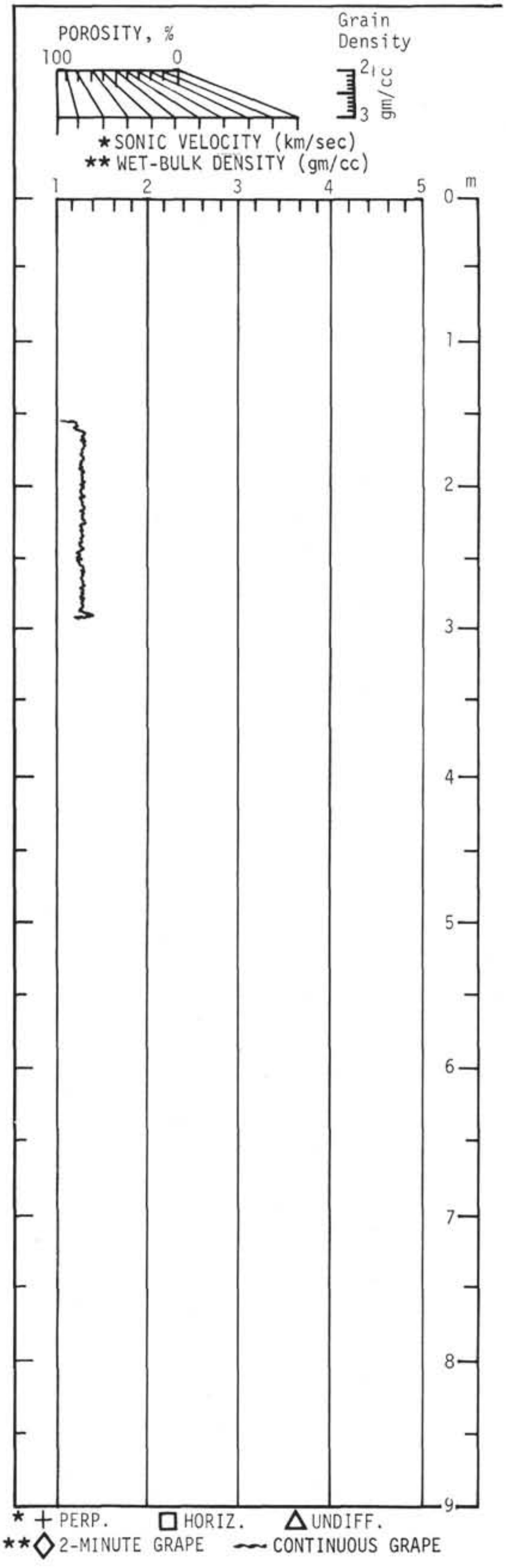
POROSITY, %
100
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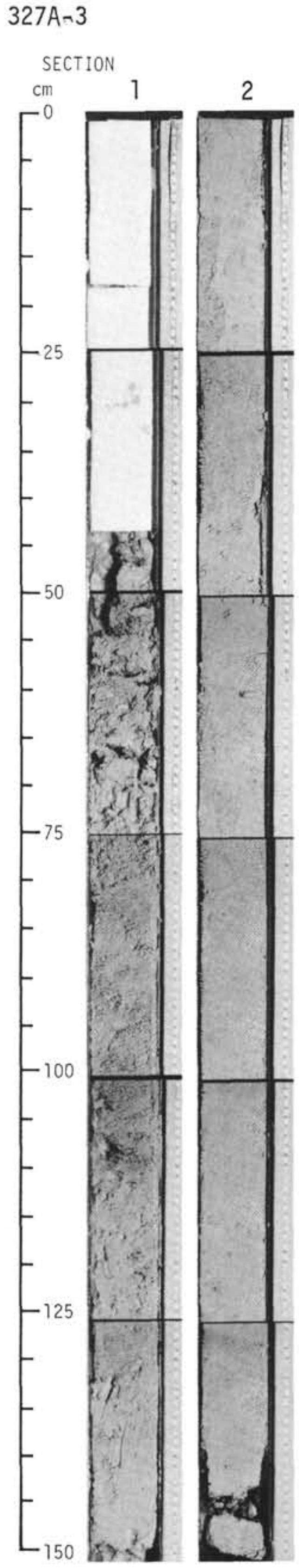
Grain Density
2
3
gm/cc
*SONIC VELOCITY (km/sec)
**WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP. □ HORIZ. △ UNDIFF.
** ◇ 2-MINUTE GRAPE ~ CONTINUOUS GRAPE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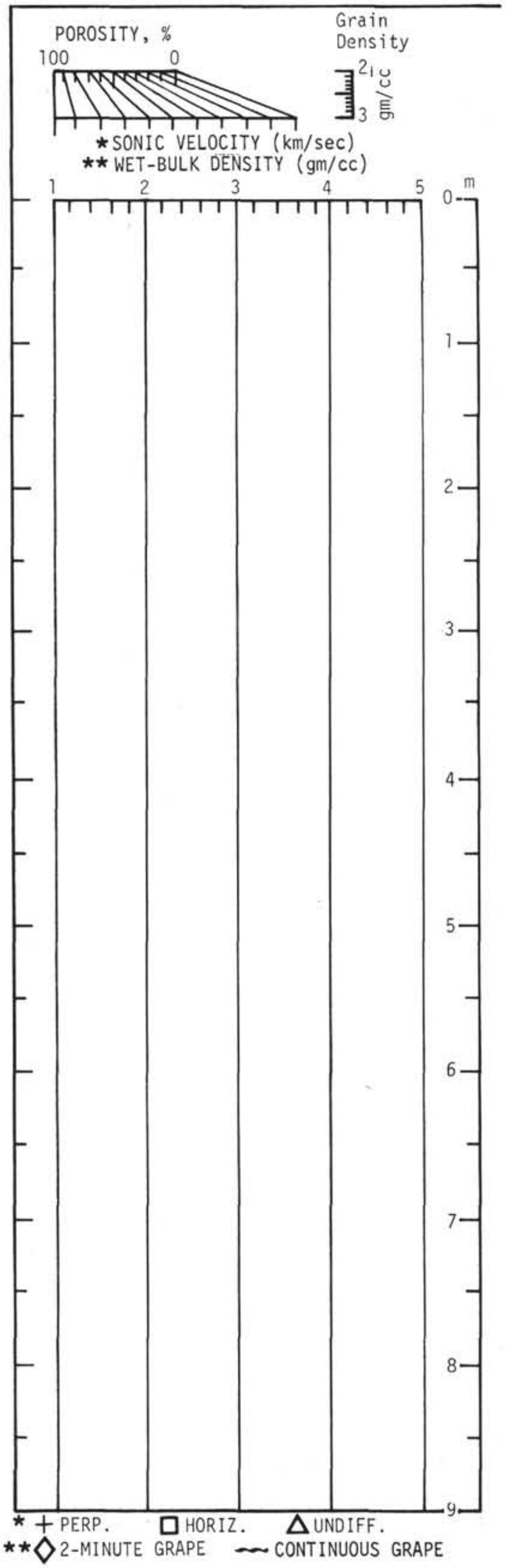
SECTION
cm
1
2
0
25
50
75
100
125
150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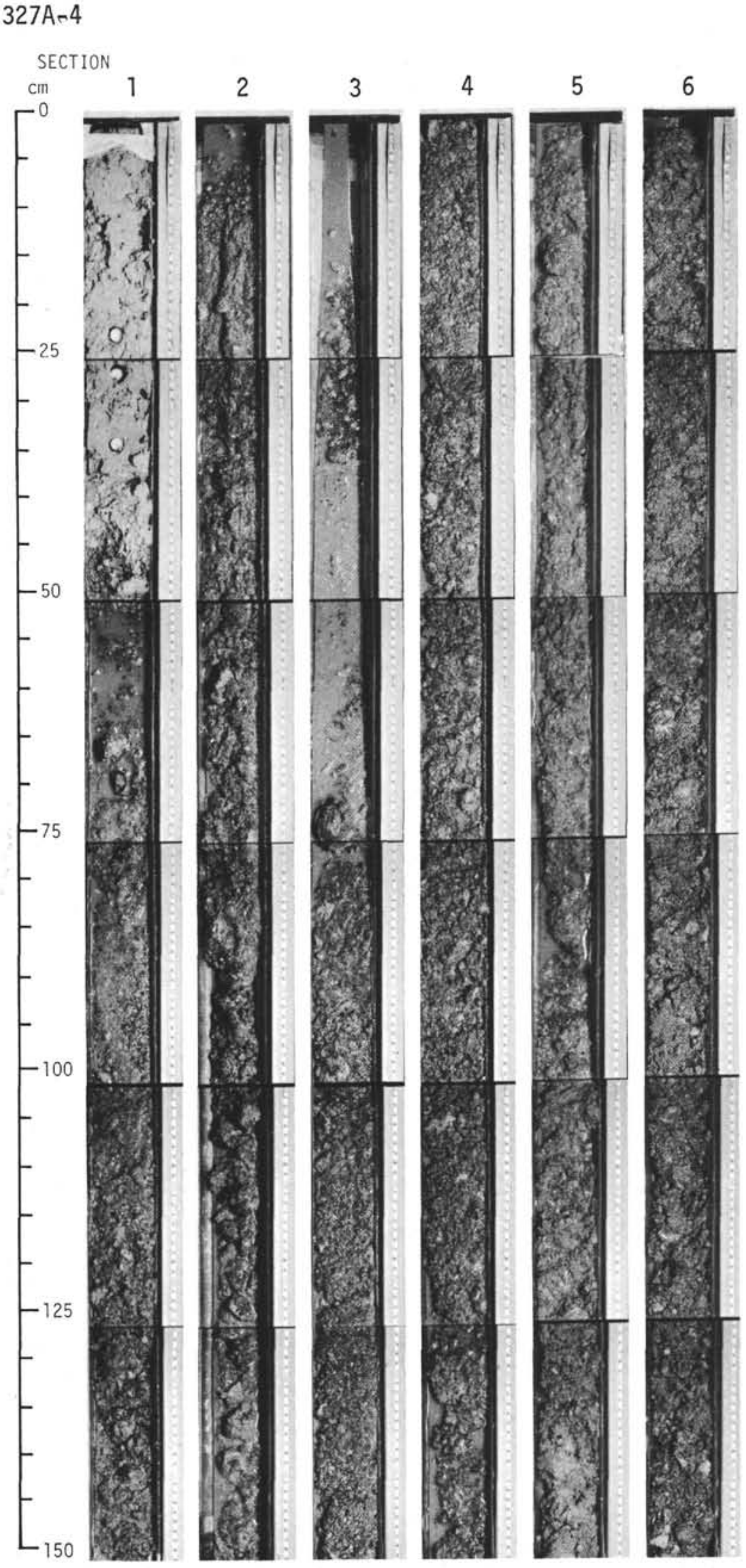
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE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cm
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75
100
125
150
1
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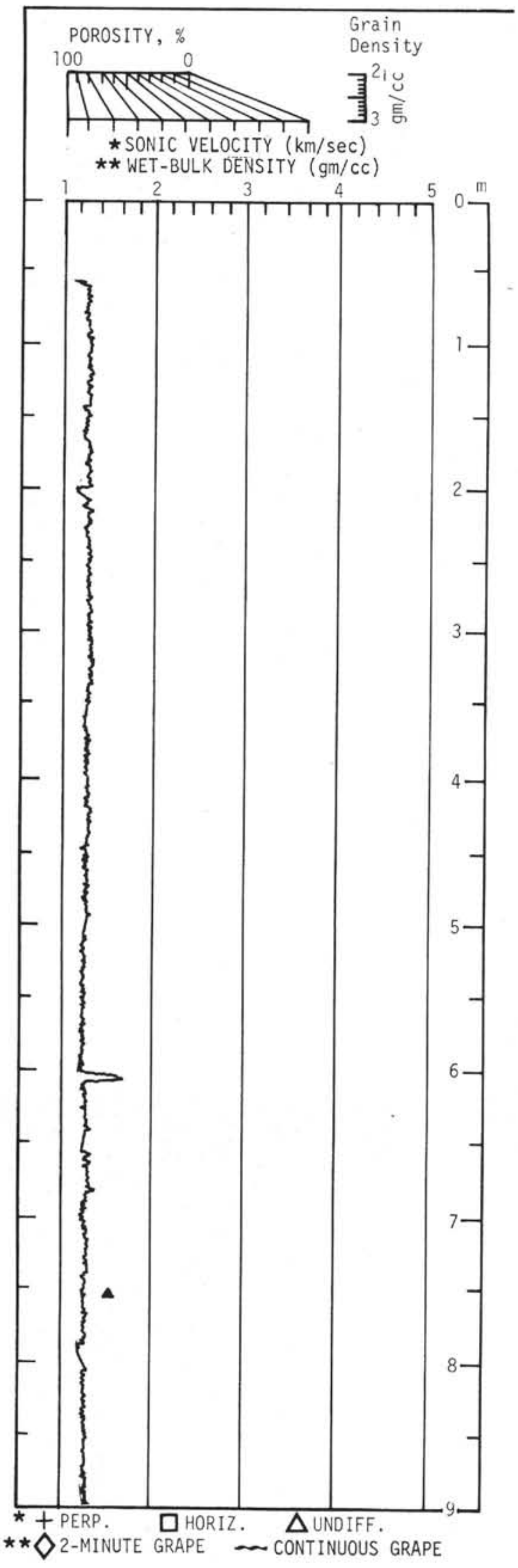
3
4
5
6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3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
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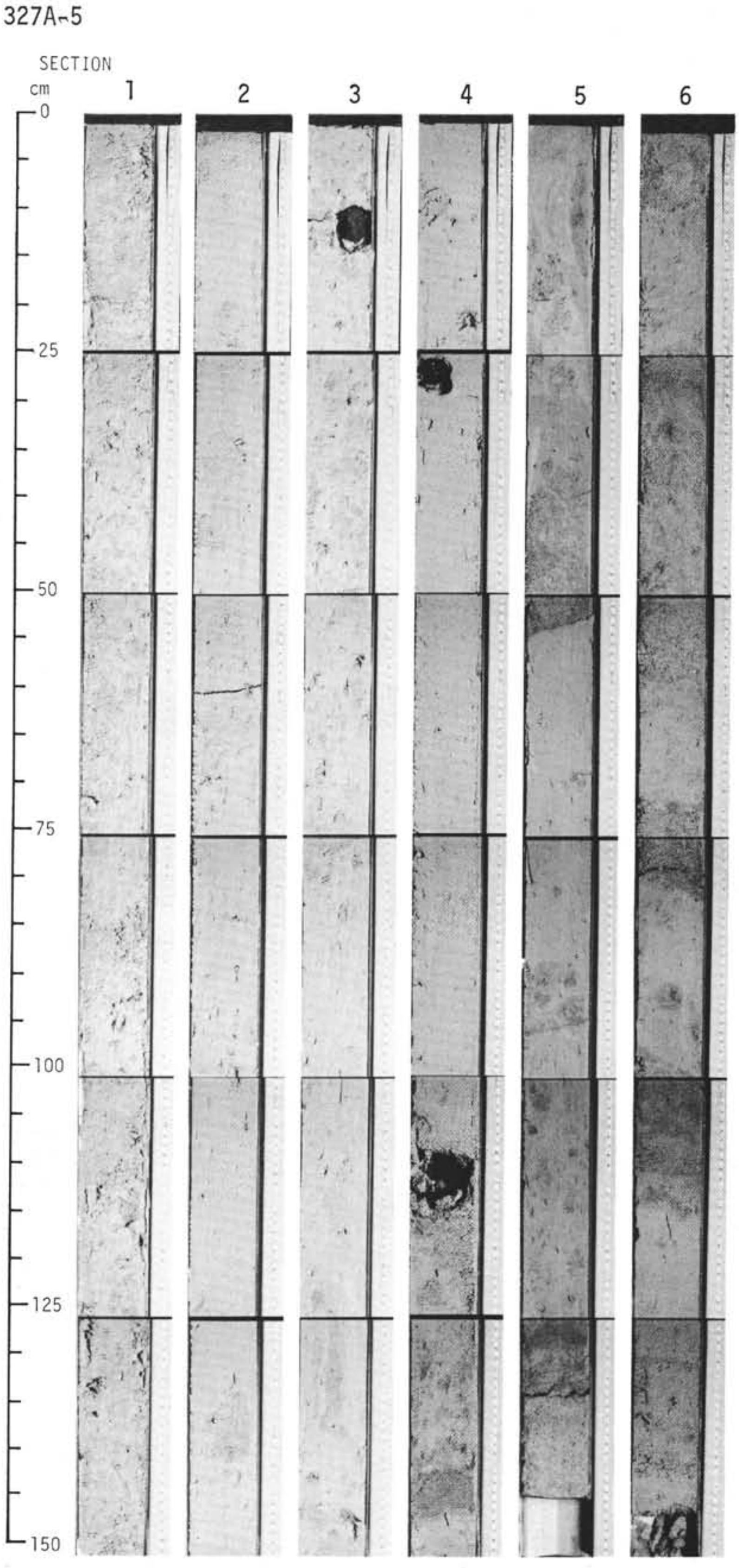
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE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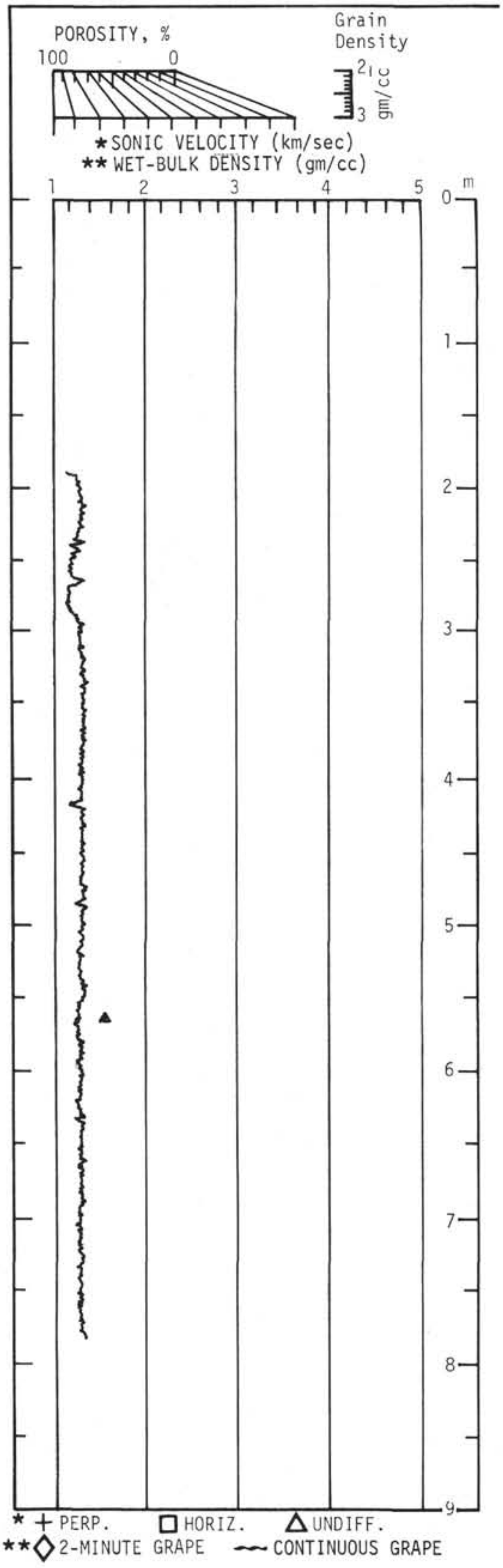
75
100
125
150
1
2
3
4
5
6

327A-6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Grain Density
2
3
gm/cc
*SONIC VELOCITY (km/sec)
**WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
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4
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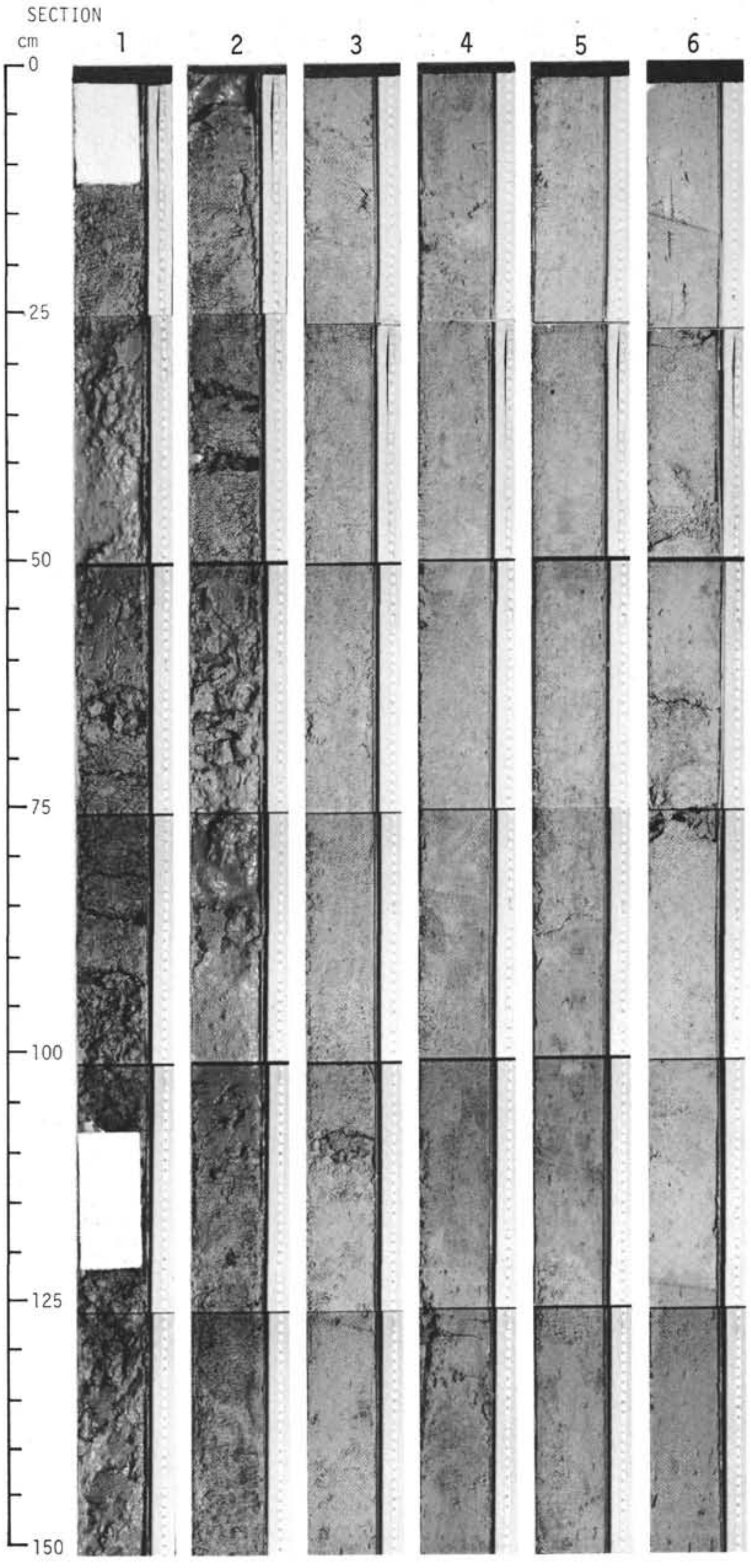
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
**◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE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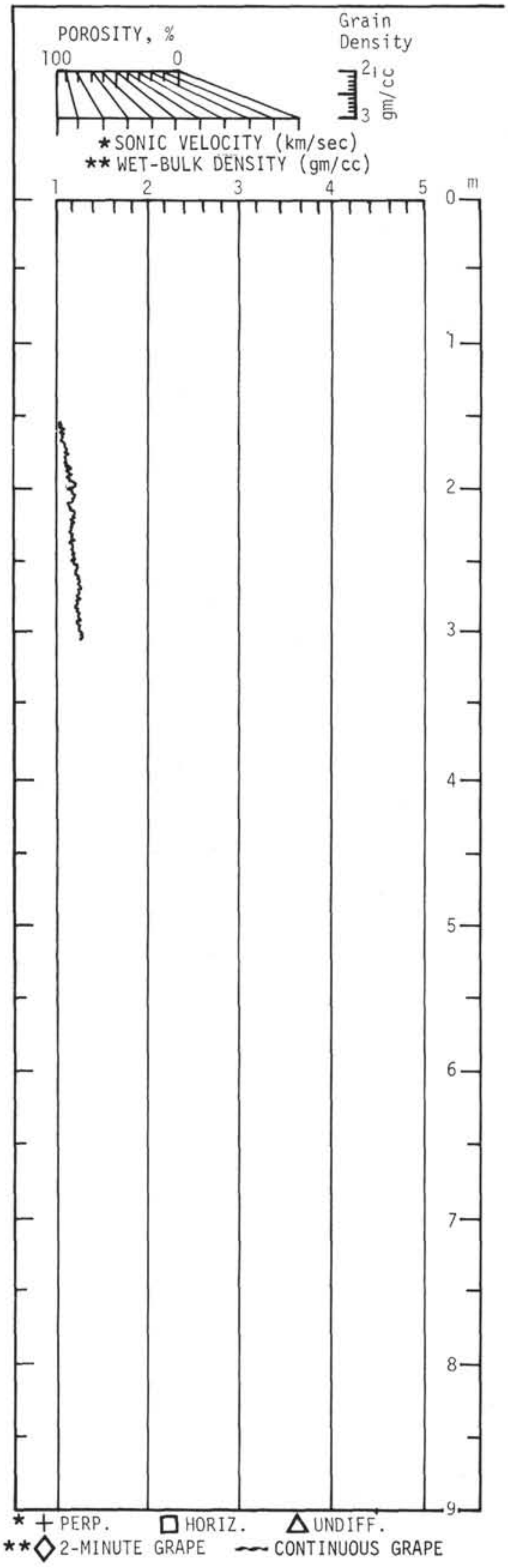
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gm/cc
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** WET-BULK DENSITY (gm/cc)
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m
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* + PERP.
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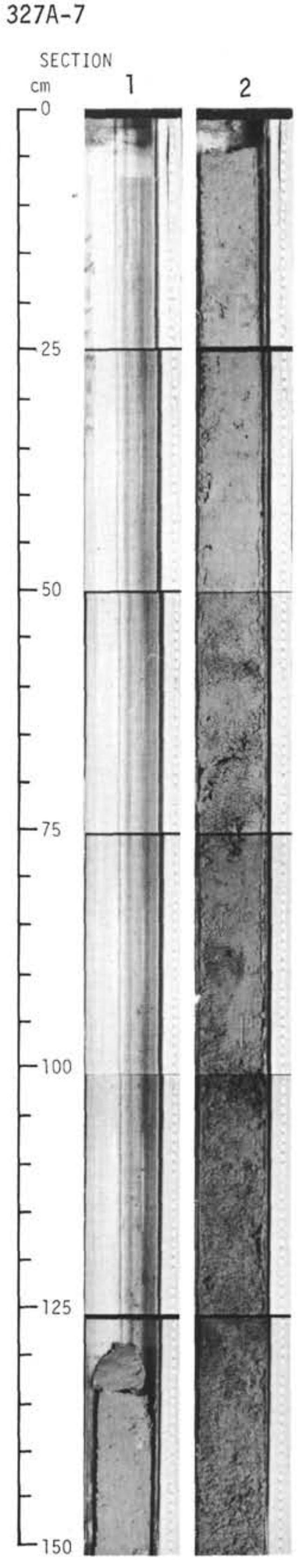
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE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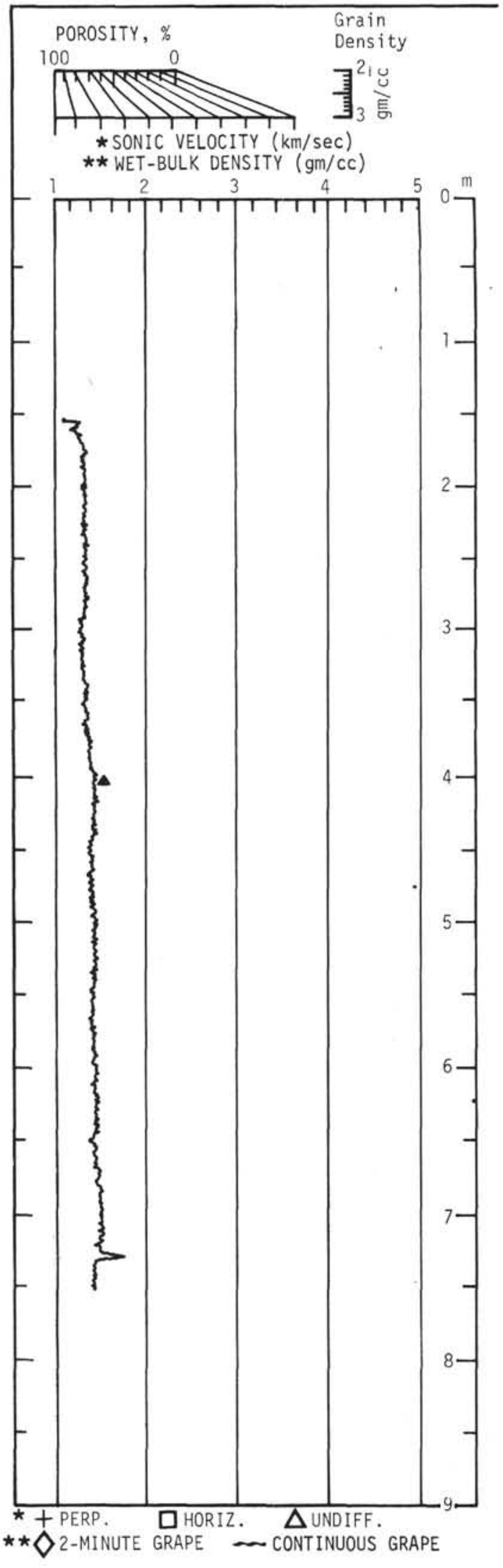
327A-8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gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
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4
5
m
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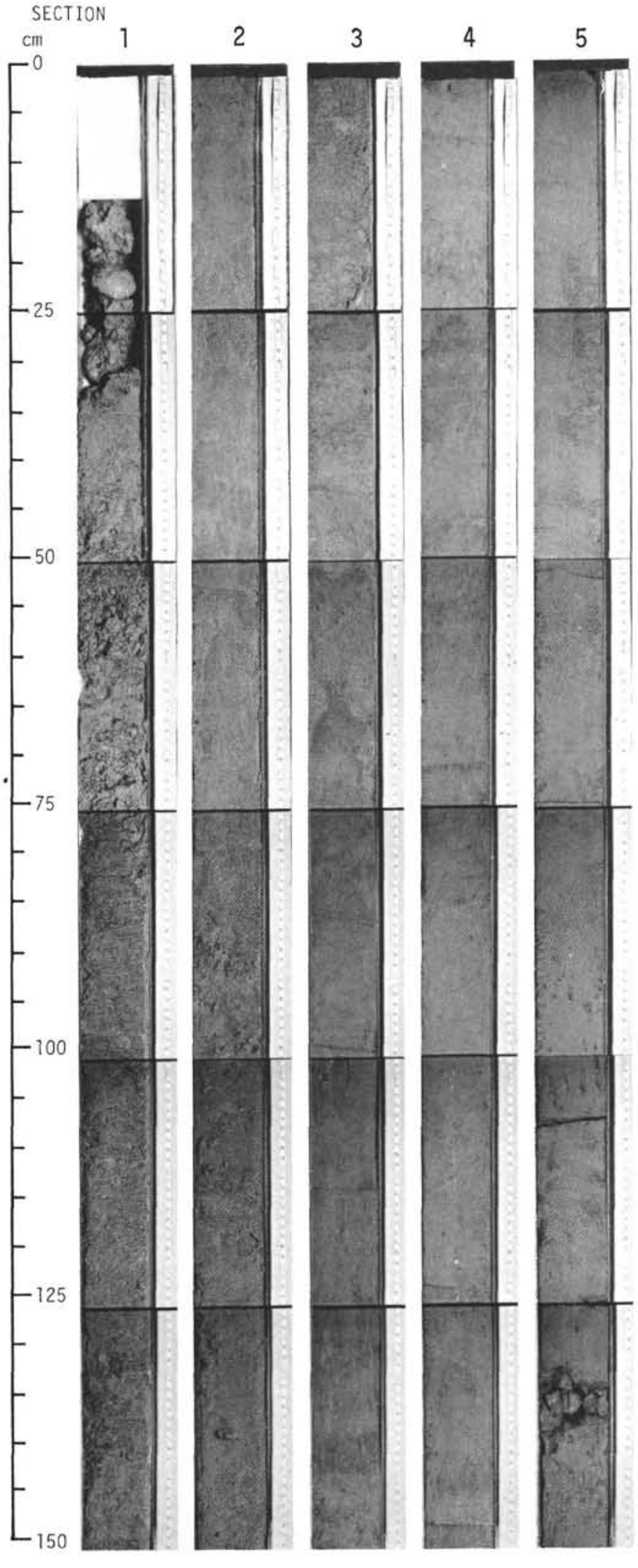
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE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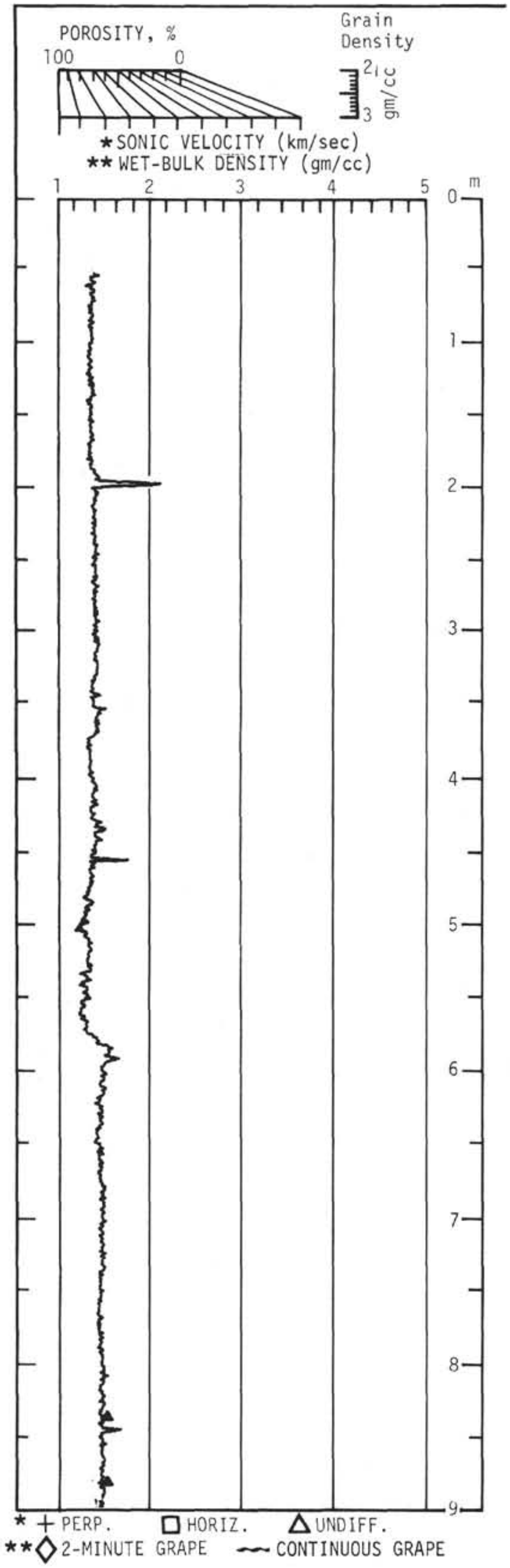
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Grain Density
2
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gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
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4
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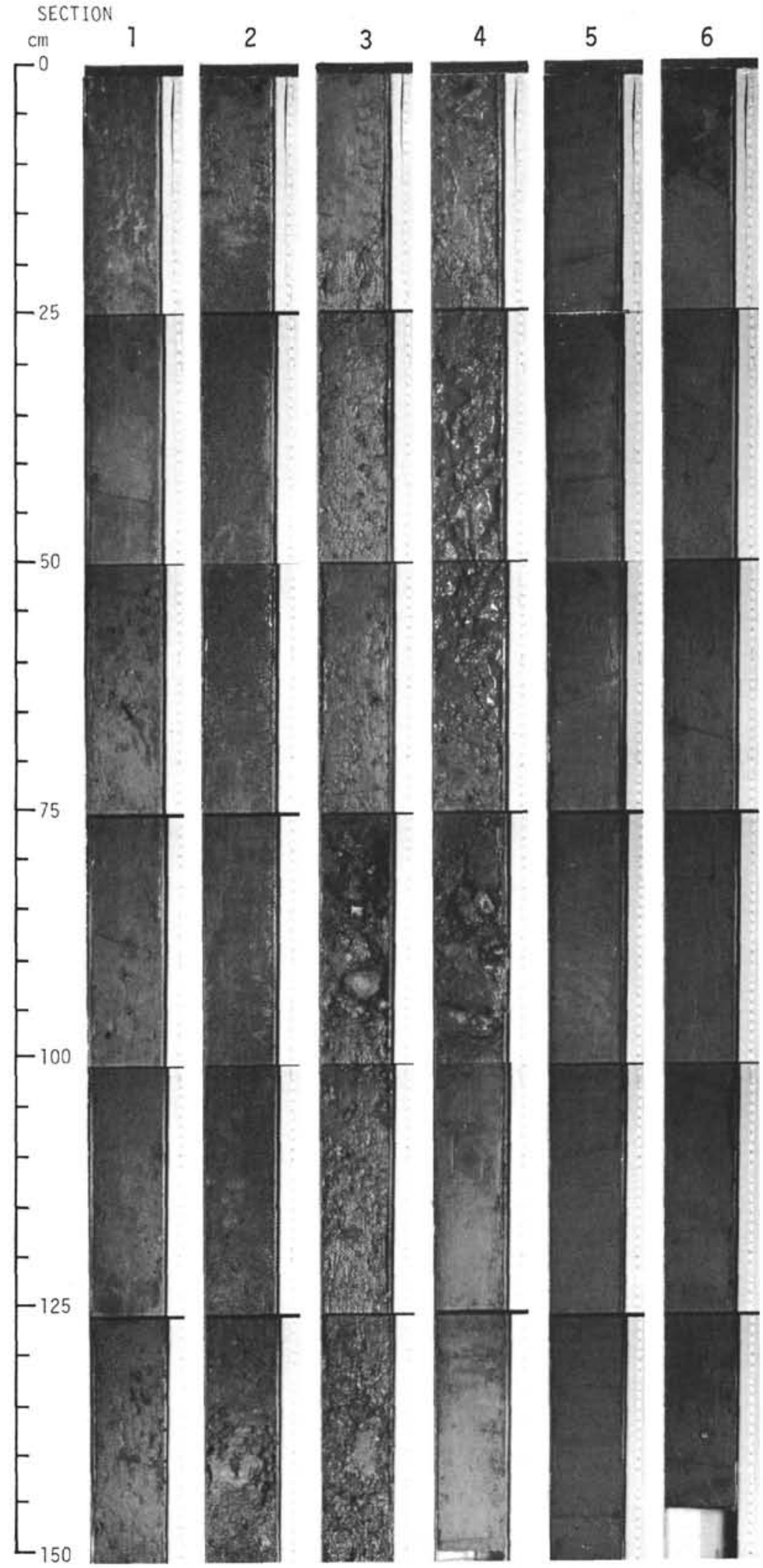
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
CONTINUOUS GRAPE

327A-9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cm
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2
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125
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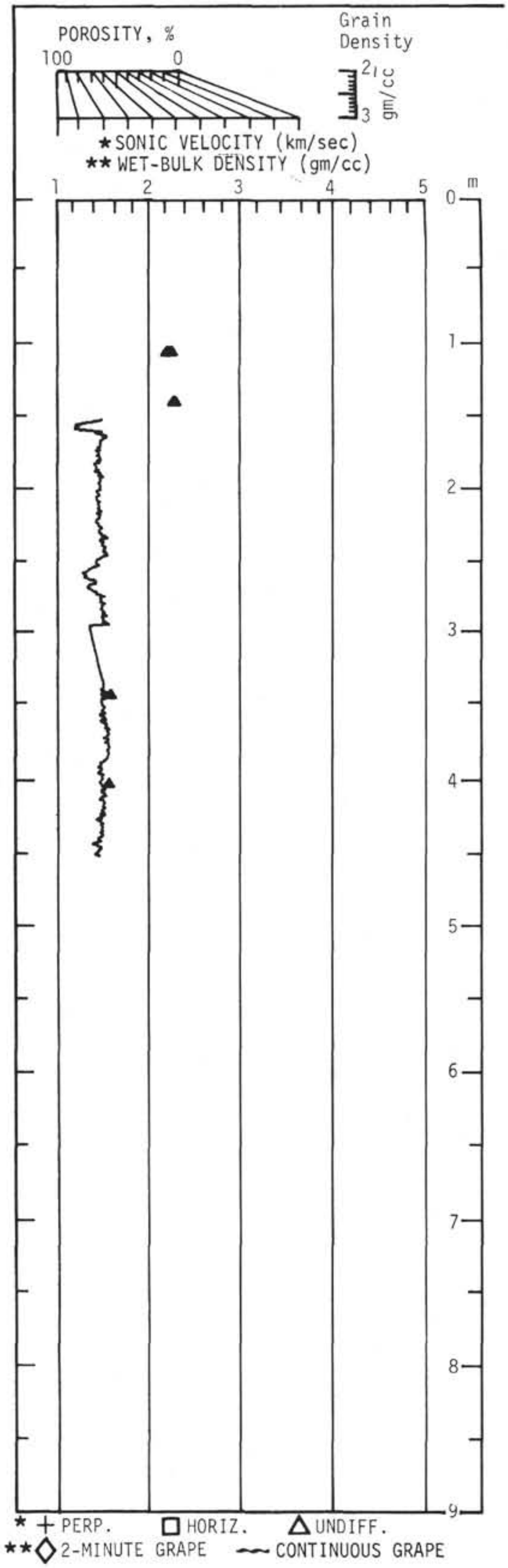
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0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
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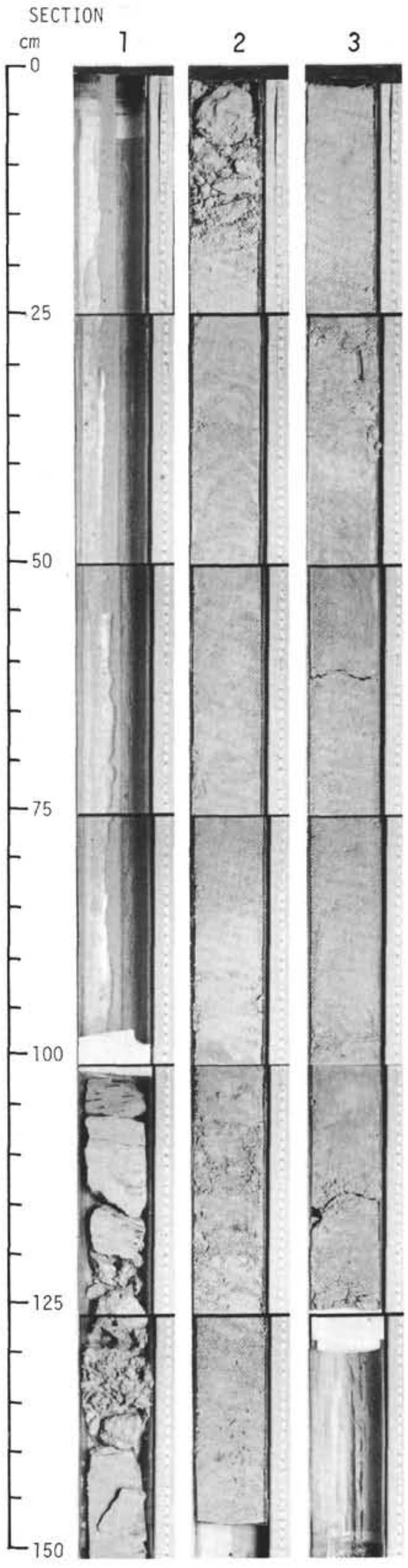
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

327A-10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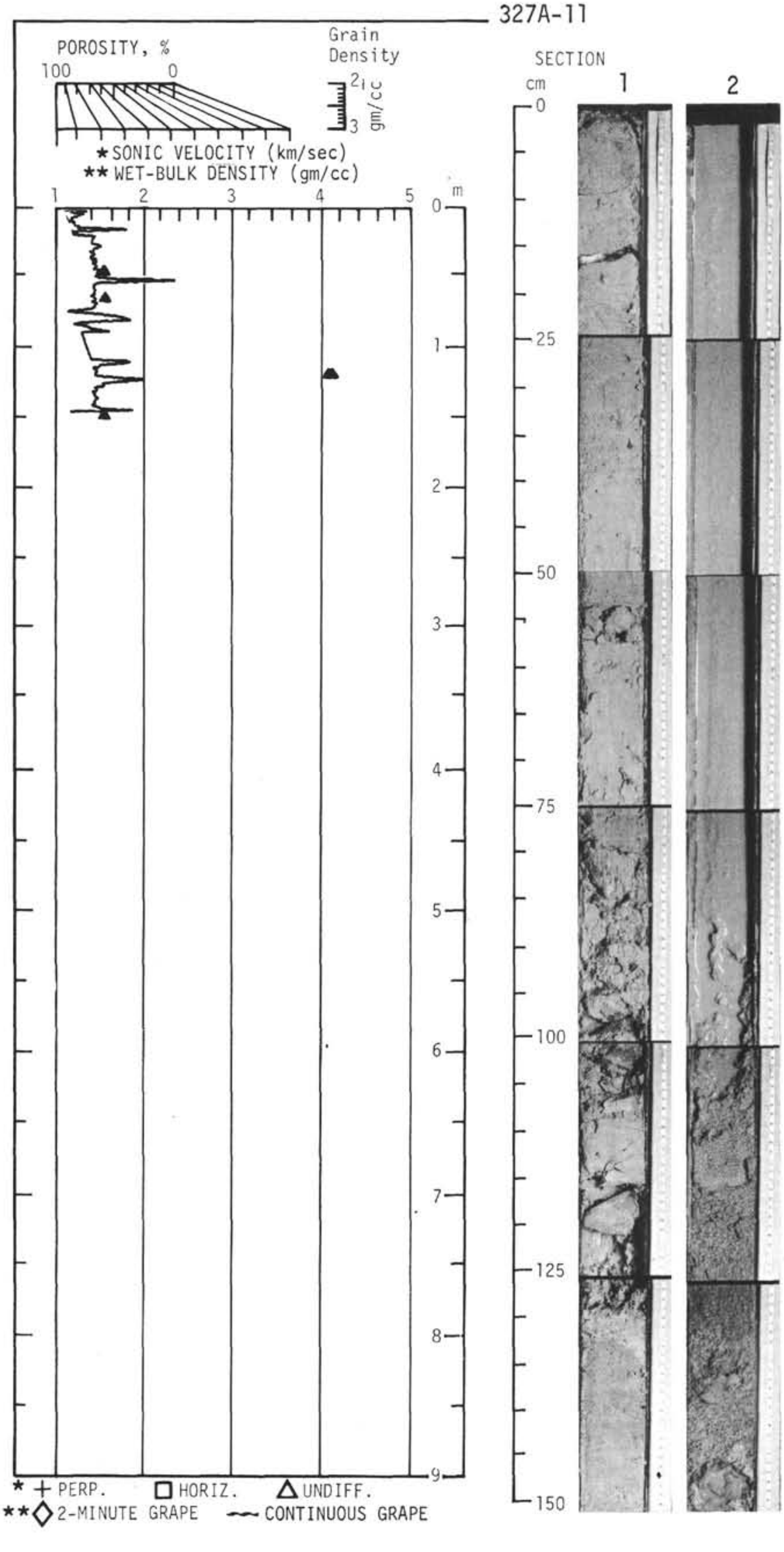
327A-11
POROSITY, %
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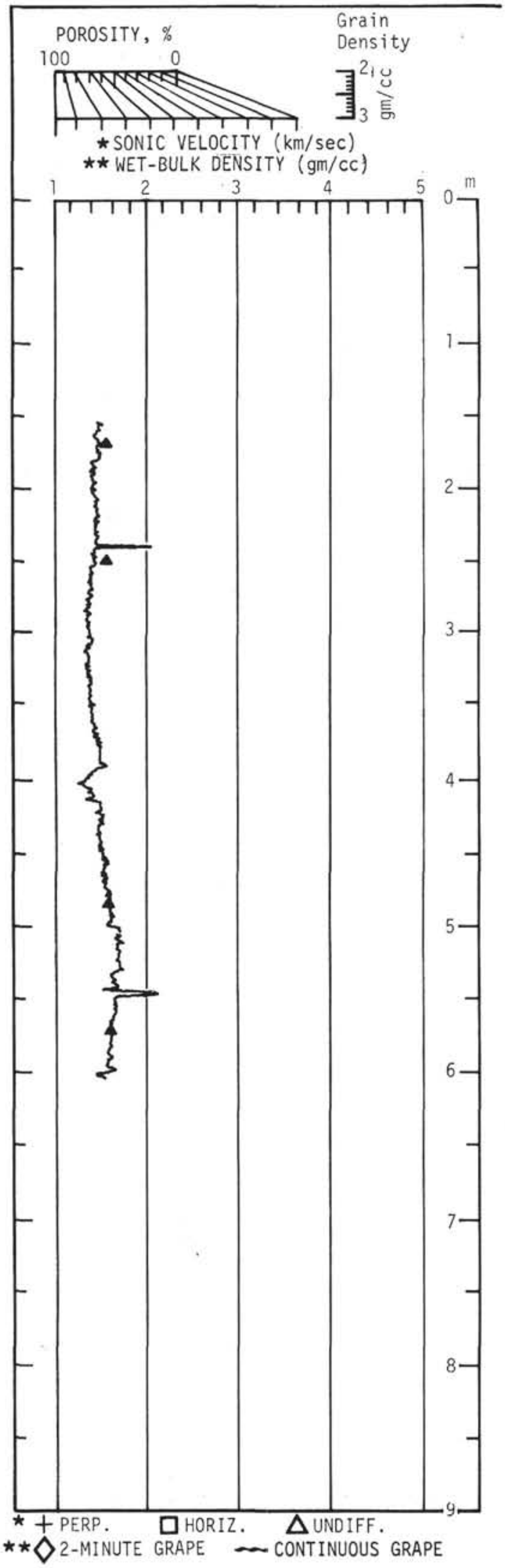
Grain Density
2
3
gm/cc
★SONIC VELOCITY (km/sec)
★★WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
★ + PERP.
□ HORIZ.
△ UNDIFF.
★★◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE
SECTION
cm
1
2
0
25
50
75
100
125
150

327A-12


POROSITY, %
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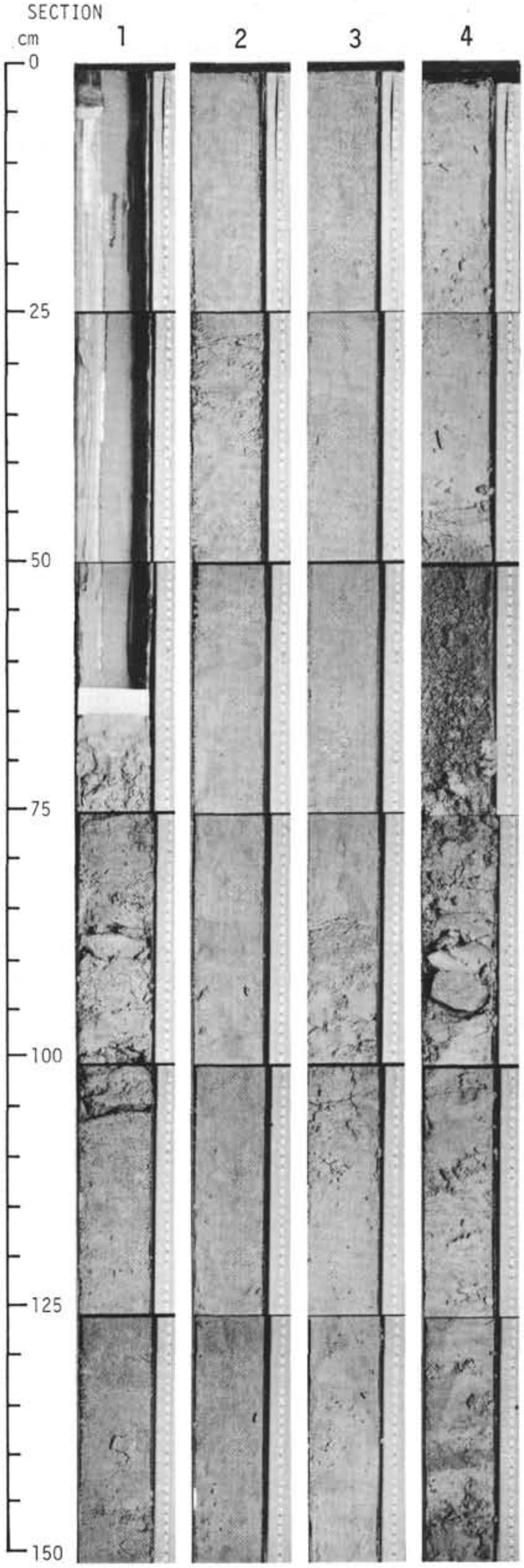
0
Grain Density
2
3
gm/cc
★SONIC VELOCITY (km/sec)
★★WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
**◇ 2-MINUTE GRAPE
CONTINUOUS GRAPE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125
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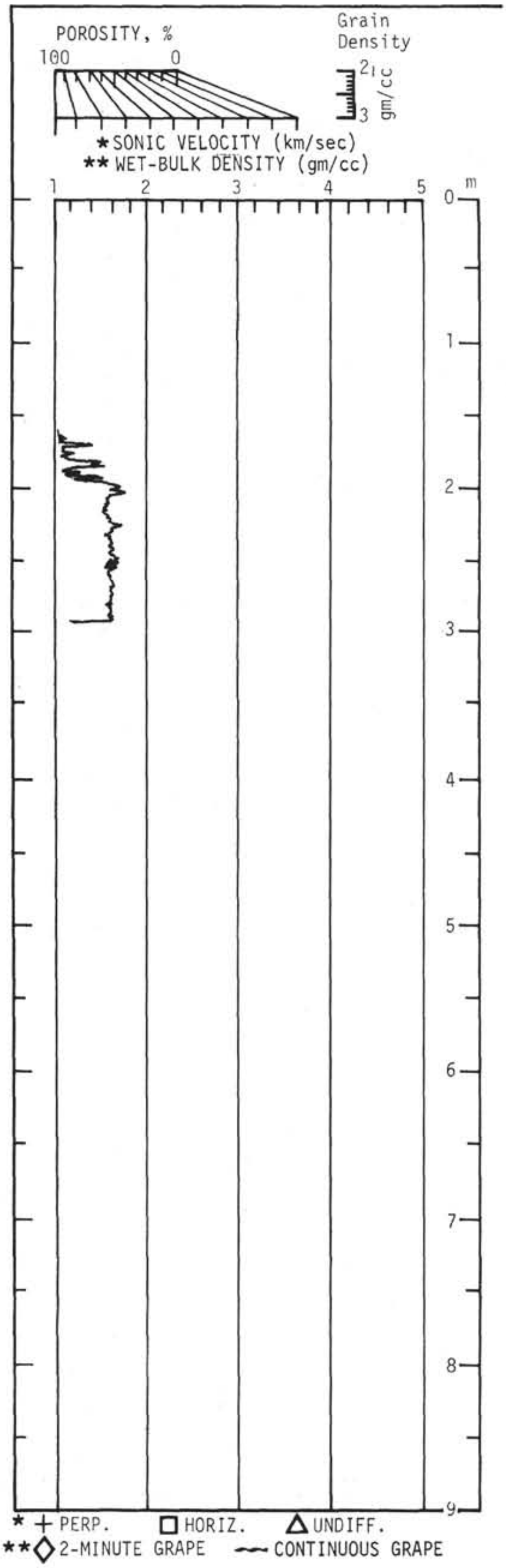
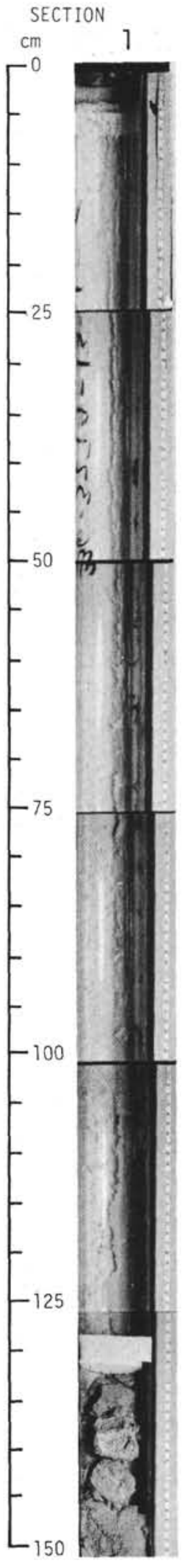


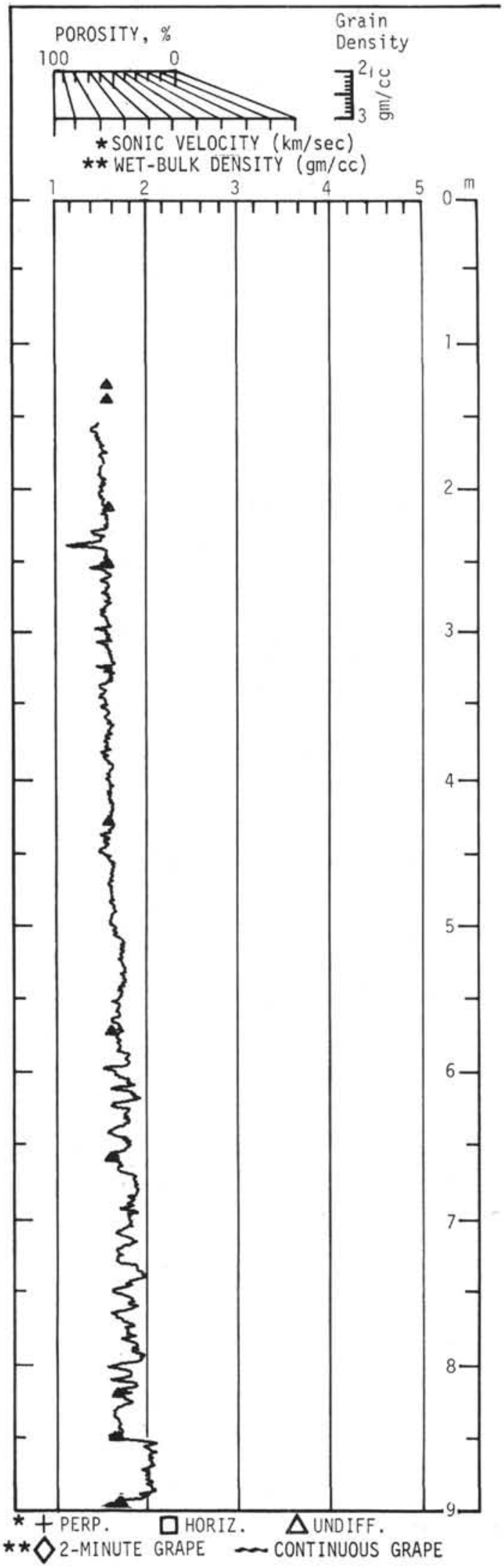
327A-13



2

NO PHOTOGRAPH AVAILABLE

327A-14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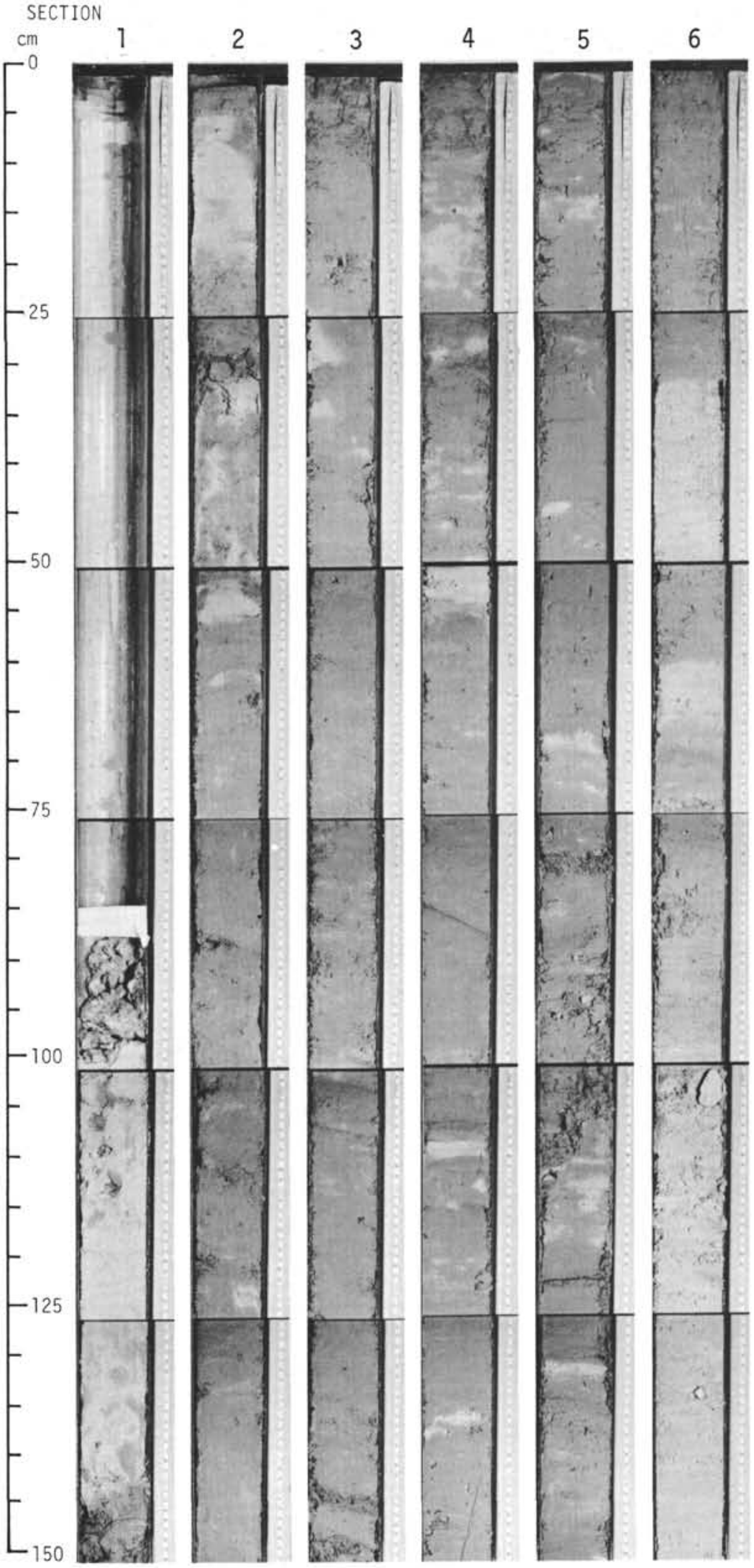
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
CONTINUOUS GRAPE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3
4
5
6
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75
100
125
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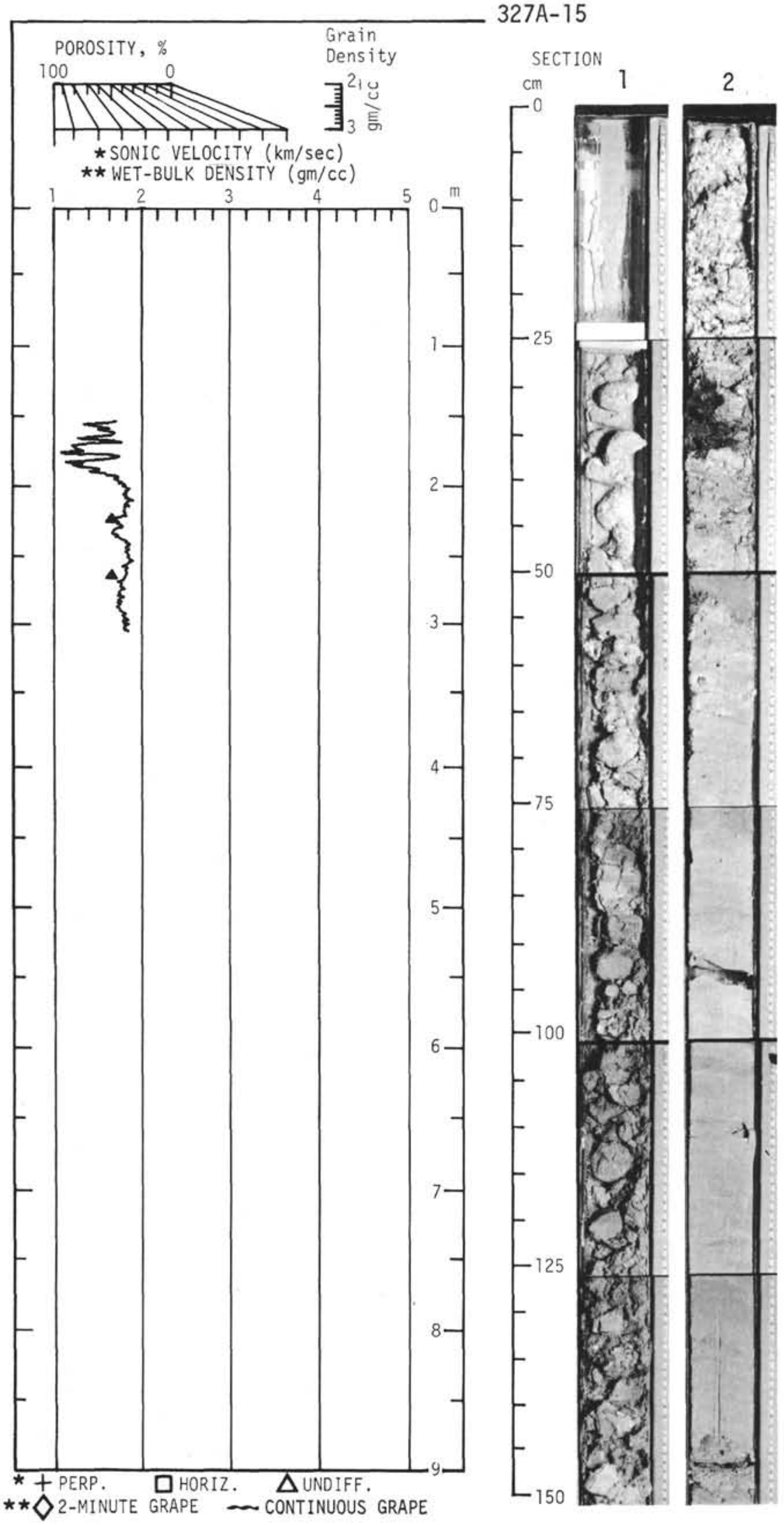
327A-15
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Grain Density
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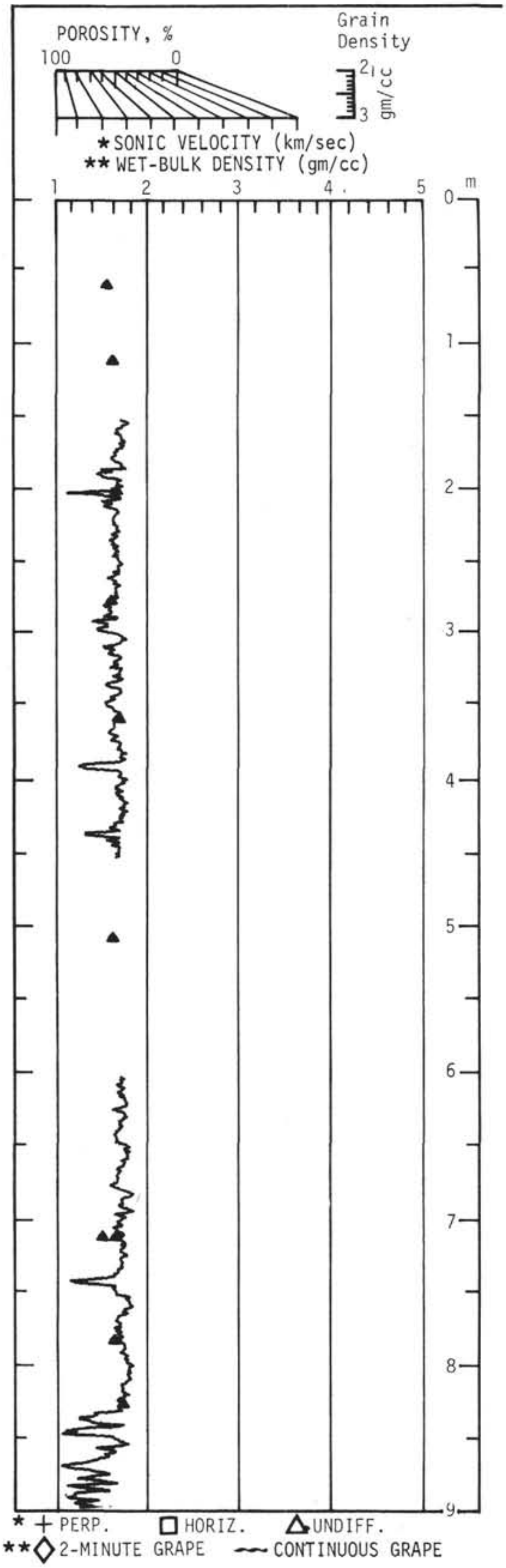
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
〜 CONTINUOUS GRAPE
SECTION
1
2
cm
0
25
50
75
100
125
150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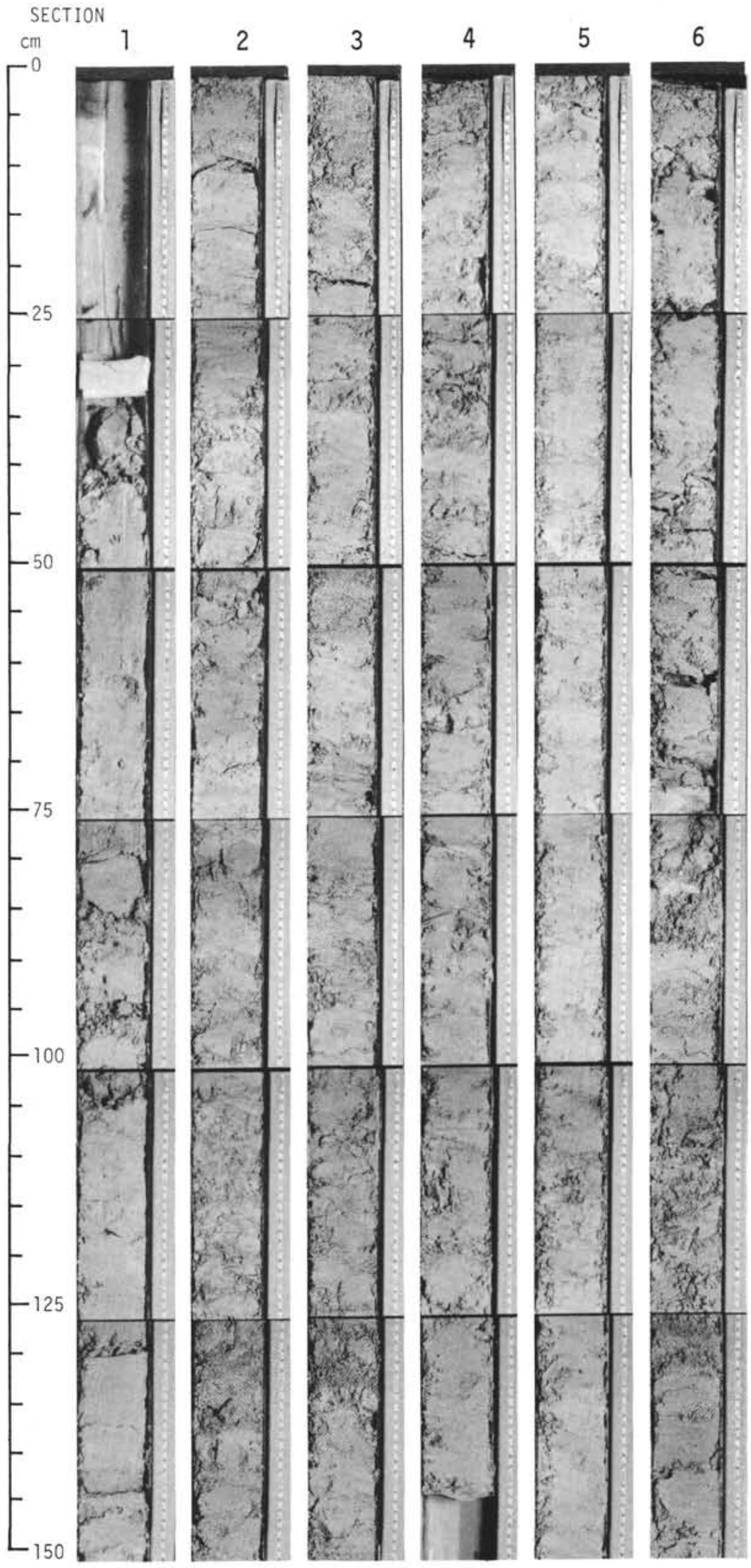
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

327A-16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2
3
4
5
6
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25
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100
125
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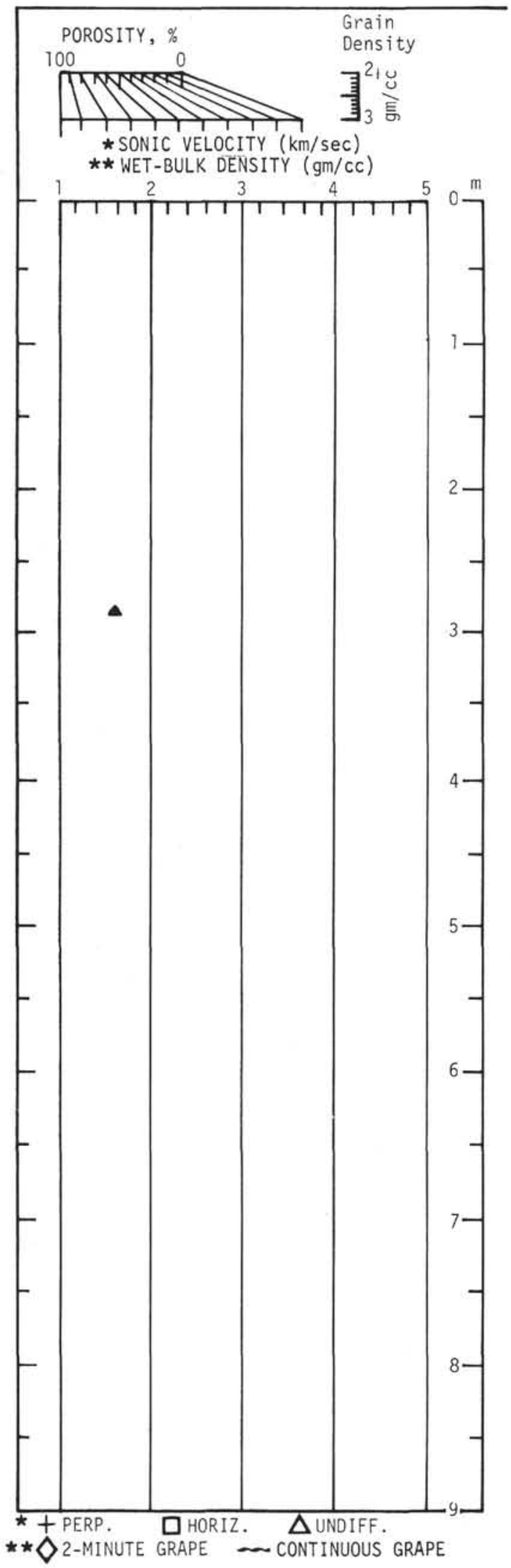
POROSITY, %
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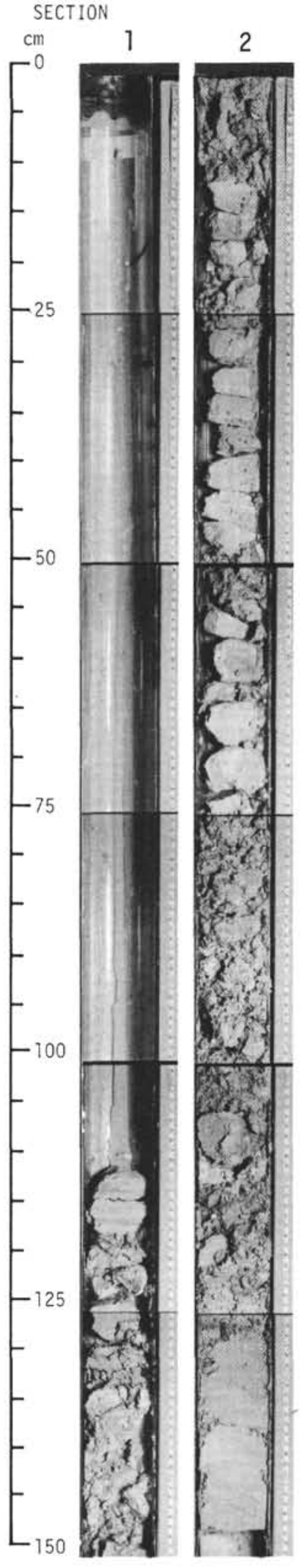
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
CONTINUOUS GRAPE

327A-17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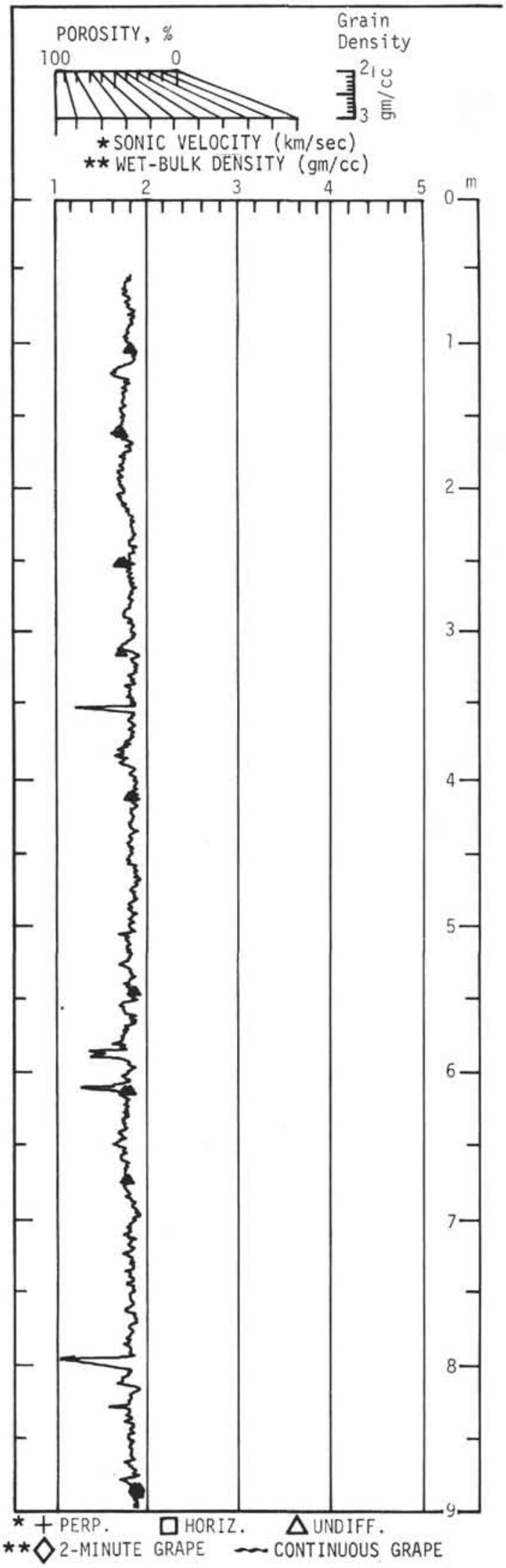
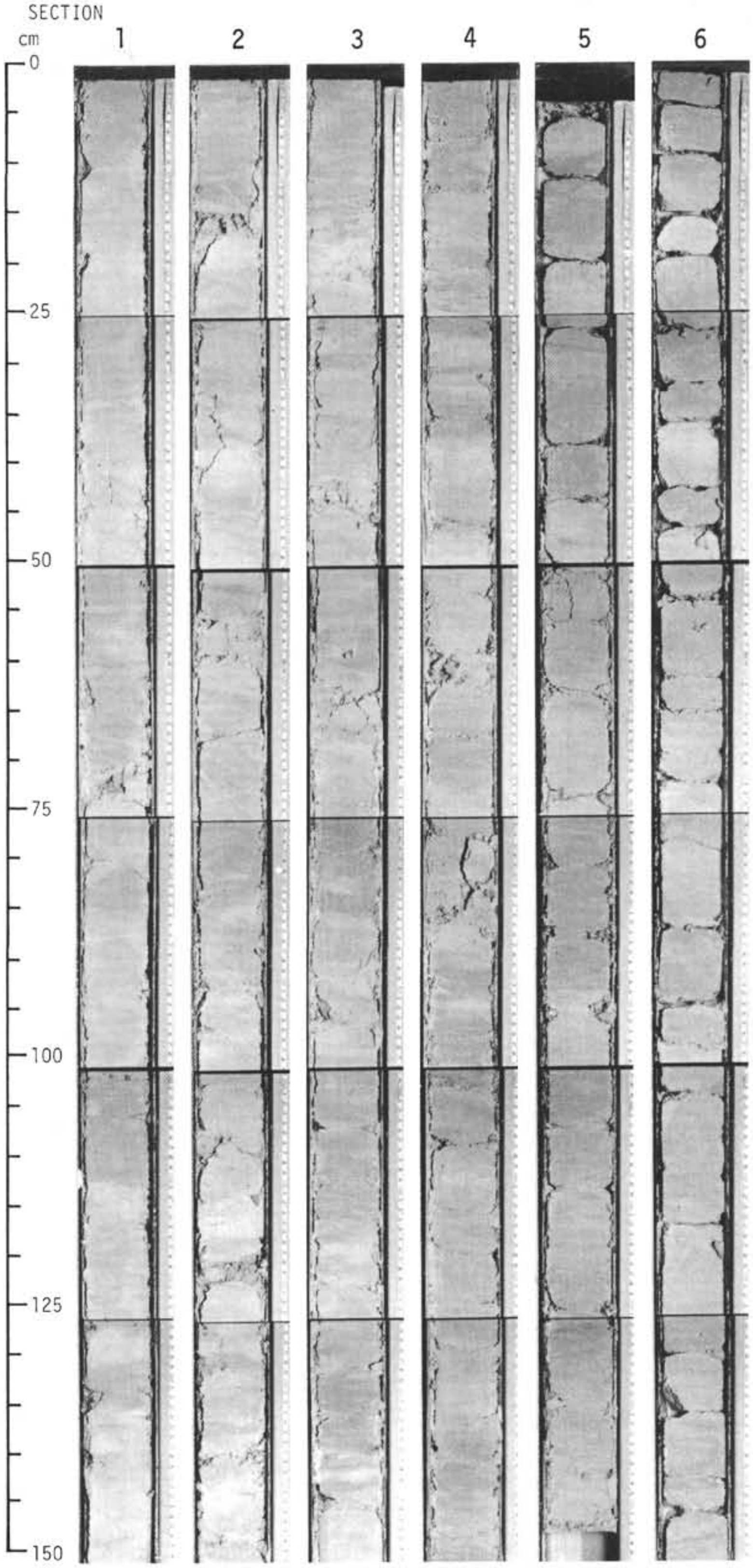
cm
1
2
0
25
50
75
100
125
150


POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP. □ HORIZ. △ UNDIFF.
** ◇ 2-MINUTE GRAPE ~~ CONTINUOUS GRAPE

327A-18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cm
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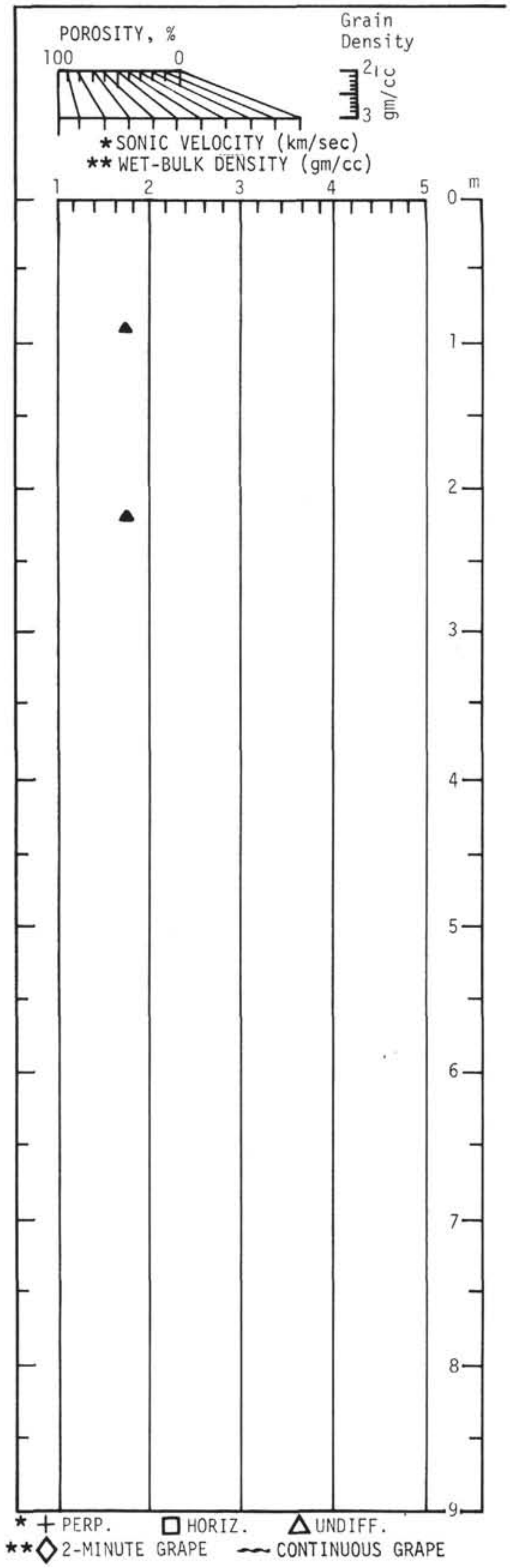
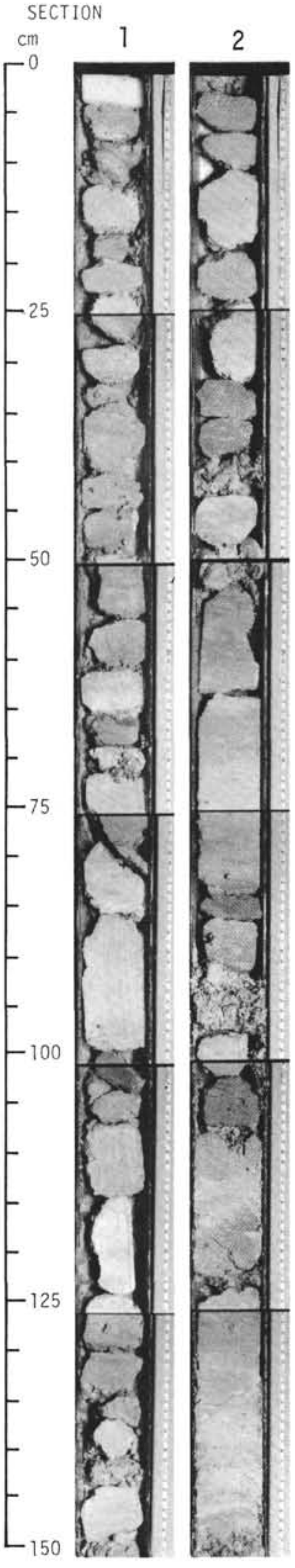
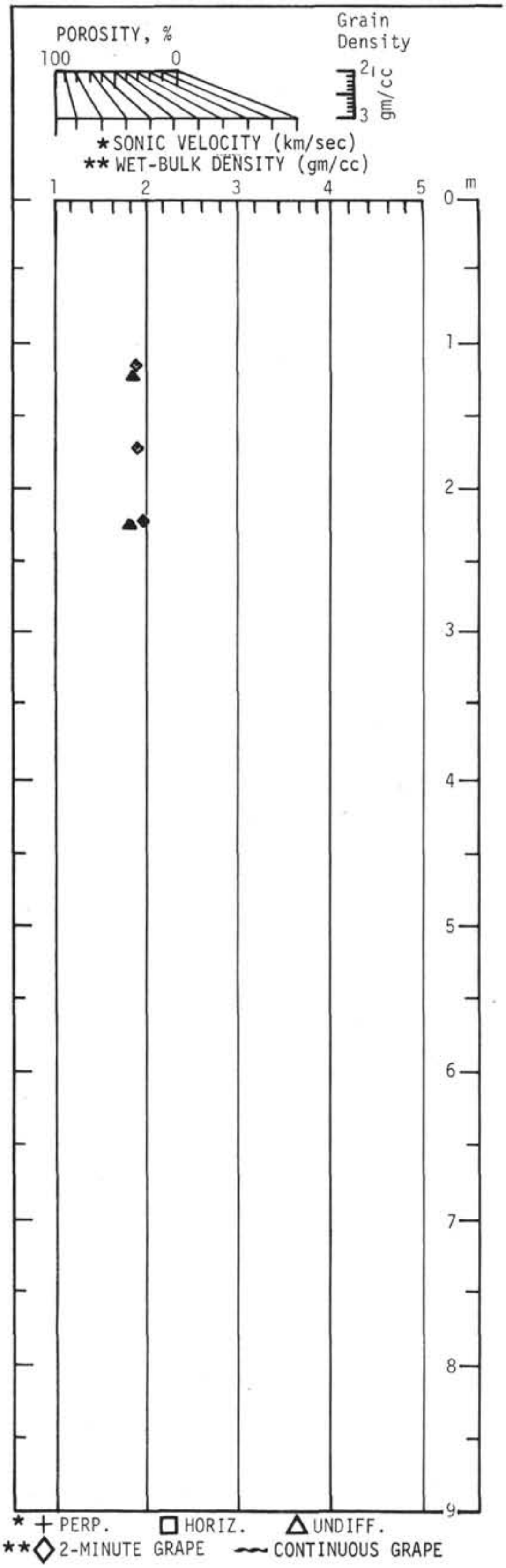
2
3
4
5
6
0
25
50
75
100
125
150

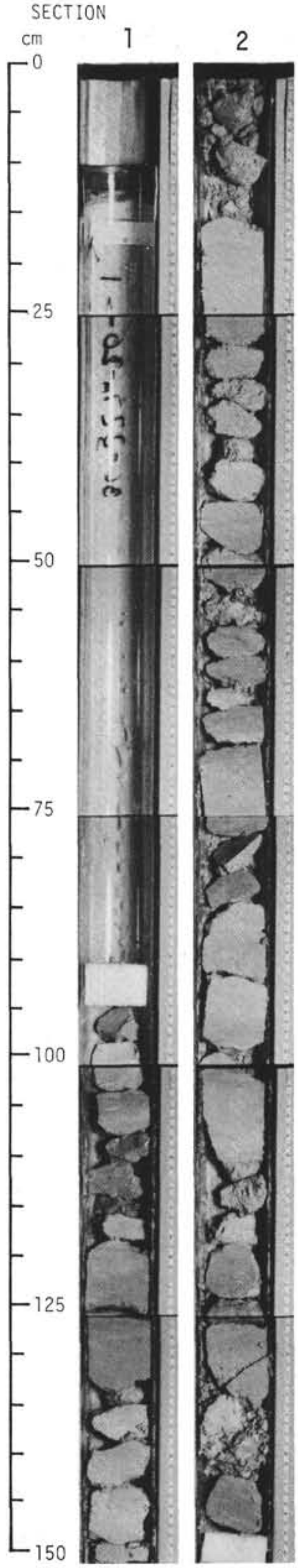

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

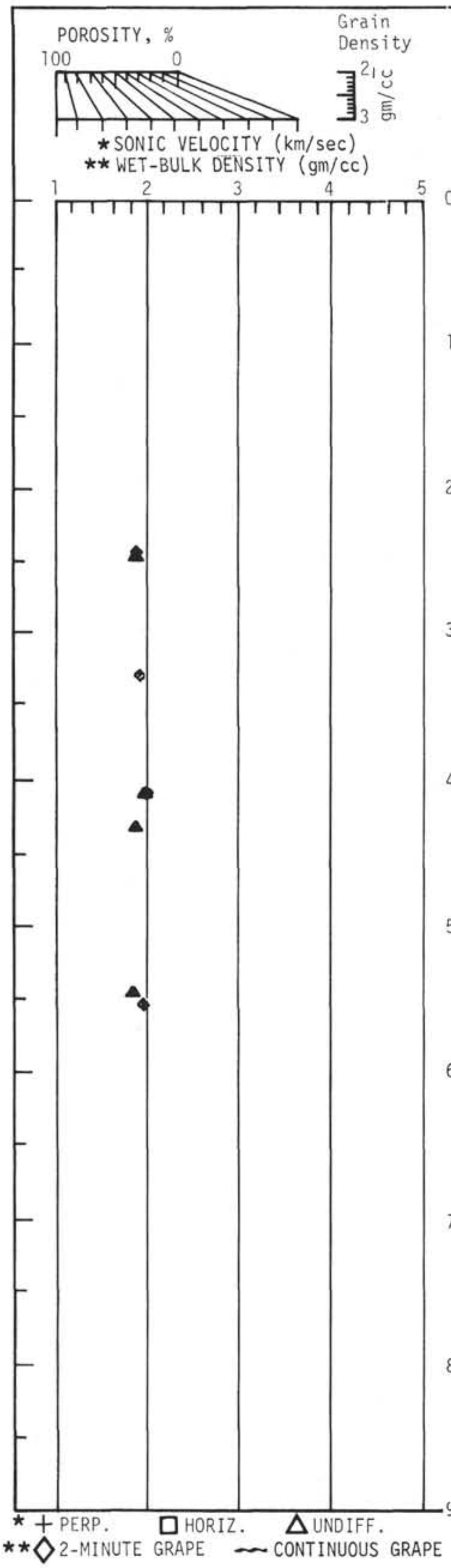
327A-19


SECTION
cm
1
2
0
25
50
75
100
125
150

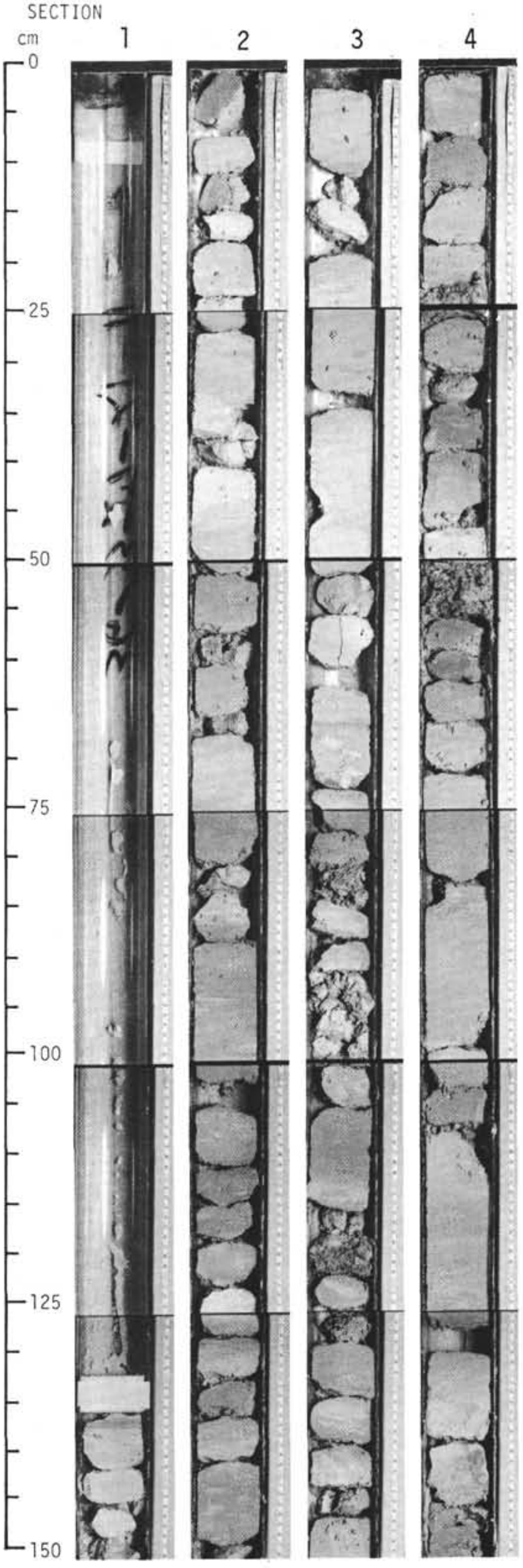

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
〰 CONTINUOUS GRAPE

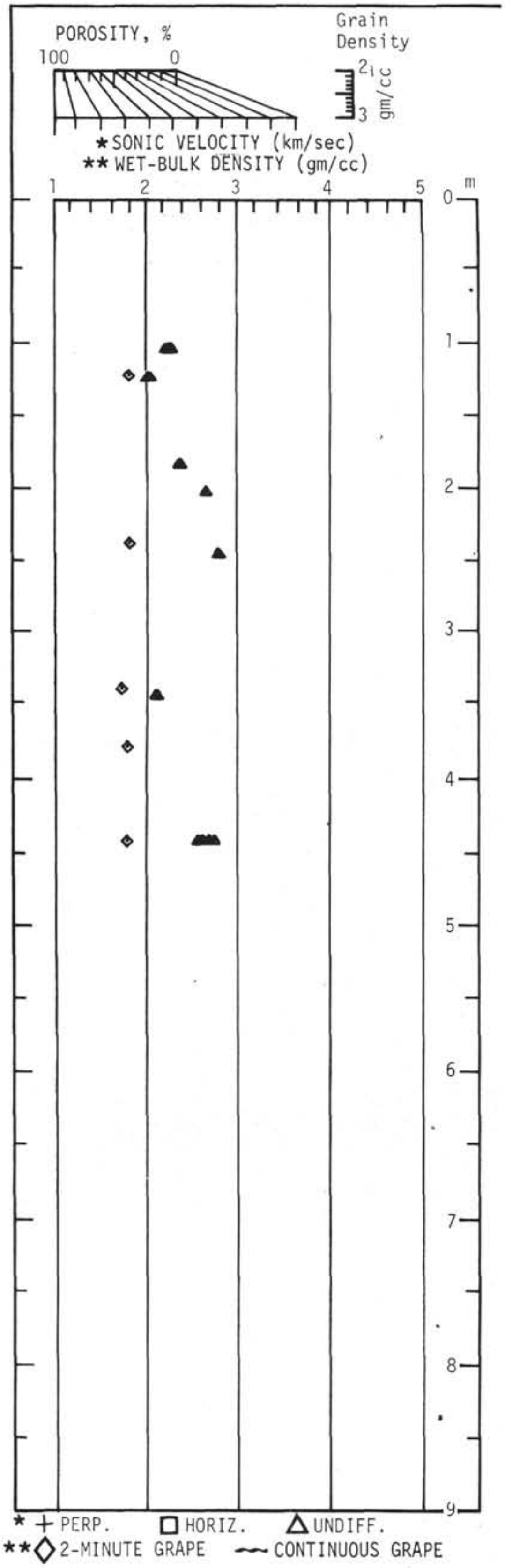
327A-20


SECTION
cm
1
2
0
25
50
75
100
125
150

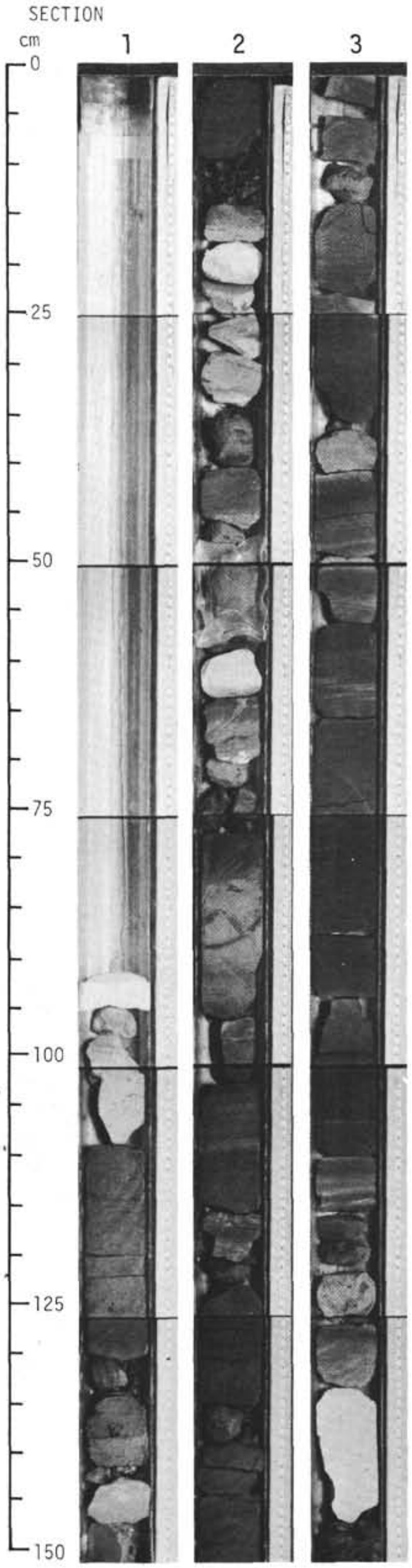

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

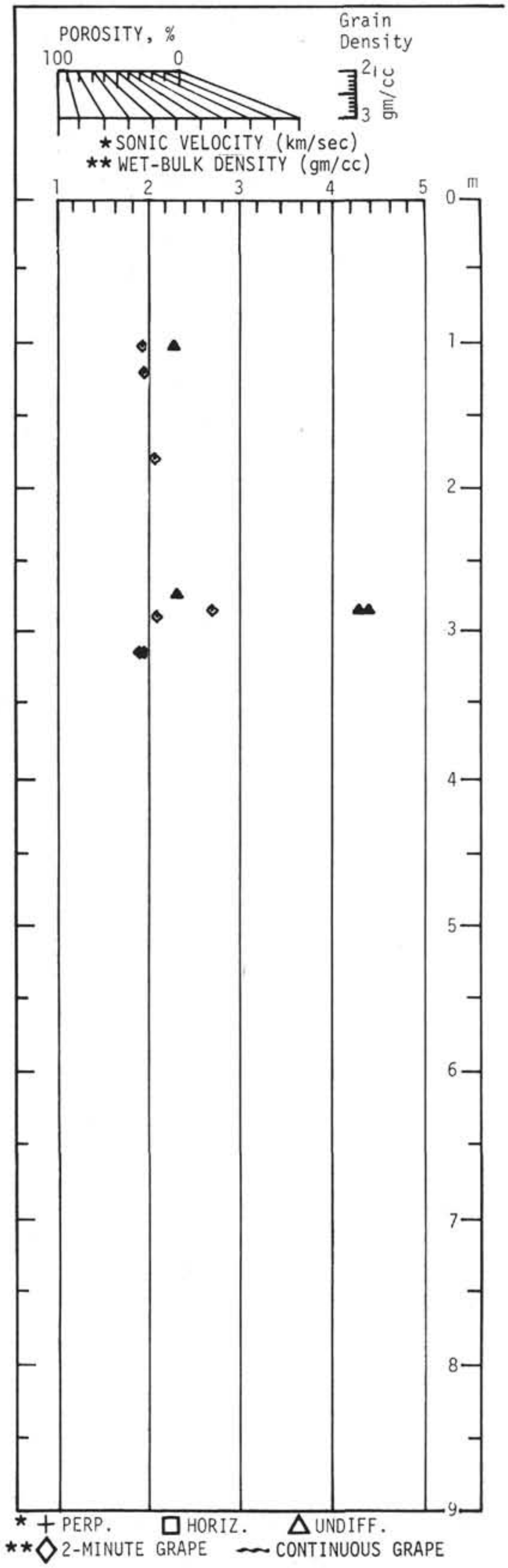
327A-21


SECTION
cm
1
2
3
4
0
25
50
75
100
125
150

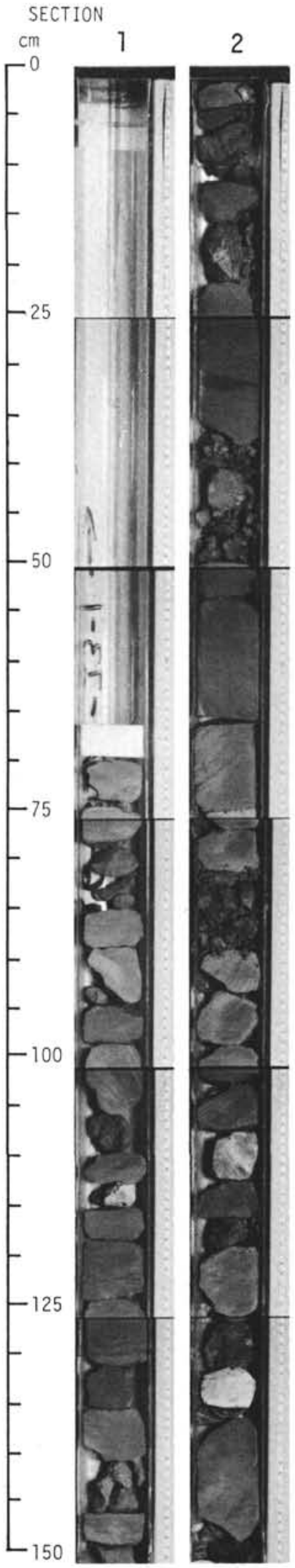

POROSITY, %
100
0
Grain Density
2
3
gm/cc
*SONIC VELOCITY (km/sec)
**WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
〰 CONTINUOUS GRAPE

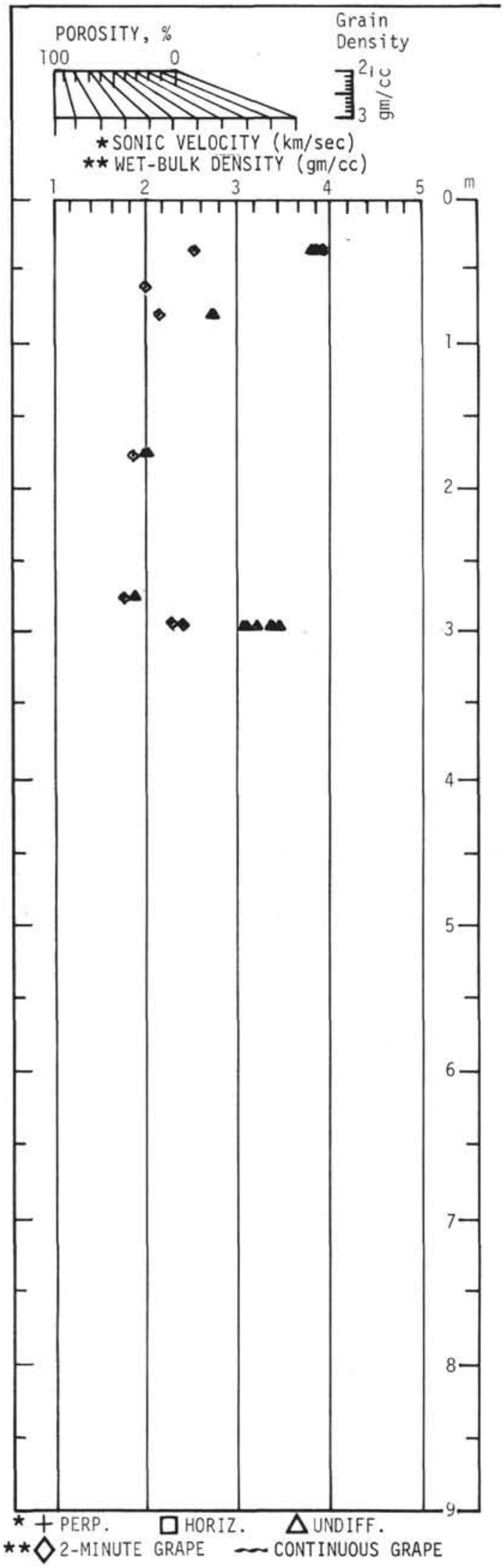
327A-22

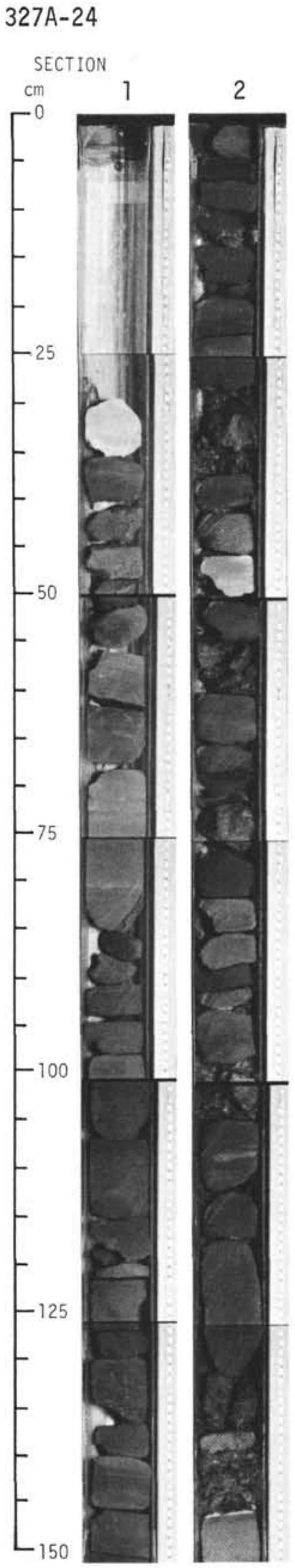

SECTION
cm
0
25
50
75
100
125
150
1
2
3

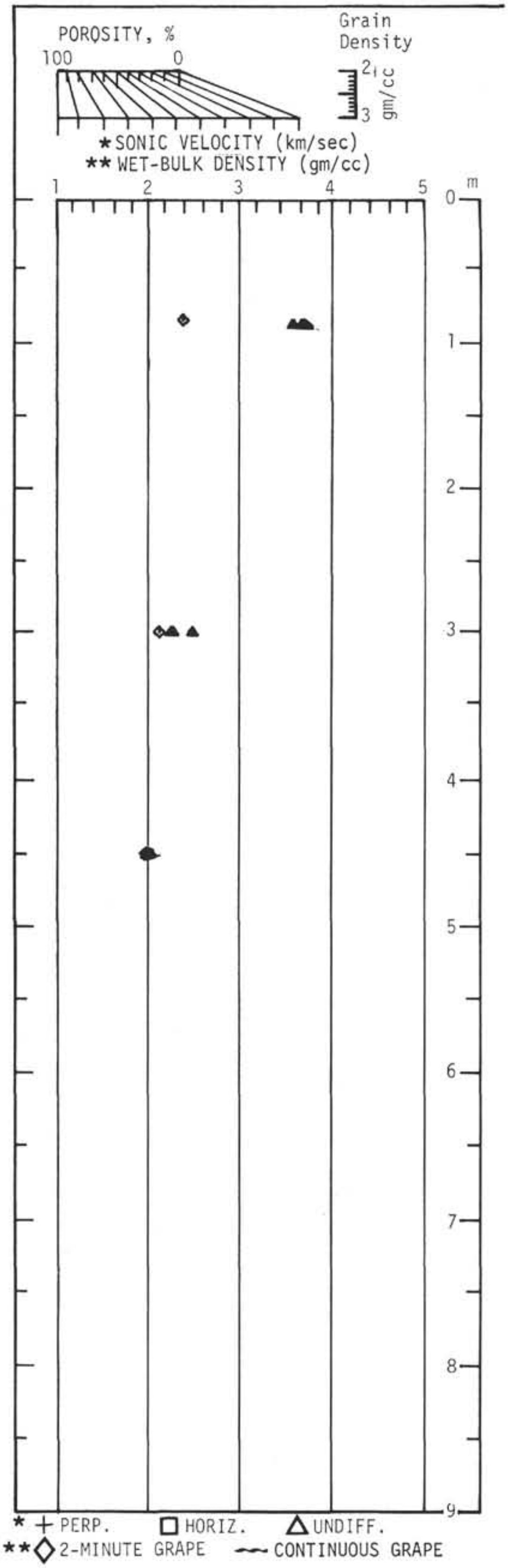

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

327A-23

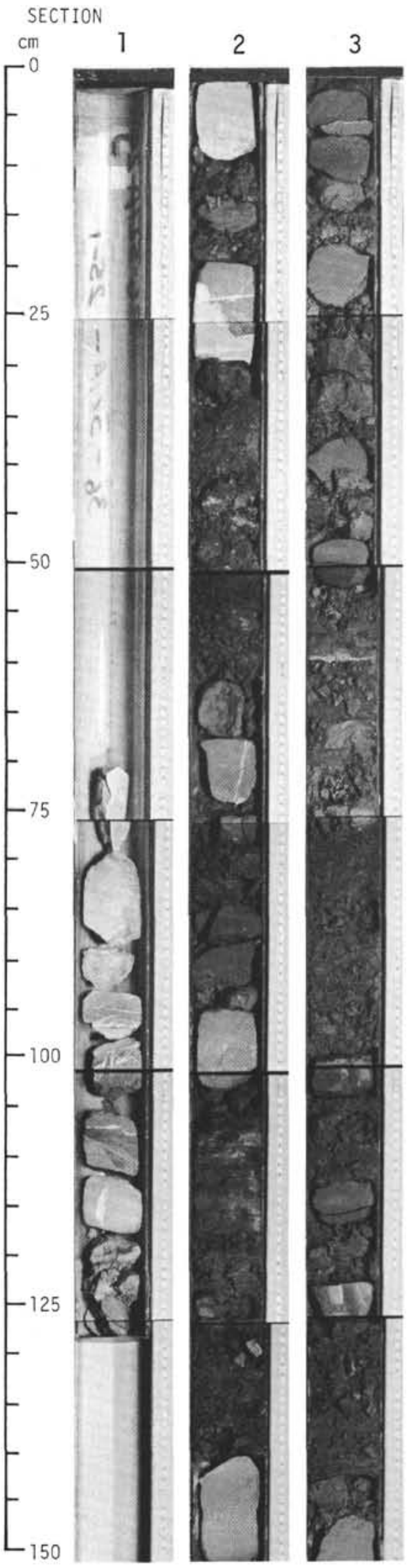

SECTION
cm
1
2
0
25
50
75
100
125
150

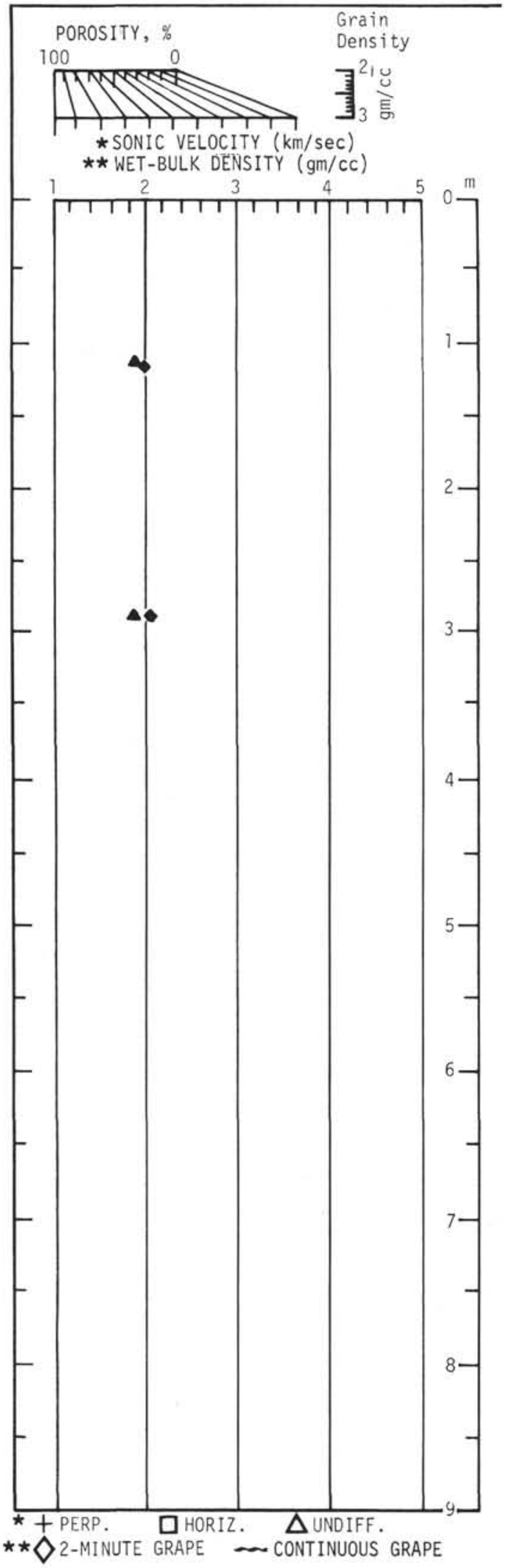

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE


327A-24
SECTION
cm
1
2
0
25
50
75
100
125
150

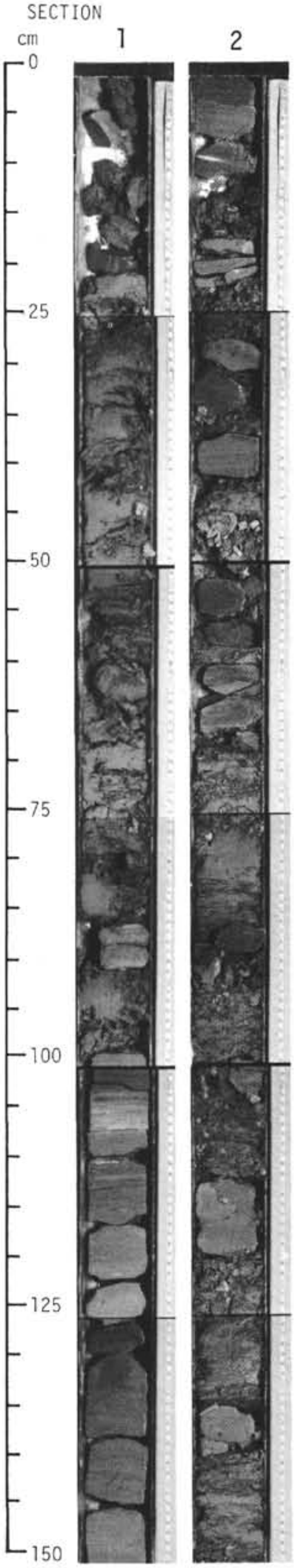

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

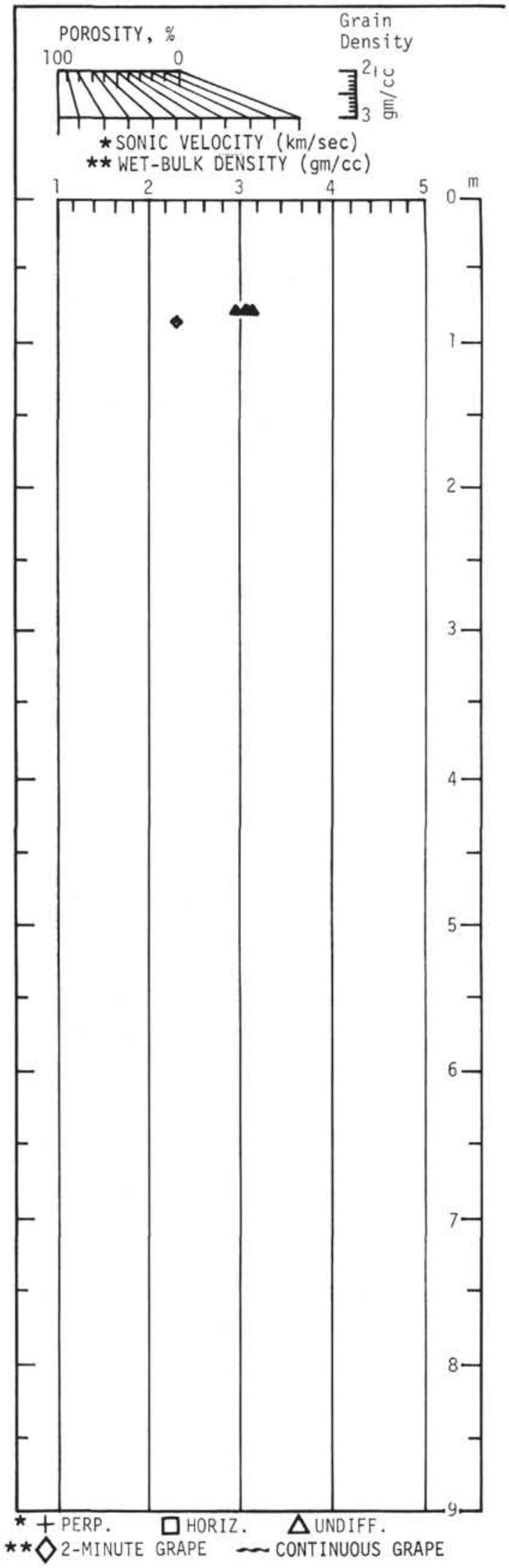
327A-25


SECTION
cm
1
2
3
0
25
50
75
100
125
150

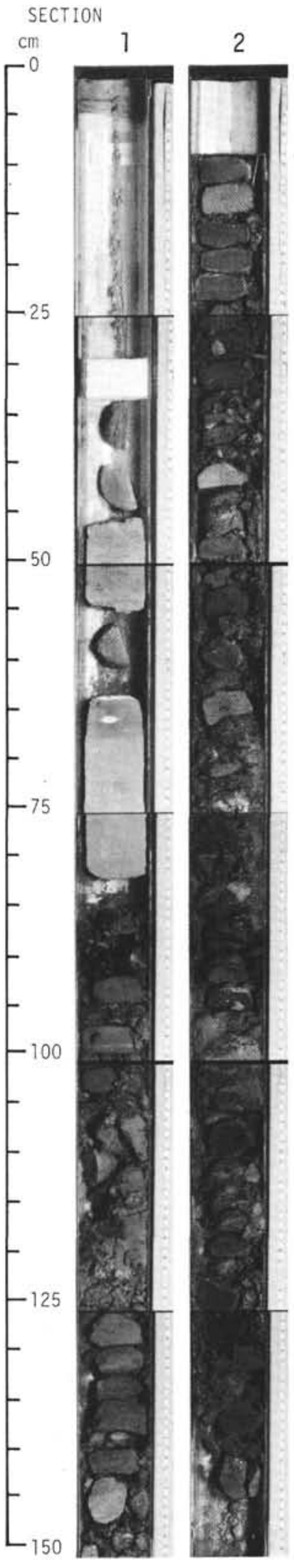

POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
□ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
〰 CONTINUOUS GRAPE

327A-26


SECTION
1
2
cm
0
25
50
75
100
125
150


POROSITY, %
100
0
Grain Density
2
3
gm/cc
* SONIC VELOCITY (km/sec)
** WET-BULK DENSITY (gm/cc)
1
2
3
4
5
m
0
1
2
3
4
5
6
7
8
9
* + PERP.
☐ HORIZ.
△ UNDIFF.
** ◇ 2-MINUTE GRAPE
~ CONTINUOUS GRAPE

327A-27


SECTION
cm
1
2
0
25
50
75
100
125
150